PROJECT MANUAL
INCLUDING CONSTRUCTION SPECIFICATIONS

for

V-S035, - TERMINAL C ASC LEVEL 2 EMERGENCY EGRESS (D/B)

ORLANDO INTERNATIONAL AIRPORT

Orlando, Florida 32827

CONTRACT DOCUMENTS
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GREATER ORLANDO AVIATION AUTHORITY

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SECTION 23 3600 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:
1. Fan-powered air terminal units.
2. Constant volume single-duct air terminal units.
3. Variable air volume single-duct air terminal units.
4. Electric heating coils.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated, include rated capacities, furnished specialties, sound-power ratings, and accessories.

B. Include letter with submittal data stating that unit controls have been completely coordinated with controls contractor.

~~C. LEED V4 BD+C Submittal:~~

~~1. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."~~

~~D.~~C. Shop Drawings: Detail equipment assemblies and indicate dimensions, required clearances, materials used in fabrication, method of field assembly, components, and location and size of each field connection.

1. Include a schedule showing unique model designation, room location, model number, size, and accessories furnished.
2. Wiring Diagrams: Power, signal, and control wiring and differentiate between factory-installed and field-installed wiring.
3. Include catalog performance ratings which indicate air flow, static pressure and NC designation.
4. Include a schedule listing discharge and radiated sound power levels, for each unit, of second to sixth octave band at inlet static pressure of 1 to 4 in. w.g. NC data alone will not be acceptable.

~~E.~~D. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

~~F.~~E. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Instructions for resetting minimum and maximum air volumes.
2. Instructions for adjusting software set points.
3. Directions for resetting constant volume regulators.
4. Parts list for each type of air terminal unit and troubleshooting maintenance guide.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of air terminal units and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

B. All units shall be the product of a manufacturer regularly engaged in the production of terminal units and all supplied units shall be clearly described by means of published catalog data from the same manufacturer.

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

D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

E. NFPA Compliance: Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

F. Air terminal units shall be certified under AHRI Standard 880-94 certification program and carry the AHRI seal.

G. Air terminal unit lining shall meet UL 181 and NFPA 90A standards. All units shall be suitable for use in a return air plenum. All components within the air stream shall conform to the NFPA 90A Standard for Flame/Smoke/Fire Contribution of 25/50/0.

H. All units shall be capable of maintaining their minimum and maximum set points within a maximum of ±5%.

I. Terminal box insulation and design suitable for 50°F primary air in 75°F, 60% RH ceiling plenum without condensation.

J. Fan-Powered air terminal units:

1. Fan powered boxes to be guaranteed to thoroughly mix 50°F primary air with 75°F recirculated air to produce a maximum of 1-1/2 F temperature differential at any place to the duct 4' downstream of the unit.

2. Manufacturer shall provide proof that the proposed units have been tested under the airflows and static pressures shown on the project schedule, in a certified laboratory as per ANSI S1.31 standard, following AHRI 880, and comply with the maximum sound power levels indicated below.

a. Maximum radiated sound power level of fan powered boxes shall not be greater than any of the following octave band limits.

Maximum Fan Powered Box Sound Power Levels
Db re: 10^{-12} Watts
Tested in Accordance with AHRI 880

Octave Band:	2	3	4	5	6	7
Center Freq. (Hz):	125	250	500	1k	2k	4k
Unit Located Over NC-35 Space:	68	61	57	52	50	44
Unit Located Over NC-40 Space:	72	66	62	57	55	49

1.5 COORDINATION

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

B. Air terminal units shall be equipped with pressure independent direct digital controls supplied by the Control Contractor and mounted at the factory by the terminal unit manufacturer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 FAN-POWERED AIR TERMINAL UNITS

A. Manufacturers:

   1. Anemostat; a Mestek Company.
   2. Environmental Technologies, Inc.; Enviro-Air Div.
   3. Titus.
   ~~3.~~4. Neptronic
   ~~4.~~5. Tuttle & Bailey.
   ~~5.~~6. Price Industries.

B. Configuration: Volume-damper assembly and fan in series or in parallel arrangement, as indicated on Drawings, inside unit casing with control components inside a protective metal shroud.

C. Casing: 0.034-inch galvanized steel.

   1. Casing Lining: 1-inch- thick, 1-1/2 lb./cu. ft. density, nylon scrim reinforced foil skin vapor barrier insulation. Insulation shall be dual thermal/acoustical fiberglass insulation meeting NFPA 90A requirements, UL 181 erosion control requirements, meet all requirements of ASTM C1071 (including C665), and carry a 25/50 rating for flame spread/smoke developed per ASTM E-84, UL 723 and have a R-value of 4.2. All cut edges of insulation shall be sealed by a heavy adhesive seal to prevent fibrous material from entering the airstream. A special sheet metal picture frame bracket may be used to enclose the liner of the discharge end to prevent the liner from dislodging under extremely high pressure conditions and to prevent damage during installation.
   2. Air Inlets: Round stub connections for duct attachment.
   3. Air Outlet: S-slip and drive connections.
   4. Access: Removable panels for access to dampers and other parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
   5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2010.

D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.
2. Damper Position: Normally open.

E. Fan Section: Acoustically lined, galvanized-steel plenum, with direct-drive, forward-curved fan with air filter and backdraft damper.

1. Motor: ECM. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

    a. Speed Control: Infinitely adjustable with electronic controls.
    b. Fan-Motor Assembly Isolation: Rubber isolators.

2. Air Filter: 1-inch- thick, fiberglass throwaway, MERV 8 according to ASHRAE 52.2.

F. Attenuator Section: 0.034-inch galvanized steel sheet metal.

1. Lining: 1-inch- thick, 1-1/2 lb./cu. ft. density, nylon scrim reinforced foil skin vapor barrier insulation. Insulation shall be dual thermal/acoustical fiberglass insulation meeting NFPA 90A requirements, UL 181 erosion control requirements, meet all requirements of ASTM C1071 (including C665), and carry a 25/50 rating for flame spread/smoke developed per ASTM E-84, UL 723 and have a R-value of 4.2. All cut edges of insulation shall be sealed by a heavy adhesive seal to prevent fibrous material from entering the airstream. A special sheet metal picture frame bracket may be used to enclose the liner of the discharge end to prevent the liner from dislodging under extremely high pressure conditions and to prevent damage during installation. Cover liner with perforated metal.

G. Factory-Mounted and -Wired Controls: Electrical components shall be mounted in control box with removable cover. Incorporate single-point electrical connection to power source.

1. Control Transformer: Factory mounted for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.
2. Wiring Terminations: Fan and controls to terminal strip, and terminal lugs shall match quantities, sizes, and materials of branch-circuit conductors. Enclose terminal lugs in terminal box that is sized according to NFPA 70.
3. Disconnect Switch: Factory-mounted, fused type.

H. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.

I. DDC Controls: Single-package unitary controller and actuator specified in Division 23 Section "Instrumentation and Control for HVAC." BMS shall furnish DDC controller, actuator, flow sensing element, power transformer. Devices factory mounted and wired at terminal unit manufacturer.

2.3 CONSTANT VOLUME SINGLE DUCT AIR TERMINAL UNITS

A. Manufacturers:

1. Anemostat; a Mestek Company.
2. Titus.
~~2.~~3. Neptronic
~~3.~~4. Tuttle & Bailey.
~~4.~~5. Environmental Technologies, Inc.
~~5.~~6. Price Industries.

B. Configuration: Volume-damper assembly inside unit casing with control components located inside a protective metal enclosure.

C. Casing: 0.034-inch galvanized steel.

1. Casing Lining: 1-inch-thick, 1-1/2 lb./cu. ft. density, nylon scrim reinforced foil skin vapor barrier insulation. Insulation shall be dual thermal/acoustical fiberglass insulation meeting NFPA 90A requirements, UL 181 erosion control requirements, meet all requirements of ASTM C1071 (including C665), and carry a 25/50 rating for flame spread/smoke developed per ASTM E-84, UL 723 and have a R-value of 4.2. All cut edges of insulation shall be sealed by a heavy adhesive seal to prevent fibrous material from entering the airstream. A special sheet metal picture frame bracket may be used to enclose the liner of the discharge end to prevent the liner from dislodging under extremely high pressure conditions and to prevent damage during installation.
2. Air Inlets: Round stub connections for duct attachment.
3. Air Outlet: S-slip and drive connections.
4. Access: Removable panels for access to dampers and other parts requiring service, adjustment, or maintenance; with airtight gasket.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2010.

D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.
2. Damper Position: Normally open.

E. Attenuator Section: 0.034-inch galvanized steel sheet metal.

1. Lining: 1-inch-thick, 1-1/2 lb./cu. ft. density, nylon scrim reinforced foil skin vapor barrier insulation. Insulation shall be dual thermal/acoustical fiberglass insulation meeting NFPA 90A requirements, UL 181 erosion control requirements, meet all requirements of ASTM C1071 (including C665), and carry a 25/50 rating for flame spread/smoke developed per ASTM E-84, UL 723 and have a R-value of 4.2. All cut edges of insulation shall be sealed by a heavy adhesive seal to prevent fibrous material from entering the airstream. A special sheet metal picture frame bracket

may be used to enclose the liner of the discharge end to prevent the liner from dislodging under extremely high pressure conditions and to prevent damage during installation.

F. Multioutlet Attenuator Section: With number and size collars as shown; each with locking butterfly balancing damper.

G. DDC Controls: Single-package unitary controller and actuator specified in Division 23 Section “Instrumentation and Control for HVAC.” BMS shall furnish DDC controller, actuator, flow sensing element, power transformer. Devices factory mounted and wired at terminal unit manufacturer.

H. Low Leakage Valves
1. Provide where indicated.
2. Provide low leak seal materials compatible with the severity of service indicated by the particular valve coating that has been specified.

I. Valves connected to fume hood exhaust or where indicated on drawings:
1. Coat LTAU with minimum 5.0 mil dry film thickness Heresite P403 coating material, applied and baked per coating manufacturer's recommendations.
2. Shaft, pivot arm and linkage, and other internal metal parts (nuts, bolts, rivets, etc.) shall be stainless steel.
3. Shaft shall be Teflon coated.

J. Shaft bearing surfaces shall be made of Teflon or polyphenylene sulfide composite.

K. Provide required valve accessories to support the controls contractor.
1. Phoenix fume hood CVV TAU require corrosion proof 316L stainless steel pressure taps for monitor installation.

2. Siemens fume hood CVV TAU require corrosion proof 316L stainless steel restricting orifices for monitor installation.

2.4 VARIABLE AIR VOLUME SINGLE DUCT AIR TERMINAL UNITS

A. Manufacturers:

1. Anemostat; a Mestek Company.
2. Titus.
3. Tuttle & Bailey.
4. Environmental Technologies, Inc.
5. Price Industries.

B. Configuration: Volume-damper assembly inside unit casing with control components located inside a protective metal enclosure.

C. Casing: 0.034-inch galvanized steel.

1. Casing Lining: 1-inch- thick, 1-1/2 lb./cu. ft. density, nylon scrim reinforced foil skin vapor barrier insulation. Insulation shall be dual thermal/acoustical fiberglass insulation meeting NFPA 90A requirements, UL 181 erosion control requirements, meet all requirements of ASTM C1071 (including C665), and carry a 25/50 rating for flame spread/smoke developed per ASTM E-84, UL 723 and have an R-value of 4.2. All cut edges of insulation shall be sealed by a heavy adhesive seal to prevent fibrous material from entering the airstream. A special sheet metal picture frame bracket may be used to enclose the liner of the discharge end to prevent the liner from dislodging under extremely high pressure conditions and to prevent damage during installation.
2. Air Inlets: Round stub connections for duct attachments.
3. Air Outlet: S-slip and drive connections.
4. Access: Removable panels for access to dampers and other parts requiring service, adjustment, or maintenance; with airtight gasket.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2010.

D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
   1. Maximum Damper Leakage: ARI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.
   2. Damper Position: Normally open.

E. Attenuator Section: 0.034-inch galvanized steel sheet metal.

   1. Lining: 1-inch-thick, 1-1/2 lb./cu. ft. density, nylon scrim reinforced foil skin vapor barrier insulation. Insulation shall be dual thermal/acoustical fiberglass insulation meeting NFPA 90A requirements, UL 181 erosion control requirements, meet all requirements of ASTM C1071 (including C665), and carry a 25/50 rating for flame spread/smoke developed per ASTM E-84, UL 723 and have a R-value of 4.2. All cut edges of insulation shall be sealed by a heavy adhesive seal to prevent fibrous material from entering the airstream. A special sheet metal picture frame bracket may be used to enclose the liner of the discharge end to prevent the liner from dislodging under extremely high pressure conditions and to prevent damage during installation.

F. DDC Controls: Single- package unitary controller and actuator specified in Division 23 Section "Instrumentation and Control for HVAC." BMS shall furnish DDC controller, actuator, flow sensing element, power transformer. Devices factory mounted and wired at terminal unit manufacturer.

2.5 ELECTRIC HEATING COILS

A. Manufacturers:

   1. Neptronics
   2. Titus
   3. Price Industries

~~A.~~B. As slip-in frame electric duct heater or i~~I~~ntegral with~~to~~ the terminal unit assembly, open-coil design with integral NEMA 1 electrical enclosure with single point connection for heater and fan, factory wired and installed. Wiring diagram with specific wiring for each unit included with unit. Tested with the fan terminal in accordance with UL and ETL standards. Meet all NEC requirements. UL Listed. Include the following features:

1. Automatic reset thermal primary and manual reset secondary overtemperature protection.
2. Nickel chrome 80/20 open coil heating elements.
3. Electronic ~~A~~airflow switch to ensure minimum air flow.
4. Interlocking disconnect switch.
5. Pressure differential switch
~~4.~~6. Supply and discharge temperature sensors
~~5.~~7. Fuses
~~6.~~8. 24 V control transformer.
~~7.~~9. Line and control terminal blocks.
~~8.~~10. ~~Magnetic contactor for each step of control.~~SCR controller (silicon controlled rectifier)
11. BACnet MS/TP communication with BMS for remote control and monitoring
12. Provide real-time feedback of heater's output capacity, temperature measurments and power consumption data.
~~9.~~13. DDC Controls: Single- package unitary controller and actuator specified in Division 23 Section "Instrumentation and Control for HVAC."

2.6 SOURCE QUALITY CONTROL

A. Identification: Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and AHRI certification seal.

B. Verification of Performance: Rate air terminal units according to AHRI 880.

C. Noise Levels at noted capacities: Units tested in accordance with ASHRAE Standard 36B or ADC, with ratings tabulated for inlet pressure of 3 in, 1 3/4 in, 1 1/2 in, and minimum static pressure.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's written installation instructions.

B. Support terminal box independent of ductwork.

C. Install air terminal units level and plumb.

D. Provide sound lining downstream of units for a minimum of 5 ft. or as recommended by unit manufacturer to maintain scheduled NC levels.

E. Maintain sufficient clearance for normal service and maintenance.

F. Coordinate access through ceilings with respective trades.

G. Coordinate the terminal box controls with the building control system contractor to ensure that all miscellaneous accessories required for proper operation are included and that the direct/reverse action normally closed/normally open functions are properly coordinated.

H. Be sure minimum and maximum CFM settings agree with the requirements of the terminal unit schedule.

I. Provide rigid metal straight duct equal to four diameters on inlet of all terminals.

J. Provide flexible duct connection at outlet plus a minimum of 12" and a maximum of 36"of straight flexible duct upstream of rigid duct at inlet.

3.2 CONNECTIONS

A. Connect ducts to air terminal units according to Division 23 Section "Metal Ducts."

B. Ground units with electric heating coils according to Division 26 Section "Grounding and Bonding for Electrical Systems."

C. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

D. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

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

B. Perform the following field tests and inspections and prepare test reports:

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

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

C. All equipment and materials shall be protected from damages, exposure to moisture and weather from the time of delivery to job site until date of substantial completion.

~~C.~~D. Remove and replace malfunctioning units, controls and equipment, and retest as specified above.

3.4 STARTUP SERVICE

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

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

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

3.5 DEMONSTRATION

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

END OF SECTION 23 36 00

SECTION 23 37 13 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Rectangular and square ceiling diffusers.
2. Linear slot diffusers.
3. Registers and Grilles.
4. Perforated diffusers.
5. Nozzle diffusers
6. Security Grille
7. Security Diffuser
8. Security Return Grille
9. Security Exhaust Grille
10. VAV Diffuser

B. Related Sections:

1. Division 08 Section "Louvers and Vents" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
2. Division 23 Section "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.3 SUBMITTALS

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

1. Data Sheet: Indicate materials of construction, finish, end cap and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.
3. Samples for Initial Selection: For diffusers, registers, and grilles with factory-applied color finishes.
4. Samples for Verification: For diffusers, registers, and grilles, in manufacturer's standard sizes to verify color selected.

B. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
5. Duct access panels.

C. Source quality-control reports.

PART 2 - PRODUCTS

2.1 GENERAL

A. Manufacturer shall examine application of each air inlet and outlet and guarantee that each will provide comfort space conditions without drafts or noise at noted capacities.

B. Noise Level: Noise levels at rated capacities shall not exceed criteria specifies under 1.4 “Quality Assurance.”

C. All outlets shall be suitable for operation at 5 percent more and at 25 percent less than noted capacities.

D. Air inlets and outlets for surface mounting shall have a concealed mounting frame, with no mounting screws visible in face frame of outlet and/or plastic frame, unless otherwise noted.

E. Scheduled air outlets shall be as manufactured by the listed manufacturer and shall, to the greatest extent possible, all be manufactured by the same manufacturer.

F. The contractor and vender shall be jointly responsible for all quantity and neck size take-offs and coordination of mounting details with the ceiling, wall, or floor mounting in which it is installed.

G. Air distribution devices shall have unit mounted opposed blade volume dampers operable from the face of the air distribution devices.

H. Diffusers in the same room shall all be the same size and type, except as otherwise indicated.

I. Contractor shall provide all required blank offs for directional pattern throws.

2.2 CEILING DIFFUSERS

A. Rectangular and Square Ceiling Diffusers:

1. Manufacturers: Subject to compliance with requirements:

   a. Krueger.
   b. METALAIRE, Inc.
   c. Price Industries.
   d. Titus.

2. Material: Aluminum.
3. Finish: ~~Coordinate~~ Refer to border and finish ~~with~~ shown on Architectual drawings and subject to approval of submitted samples.
4. Face Size: As scheduled on drawings.
5. Face Style: Plaque.

6. Mounting: Surface and T-bar.
7. Pattern: Fixed and Two position.
8. Dampers: Supplied at the takeoff of run-out ductwork.

B. Perforated Diffuser

1. Manufacturers:

   a. Krueger.
   b. METALAIRE, Inc.
   c. Price Industries.
   d. Titus.

2. Material: Steel backpan and pattern controllers, with steel face.
~~3.~~ Finish: Refer to border and finish shown on Architectual drawings and subject to approval of submitted samples.~~Coordinate border and finish with Architect.~~
~~4.~~3. Face Size: As scheduled on drawings.
~~5.~~4. Face Style: Flush.
~~6.~~5. Mounting: Surface and T-bar
~~7.~~6. Pattern: Adjustable with louvered pattern modules at inlet
~~8.~~7. Dampers: Supplied at the takeoff of run-out ductwork.

C. Louver Face Diffuser:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Price Industries
   b. Anemostat Products; a Mestek company
   c. Kruger
   d. Titus
2. Material: Steel

3. Finish: Refer to border and finish shown on Architectual drawings and subject to approval of submitted samples.~~Coordinate border and finish with Architect.~~
4. Face Size: As scheduled on drawings
5. Mounting: Coordinate with architectural reflected ceiling plans
6. Pattern: Adjustable core style
7. Dampers: Supplied at the takeoff of run-out ductwork

2.3 CEILING LINEAR SLOT OUTLETS

A. Linear Slot Diffuser:

1. Manufacturers: Subject to compliance with requirements:

    a. Krueger.
    b. METALAIRE, Inc.
    c. Price Industries.
    d. Titus.

2. Material - Shell: Aluminum.
3. Material - Pattern Controller and Tees: Aluminum.
4. Finish - Face and Shell: Refer to border and finish shown on Architectual drawings and subject to approval of submitted samples.~~Coordinate border and finish with Architect.~~
5. Finish - Pattern Controller: Refer to border and finish shown on Architectual drawings and subject to approval of submitted samples.~~Coordinate border and finish with Architect.~~
6. Finish - Tees: Baked enamel, black.
7. Slot Width: As scheduled on drawings.
8. Number of Slots: One and two slots, as shown on drawings..
9. Length: See schedule and plans for lengths.
10. Accessories: Plaster frame.

B. Mounting: Coordinate with architectural reflected ceiling plans Linear Bar Diffuser:

1. Manufacturers: Subject to compliance with requirements:

    a. Krueger.
    b. METALAIRE, Inc.
    c. Price Industries.
    d. Titus.

2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: Aluminum.
4. Finish: Coordinate finish with Architect and subject to approval of submitted samples.

5. Narrow Core Spacing Arrangement: 1/8-inch bar spaced 1/2 inch spacing, zero - degree deflection.
6. Frame: 1 inch wide.
7. Contractor shall coordinate with architectural drawings.

2.4 REGISTERS AND GRILLES

A. Fixed Face Grille:

1. Material: Aluminum.
2. Finish: Coordinate border and finish with Architect and subject to approval of submitted samples.
3. Face Arrangement: 1/2-by-1/2-by-1/2-inch grid core.
4. Core Construction: Integral.
5. Frame: 1 inch wide.
6. Mounting: Countersunk screw.

B. Fixed Face Security Grille:

1. Manufacturers: Subject to compliance with requirements:

a. Krueger.
b. METALAIRE, Inc.
c. Price Industries.
d. Titus.

2. Material: 12 gauge hot rolled steel.
3. Finish: Baked enamel, white~~.~~ and subject to approval of submitted samples
4. Face Arrangement: 45° 1/4-by-1/4-by-1-inch fixed louver blades.
5. Core Construction: Integral.
6. Frame: 1 inch wide.
7. Mounting: Attached to a wall sleeve of 3 /16 in. hot rolled steel with a rear mounting frame for a concealed and secure fastening.

2.5 Nozzle Diffusers:

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Price Industries
2. Anemostat Products; a Mestek company
3. Krueger
4. Titus
5. Seiho
6. Air Concepts

B. Throw: Extended distance for airflow rates

C. Material: Aluminum

D. Nozzles per Unit: One

E. Finish: Coordinate finish with Architect and subject to approval of submitted samples
Border: 1/2-inch width with countersunk screw holes

F. Nozzles:
1. ±35 degree deflection
2. 360 degree rotation

G. Accessory: Aperture style damper

2.6 Security Grille

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Price Industries
2. Anemostat Products; a Mestek company
3. Krueger
4. Titus

B. Security grille sizes and mounting types shall be shown on the plans and outlet schedule.

C. Grilles shall have a 3/16" thick steel face with 5/16" diameter holes on 7/16" staggered centers. The sleeve shall be 3/16" thick and shall be stitch welded to the face and along the entire length of all sleeve seams. Grilles should include 1½" x 1½" x 3/16" steel angle mill finished iron frames shipped loose for field welding to grille sleeve at back of wall penetration.

D. Air balancing volume damper serving each grille shall be accessible in ductwork location outside of the holding room.

E. Finish: white and subject to approval of submitted samples.

F. The manufacturer shall provide published airflow and sound performance data for the grille.

G. Shall be tested in accordance with ANSI/ASHRAE Standard 70.

2.7 Security diffuser

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

1. Price Industries
2. Anemostat Products; a Mestek company
3. Krueger
4. Titus

B. Security diffusers shall consist of an outer frame assembly of the sizes and mounting types shown on the plans and outlet schedule.

C. A square inlet shall be an integral part of the frame assembly and a transition piece shall be available to facilitate attachment of round duct. An inner core assembly consisting of fixed deflection louvers shall be available in 1-, 2-, 3-, or 4-way horizontal discharge patterns. The inner core assembly shall be removable in the field without tools for easy installation, cleaning, or damper adjustment.

D. All units shall be constructed of heavy gauge steel. All units shall be covered with a 12-gauge steel face with 13/16" square holes on 1" centers. All units will be provided with screw holes in the face for surface mounting. Tamper proof screws should be provided according to structural requirements.

E. Finish: white and subject to approval of submitted samples.

F. The manufacturer shall provide published airflow and sound performance data for the grille. The grille shall be tested in accordance with ANSI/ASHRAE Standard 70.

2.8 Security Return Grille

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Price Industries
2. Anemostat Products; a Mestek company
3. Krueger
4. Titus

B. Contractors shall provide security grille of sizes and mounting type shown on the plans and outlet schedule.

C. Grilles shall have a 3/16" thick steel face with 5/16" diameter holes on 7/16" staggered centers. The sleeve shall be 3/16" thick and shall be stitch welded to the face and along the entire length of all sleeve seams. Grilles shall include 1½" x 1½" x 3/16" steel angle mill finished iron frame shipped loose for field welding to grille sleeve at back of wall penetration.

D. Air balancing volume damper serving each grille shall be accessible in ductwork location outside of holding room.

E. Finish: White and subject to approval of submitted samples

F. The manufacturer shall provide published airflow and sound performance data for the grille. The grille shall be tested in accordance with ANSI/ASHRAE Standard 70.

2.9 Security Exhaust Grille

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Price Industries
2. Anemostat Products; a Mestek company
3. Krueger
4. Titus

B. Security exhaust grilles shall be have 12-gauge steel lattice faces with 13/16" square holes on 1" centers. Lattice face shall be white baked on enamel. Units shall be mounted to the exhaust duct flange and the ceiling using tamper proof security screws to meet structural requirements. Grill face shall be white baked enamel.

C. VAV Diffusers (CBP rooms in Airside building):

1. Variable air volume diffusers shall be plaque type ceiling diffusers. The diffuser size shall be nominal 24” x 24”, with a minimum 18” square appearance panel. The horizontal air discharge pattern shall be 360° type.
2. The diffusers shall be self-contained, and not require any external electrical or pneumatic connections. The damper shall consist of a spun, round aluminum disk that moves to change the effective free area of the diffuser to modulate flow. The damper shall include a perimeter seal. Each VAV diffuser shall incorporate one or more thermo-powered sensing elements that modulate the diffuser damper in response to the room temperature as sensed by the induced flow across the sensing element(s). The setpoints shall be factory pre-set at 74° F, but shall be field adjustable from 72°-78° F.
3. The diffusers shall be constructed of steel, and shall be designed to integrate with the specified ceiling system type. The diffuser shall consist of a back pan and a removable, heavy gauge appearance panel attached to the back pan. Room temperature setpoint adjustments shall be made by removing the panel, and rotating the appropriate thermo-powered sensor. No tools shall be required.
4. The appearance panel shall have aerodynamic, rigid, hemmed edges around the perimeter and shall be a single piece construction. The panel shall be flat, smooth, and shall be free of any welding or forming blemishes. Holes or plug buttons in the panel are not acceptable.
5. Diffuser finish shall be color as selected by the Architect and subject to approval of submitted samples.
6. Each diffuser shall be free from defects in material and workmanship, and shall carry a manufacturer’s warranty of 10 years.

2.10 SOURCE QUALITY CONTROL

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

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

3.2 INSTALLATION

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

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as 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.

D. Carefully install all ceiling mounted air distribution devices back pan insulation and vapor barrier. Where pre-molded insulation and vapor barrier is not furnished as an accessory to the air distribution device by the manufacturer the Contractor is responsible for field installation of insulation and vapor barrier for ceiling air distribution device back pans.

E. All visible interior surfaces of all grilles and air device accessories and components visible through the face of the outlet shall be factory painted flat black.

F. Install a manual volume damper in the branch duct to the air distribution device or at the conical bell-mouth spin-in fitting for connection of round duct to the rectangular duct for balancing purposes.

G. Provide all required blank off for directional pattern.

H. Diffusers Utilizing a Plenum Box: Provide plenum box fabricated of 24 USBG galvanized steel, with internal surfaces lined with minimum 1-1/2 inch thick duct liner for R-6 insulating valve as specified under Division 23 Section "Metal Ducts."

I. Install return and exhaust registers with blades oriented to prevent sight though outlets.

J. Transfer Grilles: Provide 2 grilles, one on each side of wall with connecting sheet metal collar.

K. Transfer Ducts: Provide 2 grilles, one at each end of duct.

3.3 ADJUSTING

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

END OF SECTION 23 37 13

SECTION 23 41 00 - PARTICULATE AIR FILTRATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Requirements Division 01, Division 23 Specification Sections, and Common Work Requirements for HVAC apply to the work specified in this Section.

1.2 SUMMARY

A. This Section Includes:

1. Factory-fabricated air-filter devices and media used to remove particulate matter from air for HVAC applications.
2. Air Filter Gauges.

1.3 DEFINITIONS

A. DOP: Dioctyl phthalate or bis-(2-ethylhexyl) phthalate.

B. HEPA: High-efficiency particulate air.

C. ULPA: Ultra low penetration air.

1.4 SUBMITTALS

A. Product Data: Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.

B. Shop Drawings: Include plans, elevations, sections, and details to illustrate component assemblies and attachments.

1. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
2. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.
3. Wiring Diagrams: Power, signal, and control wiring.

C. Samples: Submit 2 samples of replacement media of each type and filter frame.

D. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of air filters and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

B. Filter Media: ANSI/UL 900 listed, Class I or Class II as noted.

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

D. Comply with AHRI 850.

E. Comply with ASHRAE 52.1 and ASHRAE 52.2 for method of testing and rating air-filter units.

F. Comply with NFPA 70 for installing electrical components.

G. Comply with NFPA 90A and NFPA 90B.

H. Provide all filters as product of one manufacturer.

1.6 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.

1.7 EXTRA MATERIALS

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

1. Provide 1 complete set of filters for each filter bank. If system includes pre-filters, provide only 1 complete sets of pre-filters and final filters.
2. Provide one container of red oil for inclined manometer filter gage.
3. Provide one complete set of UV-C lamps for each photocatalytic air cleaner.

PART 2 - PRODUCTS

2.1 GENERAL

A. Filters shall be UL listed Class 2, unless otherwise specified Class 1.

B. Arrestance and efficiencies noted are minimum average.

C. Design air flow not to exceed catalogued capacity.

D. Initial and final resistances not to exceed scheduled values.

E. Service access as indicated on drawings.

2.2 FILTER TYPES, PROVIDE AS FOLLOWS:

A. Flat panel, replaceable - Type A.

B. Extended surface, high efficiency - Type B.

C. Catalytic Air Cleaner System - Type C.

D. Terminal, high efficiency - Type D.

2.3 MANUFACTURERS

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

1. Air Filters, Electrostatic Air Cleaners, and Filter-Holding Systems:

   a. AAF International.
   b. Farr Co.
   c. Flanders Filters, Inc.
   d. Cam/Farr Company.
   e. Bioclimatic Air System, Inc.

2. Filter Gages:

   a. Airguard Industries, Inc.
   b. Dwyer Instruments, Inc.
   c. Owner approved substitution.

2.4 DISPOSABLE PANEL FILTERS – TYPE A

A. Description: Factory-fabricated, viscous-coated, flat-panel-type, disposable air filters with holding frames.

B. Media: Interlaced glass fibers sprayed with nonflammable adhesive and anti-microbial agent. Arrestance:

1. 1 inch thick: 60 percent.
2. 2 inch thick: 70 percent.

C. Frame: Cardboard frame with perforated metal retainer.

D. Duct-Mounting Frames: Welded, galvanized steel with gaskets and fasteners and suitable for bolting together into built-up filter banks.

2.5 EXTENDED-SURFACE, DISPOSABLE PANEL FILTERS – TYPE A-2

A. Description: Factory-fabricated, dry, extended-surface filters with holding frames.

B. Media: Fibrous material or cotton cellulose, UL Class II, MERV 8 formed into deep-V-shaped pleats with anti-microbial agent and held by self-supporting wire grid.

C. Filter Thickness: 1 inch, 2 inch, or 4 inch as indicated.

D. Media and Media-Grid Frame: Nonflammable cardboard.

E. Duct-Mounting Frames: Welded, galvanized steel with gaskets and fasteners, and suitable for bolting together into built-up filter banks.

2.6 EXTENDED SURFACE, HIGH-EFFICIENCY FINAL FILTER - TYPE B

A. Description: Factory-fabricated 90-95 percent DOP per ASHRAE Standard 52.1 filters with holding casing. Classified by UL to Class 1, UL Standard 900 (MERV 14).

B. Media: Fibrous glass, water resistant, constructed of continuous sheets with closely spaced pleats with aluminum separators.

C. Frame Material: Aluminized steel, or galvanized steel. Depth per filter schedule.

D. Media to Frame Side Bond: Mechanical and chemical bond.

E. Face Gasket: Neoprene expanded rubber. Material must comply with NFPA 90A and 90B and flame spread and smoke development ratings.

F. Headers: Filters shall be double sided headers, continuously attached, suitable for use in frames by various manufacturers.

G. Duct-Mounting Frames: Construct downstream corners of holding device with cushion pads to protect media. Provide bolted filter-sealing mechanism to mount and continuously seal each individual filter.

H. Initial pressure drop shall not exceed 0.56” w.g. when operating at rated cfm and a face velocity of 500 fpm, and shall be capable of reaching 1.5” w.g. without unloading or collapsing. The air leaving side of the filter shall have metal bracing or a metal mesh guard.

2.7 PHOTOCATALYTIC AIR CLEANERS - TYPE C

A. Description: A factory-engineered and factory-installed photocatalytic air cleaner shall be supplied by the air handler manufacturer or installed in a cassette that shall be installed on site in the air handler manufacturer catalytic filter section. Field-installed fixtures shall not be allowed. Air cleaner frames shall be capable of accepting specified air cleaner/MERV 14 filter assembly.

B. Catalytic air cleaner system shall be a three part integral assembly for treatment of air by: 1) High efficiency particle filtration (MERV 14 or higher upstream of catalytic system), 2) Ultraviolet Germicidal Irradiation (UVGI) using UV-C lamps and fixtures; and 3) Photocatalytic Oxidation (PCO) catalyst media using titanium dioxide (TiO_2).

C. Catalyst Media:

D. Electrical Characteristics:
1. UV-C lamps and ballasts designed specifically to provide type-C ultraviolet light with a wavelength at or near 2537 Angstroms and shall not produce any ozone.
2. Lamps shall be Teflon-coated to reduce breakage.
3. Sufficient lamps shall be provided and positioned center point through the media equidistant from edges so as to achieve a minimum overage of 9.5 milliwatts per square inch of UVC light, upstream and downstream, across all exposed surfaces of the PCO media.
4. Lamp UVC output shall not drop below 9.5 milliwatts per square inch over their usable 10000 hr life.
5. Emitters shall include safety switches.
6. Provide a viewport in the access door servicing the UV section in order to confirm UV operation without the need to open the access door.
7. The catalyst media shall consist of six-inch deep (direction of airflow) grid with face area to match casing opening, one pleat per inch (nominal), and coated with 40-200 nanometer TiO_2.
8. The complete PCO media bank assembly shall be housed in a galvanized or stainless steel casing and placed in the air handler perpendicular to the airflow. Assemble shall be capable of withstanding 750 fpm face velocity with no structural damage.
9. Media shall have an internal mechanism to eliminate the silica produced by the oxidation of ethanol.
10. All UV lamps and PCO media shall be removable from outside the AHU casing through a side access door for maintenance purposes.

11. The substrate on which the TiO_2 is bonded shall not deteriorate when exposed to UVC light.
12. PCO media shall be washable without affecting its air cleaning efficiency.
13. UV lamps shall be independently replaceable without the need to replace the fixture or remove the PCO media.
14. The catalytic air cleaner system will be configured to operate with 460 Volt / 1 Phase electrical power.
15. All systems shall have an independent single point external power connection.
16. Electrical fixtures shall meet the UL drip proof design criteria. Component enclosures shall be constructed of galvanized steel or stainless steel to resist corrosion.
17. Fixtures shall have been tested and recognized by UL/C-UL under Category Code ABQK (Accessories, Air Duct Mounted), UL Standards 1995.
18. For line voltage options, the photocatalytic air cleaners shall be provided with a UL 508 listed panel for power distribution and over-current protection.

E. All polymeric materials that come into direct or indirect (reflected) contact with UV-C light shall be tested and certified as UV-C tolerant. Any non-conforming construction materials or components within the exposure zone shall be completely shielded from the UV-C light using a certified UV-C tolerant material. UV-C tolerance is defined as being capable of performing its intended duty for a minimum of 20 years.

F. Access Doors:
1. Access doors shall be provided at the location of catalytic air cleaner system as indicated on the plans and schedule. All access doors were there is direct or indirect contact with the UV-C lights shall have a mechanical safety interlock switch that disconnects the UV-C power upon opening.
2. Each catalytic air cleaning system shall be equipped with a factory installed, externally mounted electrical disconnect switch for maintenance purposes, with lock-out capability to prevent unwanted operation.
3. A window shall be provided on each air handler to allow visual inspection of the catalytic air cleaner system during operation. The viewing window shall be guaranteed to block UV-C light emissions below the threshold limits specified by NIOSH and/or ACGIH.
4. Units shall have a safety warning label applied to the exterior of each section containing UV-C lights.

2.8 HIGH-EFFICIENCY FILTERS – TYPE D

A. Terminal type high efficiency filter, Type D: Cells, media shall be minimum of 180 sq ft continuous sheet glass material having pleats separated by corrugated aluminum inserts. Media enclosure shall be self-supporting galvanized steel cell sides with glass packing sealant. Provide 24-inch x 24-inch x 11-1/2-inch-deep cells, UL Class II. Provide galvanized steel flanged header, having sealed and mitered corners, and corner angle supports.

1. Rated capacity shall be 1000 cfm. Dioctyl-phthalate efficiency at rated capacity shall be minimum 95 percent on 0.3 micron particles (MERV 16). Initial resistance

at rated capacity shall be 0.45 inch w.g. Filter shall be suitable for 100 percent relative humidity. Provide type similar to American Air Filter Biocel Type I.

2. Extruded aluminum framing modules shall be continuously factory welded into major sub-assembly with spring loaded retainers. Factory welded framing system shall be designed to receive HEPA filters. Each filter shall be retained with a minimum of four (4) 1 1/2 in. wide clamps, captive springs and visual control bolts. Provide framing system similar to American Air Filter Bevel Seal Grid.
3. Factory fabricated in-line housing for terminal filters: Housing shall be 18 gauge aluminum with access door for filter changing and spring loaded retainers. The door shall be constructed of No.12 gauge aluminum with permanently mounted, quarter turn cam fasteners and neoprene rubber gaskets. Housing shall be riveted and sealed air tight and non-directional with respect to air flow. Provide 1-1/2 inch wide flanges at each end and welded aluminum filter retainer with bevel seal profile. Spring loaded retainers shall be minimum 1-1/2 inch wide clamps, minimum of four clamps per filter cell, calibrated for visual determination of proper compression with captive springs. Steel parts shall be cadmium or zinc plated. Provide type similar to American Air Filter Biocel Type I Filter.

2.9 FRONT- AND REAR-ACCESS FILTER FRAMES

A. Framing System: Aluminum framing members with access for either upstream (front) or downstream (rear) filter servicing, cut to size and pre-punched for assembly into modules. Vertically support filters prevent deflection of horizontal members without interfering with either filter installation or operation.

B. Pre-filters: Incorporate a separate track, removable from front or back.

C. Sealing: Factory-installed, positive-sealing device for each row of filters to ensure seal between gasketed filter elements to prevent bypass of unfiltered air.

2.10 SIDE-SERVICE HOUSINGS

A. Description: Factory-assembled, side-service housings, constructed of galvanized steel, with flanges to connect to duct system.

B. Pre-filters: Integral tracks to accommodate 2-inch disposable or washable filters.

C. Access Doors: Continuous gaskets on perimeter and positive-locking devices. Arrange so filter cartridges can be loaded from either access door.

D. Sealing: Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

2.11 FILTER GAGES

A. Description: Diaphragm type with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.

1. Diameter: 4-1/2 inches.
2. Range: 0- to 0.5-inch wg, 0- to 1.0-inch wg, 0- to 2.0-inch wg, 0- to 3.0-inch wg, or 0- to 4.0-inch wg as required for application.

B. Manometer-Type Filter Gage: Molded plastic with epoxy-coated aluminum scale, logarithmic-curve tube gage with integral leveling gage, graduated to read from 0- to 3.0-inch wg, and accurate within 3 percent of full scale range.

C. Accessories:

1. Static-pressure tips, tubing, vent valves, gage connections, and mounting bracket.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install filter frames according to manufacturer's written instructions.

B. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

C. Install filters in position to prevent passage of unfiltered air. Do not operate fan system connected to filter bank until all filters (temporary pre-filters and specified filters) are in place.

D. Erect holding frames leak tight and structurally sound to preclude breathing action.

1. Filter banks 3 filters high or more reinforced with 3 inch wide steel stiffeners between each vertical row of filters.
2. Before joining frames caulk with DAP “Butyl Gutter and Lap Sealer” or its equivalent. Caulk leading edge joint gaps after installation.
3. Tape joints on downstream side of filter bank with 1 inch duct tape.

E. Install filter gage for each filter bank, pre-filter and after filter.

F. Install filter gage static-pressure tips upstream and downstream from filters to measure pressure drop through filter. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.

G. Coordinate filter installations with duct and air-handling unit installations.

H. Electrical wiring and connections are specified in Division 26 Sections.

I. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

3.2 TEMPORARY PRE-FILTERS FOR CONSTRUCTION

A. Protect all filters upstream of air handling units during construction with blankets of 2” fiberglass filter media or 2” disposable panel filters. UL Class II listed. Replace temporary pre-filters if final pressure is reached during construction or test and balance.

B. Prior to final acceptance of systems or operation of systems by Owner, replace temporary filters as follows:

1. For each pre-filter and final filter assembly, provide one temporary filter bank, equivalent to the specified prefilter. Before balancing and before final acceptance or turning over to owner, replace temporary filters with new prefilters and new final filters. When turning over to Owner, provide new prefilter and replace final filter with space set if air friction is greater than or equal to 0.8 inch w.g.
2. Notify Architect and/or Engineer in writing no less than 7 days before systems are operated for beneficial use of owner and temporary filters used during balancing period are replaced. In absence of such notice, filters shall be replaced on or after starting date of guaranteed period.

3.3 FIELD QUALITY CONTROL

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

B. HEPA Filters: Pressurize housing to a minimum of 3.0-inch wg or to designed operating pressure, whichever is higher; and test housing joints, door seals, and sealing edges of filter with soapy water to check for air leaks.

3.4 CLEANING

A. After completing system installation and testing, adjusting, balancing and commissioning air-handling and air-distribution systems, clean filter housings and install new filter media.

END OF SECTION 23 41 00

SECTION 23 51 00 – BREECHING, CHIMNEY & STACK

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Requirements, Division 23 Specification sections, Division 26 Specification sections apply to the work specified in this Section.

1.2 SUMMARY

A. Manufacturer shall provide factory-built modular universal stack/vent system tested and listed by Underwriters Laboratories Inc. (UL) for use with 1400˚F chimneys (engine exhaust). UL Listings shall include:

1. UL-2561 1400˚F Chimney for appliances which may produce exhaust gas at temperatures not exceeding 1400˚F under continuous operating conditions and 1800˚F under intermittent conditions.

2. Additional UL-103/2561 pressure testing for positive pressure applications up to 90 inches W.C. after 1400°F continuous exposure.

1.3 SUBMITTALS

A. Approved factory-built modular vent system manufacturer:

1. DuraVent, Inc.
2. Selkirk Corp.
3. Jeremias, Inc.
4. Or approved equal.

B. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for product.

C. Shop Drawings:

1. Manufacturer shall provide plans, elevation views, sections, and attachment details. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations and size of each field connections.

2. Details must include assembly/installation of hangers.

D. Certification: The inner diameter of the exhaust system shall be verified by the manufacturer's computations. Provide certified computations verifying compatibility of exhaust system with engine and muffler system.

1. The computations used shall be technically sound, follow ASHRAE calculation methods and shall incorporate the specific flow characteristics of the inner pipe.

2. The Contractor shall furnish the exact operating characteristics of the engine(s) and muffler(s) to the factory representative.

1.4 CONSTRUCTION

A. The double wall fiber insulated exhaust system shall be constructed of all-stainless steel. The materials and construction of modular sections and accessories shall be as specified by the terms of the product's UL listing.

a. Type 304 stainless steel inner liner.
b. 4" minimum thick ceramic fiber insulation.
c. Type 304 BA stainless steel outer jacket.
d. The entire exhaust system, including all accessories (connectors, hardware, anchor plate supports, guides, drains, and terminals), shall be Type 304 stainless steel.

B. Provide all supports, guides, bellows type expansion joints, pressure relief valves, guy sections, guy tensioners, thimbles, roof flashings, storm collars and flip top terminations as required to provide a complete system.

C. The entire exhaust system from the muffler discharge to the termination point, including all accessories shall be from one manufacturer.

D. Inner flue shall have an overlapping male/female socket that protects the rolled flange with sealant against condensate and high-pressure cleaning. The inner joints shall be secured with vee bands on the inner and overlapping locking band on the outer jacket.

E. Double-wall exhaust system shall be constructed so the outer jacket is floating and not welded to the inner liner.

F. Exhaust system shall be designed to compensate for all temperature induced thermal expansion, installed to be gastight, and thus prevent leakage of combustion products into a building.

G. Exhaust system is based upon Jeremias Model DWFL. Detailed manufacturer's submittal drawings shall be provided for approval prior to installation of the exhaust system.

PART 2 – EXECUTION

2.1 INSTALLATION

A. Roof and wall penetrations shall be factory insulated and UL listed as not to require air ventilation for safe installation around combustible materials.

B. Entire exhaust system from the appliance outlet to the termination point, including accessories shall be from one manufacturer, except where noted.

C. Suspend the exhaust system independent of their generator connection.

PART 3 – WARRANTY

3.1 WARRANTY

A. The factory-built modular exhaust system shall be warranted against functional failure for a minimum of Fifteen (15) years from substantial completion.

B. Manufacturer shall provide ASHRAE flue sizing calculations, or certificate of vent equivalent feet, confirming the inner diameter is in complete compliance with appliance manufacturer's installation instructions.

C. Manufacturer shall provide certificate of code compliance for all required local and national codes for the installation with the scheduled appliances.

END OF SECTION 23 51 00

SECTION 23 57 00.01 - PCA HEAT EXCHANGERS

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 plate heat exchangers.

1.3 DEFINITIONS

A. TEMA: Tubular Exchanger Manufacturers Association.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Design Calculations: Calculate requirements for selecting seismic restraints and for designing bases.
2. Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.

C. Delegated-Design Submittal: Details and design calculations for seismic restraints for heat exchangers.

1.5 INFORMATIONAL SUBMITTALS

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

1. Tube-removal space.
2. Structural members to which heat exchangers will be attached.

B. Seismic Qualification Certificates: For heat exchanger, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Heat Exchanger: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of heat exchanger anchorage devices on which certification is based and their installation requirements.

C. Product Certificates: For each type of shell-and-tube heat exchanger. Documentation that shell-and-tube heat exchangers comply with "TEMA Standards."

D. Source quality-control reports.

E. Field quality-control reports.

F. Sample Warranty: For manufacturer's warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For heat exchangers to include in emergency, operation, and maintenance manuals.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of domestic-water heat exchangers that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures including heat exchanger, storage tank, and supports.
b. Faulty operation of controls.
c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Periods: From date of Substantial Completion.

a. Plate, Domestic-Water Heat Exchangers:
1) Plate-and-Frame Type: 5 year(s).

PART 2 - PRODUCTS

2.1 GASKETED-PLATE HEAT EXCHANGERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
1. Armstrong Pumps, Inc.
2. ITT Corporation; Bell & Gossett.
3. TACO Incorporated.

B. Configuration: Freestanding assembly consisting of frame support, top and bottom carrying and guide bars, fixed and movable end plates, tie rods, individually removable plates, and one-piece gaskets.

C. Construction: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1.

D. Frame:

1. Capacity to accommodate 20 percent additional plates.
2. Painted carbon steel with provisions for anchoring to support.

E. Top and Bottom Carrying and Guide Bars: Painted carbon steel, aluminum, or stainless steel.

1. Fabricate attachment of heat-exchanger carrying and guide bars with reinforcement strong enough to resist heat-exchanger movement during seismic event when heat-exchanger carrying and guide bars are anchored to building structure.

F. End-Plate Material: Painted carbon steel.

G. Tie Rods and Nuts: Steel or stainless steel.

H. Plate Material: 0.024 inch (0.6 mm) thick before stamping; Type 304 stainless steel.

I. Gasket Materials: Nitrile HT.

J. Piping Connections: Factory fabricated of materials compatible with heat-exchanger shell. Attach tappings to shell before testing and labeling.

1. NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
2. NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.

K. Enclose plates in solid aluminum removable shroud.

2.2 ACCESSORIES

A. Hangers and Supports:

1. Factory-fabricated steel supports to ensure both horizontal and vertical support of heat exchanger. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment.

B. Drip Pan: Stainless Steel.

2.3 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect heat exchangers according to ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1. Affix ASME label.

B. Hydrostatically test heat exchangers to minimum of one and one-half times pressure rating before shipment.

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

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas for compliance with requirements for installation tolerances and for structural rigidity, strength, anchors, and other conditions affecting performance of heat exchangers.

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

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

3.2 GASKETED-PLATE HEAT-EXCHANGER INSTALLATION

A. Install gasketed-plate heat exchanger on custom-designed wall supports anchored to structure as indicated on Drawings.

B. Install metal shroud over installed gasketed-plate heat exchanger according to manufacturer's written instructions.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in other Section 232113.01 "PCA Hydronic Piping" and Section 232116 Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Install piping adjacent to heat exchangers to allow space for service and maintenance of heat exchangers. Arrange piping for easy removal of heat exchangers.

D. Install shutoff valves at heat-exchanger inlet and outlet connections.

E. Install relief valves on heat-exchanger heated-fluid connection and install pipe relief valves, full size of valve connection, to floor drain.

F. Install vacuum breaker at heat-exchanger steam inlet connection.

G. Install hose end valve to drain shell.

H. Install thermometer on heat-exchanger and inlet and outlet piping, and install thermometer on heating-fluid inlet and outlet piping. Comply with requirements for thermometers specified in Section 230519 "Meters and Gages for HVAC Piping."

I. Install pressure gages on heat-exchanger and heating-fluid piping. Comply with requirements for pressure gages specified in Section 230519 "Meters and Gages for HVAC Piping."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Heat exchanger will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 CLEANING

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

3.6 DEMONSTRATION

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

END OF SECTION 235700.01

SECTION 23 64 16 - CENTRIFUGAL WATER CHILLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Requirements Division 01, Division 23 Specification Sections, including Common Work Requirements for HVAC, apply to the work specified in this Section.

B. Related Work in the Following Sections apply to this Section:
1. Common Motor Requirements for HVAC Equipment
2. Vibration and ~~Seismic~~ Controls for HVAC ~~Piping and Equipment~~
3. Hydronic Piping
4. Refrigerant Piping
5. Identification for HVAC Piping and Equipment
6. HVAC ~~Equipment~~ Insulation
7. Instrumentation and Control for HVAC
8. Variable Frequency Motor Controllers

1.2 SUMMARY

A. Section Includes:

1. Packaged, water-cooled, electric-motor-driven centrifugal chillers.
2. Packaged, portable refrigerant recovery units.
3. Motor controllers.
4. Charge of refrigerant and oil.
5. Accessories.

B. Related Section:

1. Division 23 Section "Refrigerant Detection and Alarm" for refrigerant monitors, alarms, supplemental breathing apparatus, and ventilation equipment interlocks.

1.3 DEFINITIONS

A. BMS: Building management system.

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

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

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

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

F. NPLV: Nonstandard part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by AHRI 550/590 and intended for operating conditions other than the AHRI standard rating conditions.

1.4 PERFORMANCE REQUIREMENTS

A. Condenser-Fluid Temperature Performance:
1. Minimum Operating Condenser-Fluid Temperature: Chiller shall be capable of starting, loading, and continuous operation over the entire capacity range indicated with an entering condenser-fluid temperature of 55 deg F.
2. Make factory modifications to standard chiller design if necessary to comply with performance indicated.

B. Performance Tolerance: Comply with the following over and above the requirements of AHRI 550/590:

1. Allowable Capacity Tolerance: Zero percent.

C. Maximum Sound Power Levels of 87 dBA in accordance with ANSI standard method S1.2

1.5 SUBMITTALS

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

1. Manufacturer’s certified performance data at full load plus IPLV or NPLV.

2. Performance at AHRI standard conditions and at conditions indicated.
3. Performance at AHRI standard unloading conditions.
4. Minimum and maximum evaporator flow rate.
5. Refrigerant capacity of chiller.
6. Oil capacity of chiller.
7. Fluid capacity of evaporator and condenser.
8. Characteristics of safety relief valves.
9. Minimum entering condenser-fluid temperature.

10. Performance at varying capacities with constant design condenser-fluid flow. Repeat performance at varying capacities for different condenser-fluid temperatures from design to minimum in 5 deg F. increments.

B. Performance Data:

1. NPLV calculation based on the values indicated in the paragraph entitled "NPLV CALCULATION PROCEDURE".
2. Maximum and minimum water flow allowed through the evaporator and the pressure drop in feet of water at each condition (maximum, minimum and design).
3. Pressure drop through the condenser in feet of water at the design water flow.
4. Speed/torque curve under the most severe starting conditions.
5. Maximum allowable voltage drop during starting.
6. Locked rotor current.
7. Waterside number of passes, arrangements and connections for the evaporator.
8. Waterside number of passes, arrangements and connections for the condenser.
9. Maximum sound pressure level (dBA) at operating conditions.
10. Performance at AHRI standard conditions and at conditions indicated.
11. Performance at AHRI standard unloading conditions and at unloading conditions indicated.
12. Refrigerant capacity of chiller.
13. Oil capacity of chiller for Oil containing machines.
14. Fluid capacity of evaporator, condenser.
15. Characteristics of safety relief valves.
16. Minimum entering condenser-fluid temperature

C. LEED V4 BD+C Submittal:

1. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.

D. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, load distribution, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring. Diagram of control system indicating points for field interface and field connection. Diagram shall fully depict field and factory wiring.

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

1. Structural supports.
2. Piping roughing-in requirements.
3. Wiring roughing-in requirements, including spaces reserved for electrical equipment.

4. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.

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

G. Source quality-control reports.

H. Startup service reports.

I. Operation and Maintenance Data: For each chiller to include in emergency, operation, and maintenance manuals. Include start-up instructions, maintenance data, parts lists, controls, accessories, and troubleshooting guide.

J. Warranty: Sample of special warranty.

1.6 CODES AND STANDARDS

A. American Society of Mechanical Engineers (ASME):

1. Boiler and Pressure Vessel Code, Section VIII, Division 1, “Rules for Construction of Pressure Vessels.”
2. Boiler and Pressure Vessel Code, Section IX, “Welding and Brazing Qualifications.”
3. B31.1, “Power Piping.”
4. B31.5, “Refrigeration Piping and Heat Transfer Components.”

B. Air-Conditioning Heating and Refrigeration Institute (AHRI):

1. Standard 550/590, “Performance Rating of Water Chilling Packages Using the Vapor Compression Cycle.”
2. Standard 575, “Method of Measuring Machinery Sound Within an Equipment Space.”

C. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):

1. Standard 15, “Safety Standard for Refrigeration Systems.”
2. Standard 147, “Reducing the Release of Halogenated Refrigerants from Refrigerating and Air-Conditioning Equipment and Systems.”
3. Standard 90.1, “Energy Standard for Buildings Except Low-Rise Residential Buildings.”

D. National Fire Protection Association (NFPA)

1. Standard 70, National Electrical Code (NEC)

E. American Gear Manufacturers Association (AGMA)

F. American National Standards Institute (ANSI)

G. American Society for Testing and Materials (ASTM)

H. Institute of Electrical and Electronics Engineers (IEEE)

I. National Electrical Manufacturers Association (NEMA)

J. Underwriters Laboratories (UL)

K. Occupational Safety & Health Act (OSHA)

1.7 QUALITY ASSURANCE

A. AHRI Certification: Certify chiller according to AHRI 550 certification program.

B. AHRI Rating: Rate chiller performance according to requirements in AHRI 550/590.

C. ASHRAE Compliance:

1. ASHRAE 15 for safety code for mechanical refrigeration.
2. ASHRAE 147 for refrigerant leaks, recovery, and handling and storage requirements.

D. ASHRAE/IESNA Compliance: Applicable requirements in the latest edition of ASHRAE/IESNA 90.1 2010 as referenced in the Florida Building Code Series.

E. Chiller manufacturer must be ISO Certified.

F. The Chiller shall be tested to job conditions at the manufacturer’s plant.

G. ASME Compliance: Fabricate and label chillers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. For chillers charged with R-134a refrigerant or medium pressure HFO or HFO blend refrigerants, include an ASME U-stamp and nameplate certifying compliance.

H. Comply with NFPA 70.

I. Comply with requirements of UL, UL Canada, and include label by a qualified testing agency showing compliance.

J. All major components of the chiller shall be produced and assembled within the United States of America.

K. Green Seal Compliance: Signed by manufacturer certifying compliance with GS-31.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Ship chillers from the factory fully charged with refrigerant.

B. Charge each chiller with nitrogen if refrigerant is shipped in containers separate from chiller.

C. Ship each oil-lubricated chiller with a full charge of oil.

   1. Ship oil factory installed in chiller.

D. Package chiller for shipping on skids with a weather resistant cover.

E. Ship chillers from the factory fully assembled and tested, or as specified herein.

F. Ship each chiller with a firmly attached metal nameplate indicating name of manufacturer, model number, equipment type and refrigerant used.

G. Reject any damaged chiller equipment upon arrival at site. Replace damaged equipment or material at no cost to Owner.

H. Store chiller equipment to prevent damage, and protect from weather, dirt, fumes, water and construction debris. Provide a clean, dry space for storage if one is not available at the site.

I. Handle chiller equipment according to the manufacturer’s rigging and installation instructions for unloading and transporting into the final location. Leave protective covers in place until installation.

1.9 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

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

1.10 WARRANTY

A. Provide a full parts and labor warranty for 60 months from start-up or 72 months from ship date, whichever is longer.

B. The warranty items include, but are not limited to the following:

   1. Whole Units Parts Warranty

2. Whole Unit Labor Warranty
3. Pump Parts & Labor Warranty
4. Refrigerant Warranty

C. Provide an extended compressor parts only warranty for a total of 120 months that commences on the date that the general 60 or 72 month warranty expires.

D. Provide to the Owner an extended service warranty on the chillers (Quarterly Inspections/Preventative Maintenance) for the first 60 months from start-up or 72 months from ship date, whichever is longer, on all materials and labor.

E. Provide to the Owner a separate written refrigerant loss warranty for the lesser of 120 months from initial start-up or 126 months from date of shipment. During this period, manufacturer shall furnish (at its cost) replacement refrigerant which is lost due to a leak in the machine. Once a leak is determined, action must be taken to eliminate the source of the leak. Replacement parts and labor are not included.

F. Provide to the Owner a separate written warranty that guarantees that the type of refrigerant included in the original chillers will be available for the lifespan of the chiller (20 years) for an agreed cost based upon the market price at the time of the announced phase-out or the Manufacturer shall replace or convert the chillers to obtain a substantially similar efficiency at no cost to the Owner. This warranty shall include a commitment from the Manufacturer to pay the Owner for any additional operation and maintenance costs as a result of the replacement refrigerant or replacement chillers.

1.11 MAINTENANCE

A. Maintenance of the chillers in strict accordance with GOAA maintenance requirements and Manufacturer’s recommendations as published in the operation and maintenance manuals shall be the responsibility of the Contractor prior to Substantial Completion of the STC Program. The chiller Manufacturer shall provide full maintenance coverage as required according to Manufacturer’s recommendations to each chiller for the first 60 months from start-up or 72 months from ship date, whichever is longer, on all materials and labor. The extended services included in the warranty shall include, as a minimum, three quarterly inspections plus one annual inspection in which the condenser water tubes are cleaned, for a total of four annual visits.

1.12 FACTORY PERFORMANCE VERIFICATION

A. General: Each chiller shall undergo a factory performance test in an AHRI-certified test facility. The chiller manufacturer shall supply the certified original test report confirming specified performance. The factory tests shall be conducted in accordance with AHRI Standard 550 procedures and tolerances (with exceptions noted in Section 1.4.B), and the calibration of all instrumentation shall be traceable to a National Institute of Standards and Technology reference.

B. Performance Test Witnessing: Provide accommodations, including travel, meals and lodging expenses, for the Owner and Engineer to witness the chiller performance testing in the factory.

C. Acceptance: The chillers shall be accepted if the test procedures and results are within allowable tolerances of the testing standard; otherwise, the manufacturer shall make revisions to the equipment and retest as required, at no additional cost to the Owner.

D. Performance Penalties: In the event the chiller fails to achieve the submitted performance, the following penalties shall be imposed:

1. Capacity Test: For each ton below the allowable capacity for the unit, four thousand dollars per ton shall be assessed. Allowable capacity is equal to the design capacity submitted by the manufacturer with zero tolerance.

2. Power Consumption Penalty: The power consumption penalty shall be calculated as follows:

   Power Consumption Penalty = [Measured kW - (Measured tons x allowable kW/ton)] x $4000 /kW, where:

   Allowable kW/ton = (1 + AHRI 550/590 Tolerance) x Design kW/ton.

3. Total Penalty: The total performance penalty shall be the sum of the capacity penalty and the power consumption penalty, for each chiller~~s~~. Penalties shall be deducted from the contract price prior to submitting the invoice for the chillers.

E. Test Procedures: Factory performance tests shall be based on the design conditions as indicated in the paragraph entitled "NPLV CALCULATION PROCEDURE".

1.13 NPLV CALCULATION PROCEDURE

A. Chiller Efficiency: The chiller efficiency shall be established by computer algorithm simulation, and shall be verified through a factory test in accordance with the Non-Standard Part-Load Value methodology and criteria of AHRI Standard 550/590-2011. The chiller witness testing shall be at the conditions listed in VFD Centrifugal Chiller Load Data within the Bid Form to establish acceptance of the chiller performance.

B. NPLV Evaluation: The NPLV shall be the weighted sum of the chiller performance at the different operating points, as indicated in VFD Centrifugal Chiller Load Data within the Bid Form

C. Table 1 –VFD Centrifugal Chiller Load Data will be the basis for NPLV testing at the factory. Factory witness testing shall be in accordance with AHRI 550/590-2011.

D. Testing tolerances will be based on Table 10: Definition of Tolerances of that AHRI 550/590-2011 with exceptions as noted in section 1.4.B..

E. Confirm with ASHRAE Std. 15 the requirements for self-contained breathing apparatus (SCBA). SCBA provided by chiller vendor or Owner. Local Fire Marshal has authority over this issue. Confirm with Fire Marshal.

1.14 ADDITIONAL FACTORY TESTING

A. Each chiller shall have the integrity of 100% of evaporator and 100% of condenser tubes tested at the factory via eddy current testing. Material or workmanship defects discovered during eddy current testing shall be remedied prior to shipment of the chiller.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Base Bid Product : Equipment manufactured by York (Johnson Control Company [Model - YK], Daikin Applied [Model - WSC], Carrier [Model - 19XR] and Trane [Model CVHH] as scheduled on drawings. These manufacturers with oil lubricated compressors, water-cooled condensers and unit mounted variable-speed compressors are acceptable. Equipment featuring one or two compressors per machine are acceptable. Refer to Specification 012300 BID ALTERNATES, Bid Alternate CEP-01 for additional information.

B. Bid Alternate #1: Daikin Applied® Magnitude Model WME, including the standard product features and all special features as required per drawings and specifications. Refer to Specification 012300 BID ALTERNATES, Bid Alternate CEP-01 for additional information.

C. Bid Alternate #2: Equipment manufactured Trane as scheduled on drawings and operating with a condenser water flow equal to 2 gallons per minute (gpm) per Ton of refrigeration capacity. Equipment featuring one or two compressors per machine are acceptable. Refer to Specification 012300 BID ALTERNATES, Bid Alternate CEP-01 for additional information.

D. Other manufacturers with a similar product may be acceptable as an approved substitution for the base bid or bid alternates provided they meet all the requirements of the specifications and the following criteria:

1. Major components of the product are produced and assembled within the United States, and listed for their intended use.

2. The product manufacturer has local representation within 50 miles of Orlando International Airport.

3. Manufacturer's representative must have been representing chiller product locally for a minimum of 2 year.

4. Equipment proposed "as an-approved substitution", must meet the specifications including all architectural, mechanical, electrical, and structural details, all scheduled performance and the job design, plans and specifications.

5. Equipment shall comply with the requirements of UL United States or UL Canada, and include permanent label by a qualified testing agency showing compliance.

2.2 MANUFACTURED UNIT

A. Base ~~Bid~~ Chiller Description

1. Provide a complete factory assembled, charged, and tested water-cooled packaged centrifugal chiller with a design condenser water flow rate of 3 gpm per ton of refrigeration capacity. Factory assembled, single piece, liquid chiller shall consist of semi-hermitically sealed compressor, motor, unit-mounted variable frequency drive, lubrication system, cooler, condenser, initial oil and refrigerant operating charges, microprocessor control system, and documentation required prior to start-up. Chillers shall be charged with refrigerant HFC-134a or HFO refrigerant featuring a global warming Potential (GWP) of less than 2. Chiller Manufacturer shall provide for refrigerant availability guarantees specified in Paragraph 1.10.F and G for any and all refrigerants proposed.

2. For chillers with dual compressors, provide each compressor with a dedicated motor and motor controller, and provide for continued operation when either compressor-drive assembly fails or is being serviced.

3. Performance: Refer to chiller performance ratings in equipment schedules for basis of design performance.

B. ~~Bid~~ Alternate #1 Chiller Description

1. Provide a complete factory-assembled, charged and tested water-cooled, semi-hermetic oil-free centrifugal compressor water chiller as specified herein. The unit shall consist of one or two magnetic bearing, completely oil-free centrifugal compressors, refrigerant, condenser and evaporator, and control systems including integrated variable frequency drive, operating controls and equipment protection controls. Chillers shall be charged with refrigerant HFC-134a or HFO refrigerant featuring a global warming Potential (GWP) of less than 2. Chiller Manufacturer shall provide for refrigerant availability guarantees specified in Paragraph 1.10.F and G for any and all refrigerants proposed.

2. For chillers with dual compressors, provide each compressor with a dedicated motor and motor controller, and provide for continued operation when either compressor-drive assembly fails or is being serviced

3. Performance: Refer to chiller performance ratings in equipment schedules for basis of design performance.

C. ~~Bid~~ Alternate #2 Chiller Description

1. Provide a complete factory assembled, charged, and tested water-cooled packaged centrifugal chiller with a design condenser water flow rate of 2 gpm per ton of refrigeration capacity. Factory assembled, single piece, liquid chiller shall consist of semi-hermitically sealed compressor, motor, unit-mounted variable frequency drive, lubrication system, cooler, condenser, initial oil and refrigerant operating charges, microprocessor control system, and documentation required prior to start-up. Chillers shall be charged with refrigerant HFC-134a or HFO refrigerant featuring a global warming Potential (GWP) of less than 2. Chiller Manufacturer shall provide for refrigerant availability guarantees specified in Paragraph 1.10.F and G for any and all refrigerants proposed.

2. For chillers with dual compressors, provide each compressor with a dedicated motor and motor controller, and provide for continued operation when either compressor-drive assembly fails or is being serviced.

3. Performance: Refer to chiller performance ratings in equipment schedules for basis of design performance.

D. Each chiller shall be factory run-tested under load conditions for a minimum of one hour on an AHRI certified test stand with evaporator and condenser water flow at job conditions. Operating controls shall be adjusted and checked. The refrigerant charge shall be adjusted for optimum operation and recorded on the unit nameplate. Any deviation in performance or operation shall be remedied prior to shipment and the unit retested if necessary to confirm repairs or adjustments. Manufacturer shall supply a certificate of completion of a successful run-test upon request.

2.3 COMPRESSOR-DRIVE ASSEMBLY

A. Description: Single-stage or multistage, variable-displacement, centrifugal-type compressor driven by an electric motor.

1. Not used.

B. Compressors:

1. The base bid unit shall utilize oil or refrigerant lubricated bearings, semi-hermetic centrifugal compressors. Bid Alternate units can feature oil-free magnetic bearings. The compressor drive train shall be capable of coming to a controlled, safe stop in the event of a power failure.

2. The motor shall be of the semi-hermetic type, of sufficient size to efficiently fulfill compressor horsepower requirements. It shall be liquid refrigerant cooled with internal thermal sensing devices in the stator windings. The motor shall be compatible with variable frequency drive operation

3. If a semi-hermetic motor is not utilized, the Manufacturer shall calculate, and indicate in it's performance data in the bid form Tables 1A and 1B, the motor heat rejection to the machinery space and the heat rejection will be factored into the chiller performance and life cycle cost comparison.

   a. If the compressor design requires a shaft seal to contain the refrigerant, the manufacturer shall supply a 20 year parts and labor warranty on the shaft seal and a lifetime refrigerant replacement warranty if a seal failure leads to refrigerant loss, or the chiller manufacturer shall assume all costs to supply and install a self-contained air conditioning system in the mechanical space sized to handle the maximum heat output the open drive motor. The energy required to operate this air conditioning system shall be added to the chiller power at all rating points for energy evaluation purposes.

   b. If the compressor/motor uses any form of antifriction bearing (magnetic, roller, ball, etc), the chiller manufacturer shall provide the following at no additional charge:

      1) At start up a three-axis vibration analysis and written report to establish bearing condition baseline.
      2) An annual three-axis vibration analysis and written report indicating bearing condition.

4. Each chiller shall be equipped with an integrated Variable Frequency Drive (VFD) to automatically regulate compressor speed in response to cooling load and the compressor pressure lift requirement. Movable inlet guide vanes and variable compressor speed, shall provide unloading. The chiller controls shall coordinate compressor speed and guide vane position to optimize chiller efficiency.

5. Each compressor circuit shall be equipped with a line reactor to help protect against incoming power surges and help reduce harmonic distortion. A harmonic filter shall be required if Total Harmonic Distortion exceeds 5%. If Distortion is more than 5%, then an external Harmonic Mitigation Filter shall be provided by the Manufacturer. Testing shall be performed and certified in accordance with IEEE per Manufacturer or an independent certified Electrical Testing Laboratory specialized in these tests.

6. Chiller Motor: Each chiller shall meet IEEE Standard 519 Total Demand Distortion limits at an Isc/IL ratio no greater than 20. Testing shall be performed and certified in accordance with IEEE per Manufacturer or an independent certified Electrical Testing Laboratory specialized in these tests.

C. Vibration Balance: Balance chiller compressor and drive assembly to provide a precision balance that is free of noticeable vibration over the entire operating range. Operating speed shall be below the first critical speed.

1. Overspeed Test: 25 percent above design operating speed.

D. Service: Easily accessible for inspection and service.

1. Compressor's internal components shall be accessible without having to remove compressor-drive assembly from chiller.

2. Provide lifting lugs or eyebolts attached to casing.

E. Economizers: For multistage chillers, provide interstage economizers.

2.4 REFRIGERATION

A. Refrigerant:

1. Type: R-134a; ASHRAE 34, Class A1.

2. Type: R-1233zd(E); ASHRAE 34, Class A1.

3. Type: R-514A; ASHRAE 34, Class B1.

4. Compatibility: Chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.

B. Refrigerant Flow Control: Manufacturer's standard refrigerant flow-control device satisfying performance requirements indicated.

C. Pressure Relief Device:

1. Comply with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

2. For Chillers Using R-134a, or R-514A: ASME-rated, spring-loaded, pressure relief valve; single- or multiple-reseating type. Pressure relief valve(s) shall be provided for each heat exchanger. Condenser shall have dual valves with one being redundant and configured to allow either valve to be replaced without loss of refrigerant.

D. Refrigerant Transfer: Provide service valves and other factory-installed accessories required to facilitate transfer of refrigerant from chiller to a remote refrigerant storage and recycling system. Comply with requirements in ASHRAE 15 and ASHRAE 147.

E. Refrigerant Isolation for Chillers Using R-134a, or R-514A: Factory install isolation valves in the compressor discharge line to the condenser and the refrigerant liquid line leaving the condenser to allow for isolation and storage of full refrigerant charge in the chiller condenser shell.

2.5 EVAPORATOR AND CONDENSER

A. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell.

B. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.

C. The evaporator and condenser shall be separate vessels of the shell-and-tube type, designed, constructed, tested and stamped according to the requirements of the ASME Code, Section VIII. Regardless of the operating pressure, the refrigerant side of each vessel will bear the ASME stamp indicating compliance with the code and indicating a test pressure of 1.1 times the working pressure, but not less than 100 psig. The tubes shall be individually replaceable and secured to the intermediate supports without rolling or expanding to facilitate replacement.

D. The evaporator shall be flooded type with 0.025 in. wall copper internally and externally enhanced tubes rolled into carbon steel tubesheets. The water side shall be designed for a minimum of 150 psig. The refrigerant side shall be designed for a minimum of 200 psi. Provide intermediate tube supports. The heads shall be carbon steel. Water connections shall be flanged or grooved suitable for Victaulic couplings. The evaporator shall be equipped with marine waterboxes with hinged covers and vent and drain connections.

E. The condenser shall have 0.028 in. wall copper internally and externally enhanced tubes rolled into carbon steel. Water connections shall be flanged or grooved suitable for Victaulic couplings. The water side shall be designed for a minimum of 150 psig. The refrigerant side shall be designed for a minimum of 200 psi. Provide intermediate tube supports. The condenser shall be equipped with marine waterboxes with hinged covers and vent and drain connections.

F. The evaporator and condenser heads and water boxes shall feature a corrosion resistant epoxy coating similar to Devcon as manufactured by ITW Ploymers Adhesives or approved substitutionl. Corrosion resistant coatings shall be covered under the terms of the special warranty provisions of section 1.10.

G. The evaporator and condenser tube sheets shall feature a corrosion resistant ceramic coating as manufactured by Enercon Industries Co., or approved substitution. Corrosion resistant coatings shall be covered under the terms of the special warranty provisions of section 1.10.

H. Provide sufficient isolation valves and condenser volume to hold the full unit refrigerant charge in the condenser during servicing or provide a separate pumpout system and storage tank sufficient to hold the charge of the largest unit being furnished.

I. An electronic expansion valve shall or fixed orifice device shall control refrigerant flow to the evaporator. Float controls with hot gas bypass are not acceptable because of inefficient control at low load conditions. The liquid line shall have moisture indicating sight glass.

J. Re-seating type spring loaded pressure relief valves according to ASHRAE-15 safety code shall be furnished. The evaporator shall be provided with single or multiple valves. The condenser shall be provided with dual relief valves equipped with a transfer valve so one relief valve can be removed for testing or replacement without loss of refrigerant or removal of refrigerant from the condenser.

K. The evaporator, including water heads, suction line, and any other component or part of a component subject to condensing moisture shall be insulated with UL recognized 1 ½ inch closed cell insulation. All joints and seams shall be carefully sealed to form a vapor barrier.

L. The evaporator waterbox shall be insulated with UL recognized 1 ½ inch closed cell insulation. All joints and seams shall be carefully sealed to form a vapor barrier.

M. Provide factory-mounted and wired, thermal-dispersion water flow switches on each vessel to prevent unit operation with no or low water flow. Paddle and pressure differential type switches are not acceptable due to high rates of failure and false indications from these types of flow indicators.

N. Vibration Isolation: Provide neoprene waffle-type vibration isolators for each corner of the unit.

2.6 CHILLER CONTROL

A. Chiller Control:

1. The unit shall have a microprocessor-based control system consisting of a 15-inch VGA touch-screen operator interface and a unit controller.

2. The touch-screen shall display the unit operating parameters, accept setpoint changes (multi-level password protected) and be capable of resetting faults and alarms. The following parameters shall be displayed on the home screen and also as trend curves on the trend screen:

   a. Entering and leaving chilled water temperatures
   b. Entering and leaving condenser water temperatures
   c. Evaporator saturated refrigerant Pressure
   d. Condenser saturated refrigerant pressure

e. Percent of 100% speed (per compressor)
f. % of rated load amps for entire unit

3. In addition to the trended items above, all other important real-time operating parameters shall also be shown on the touch-screen. These items shall be displayed on a chiller graphic showing each component. At a minimum, the following critical areas must be monitored:

a. Compressor actual speed, maximum speed, percent speed
b. Evaporator water in and out temperatures, refrigerant pressure and temperature
c. Condenser water in and out temperatures, refrigerant pressure and temperature
d. Liquid line temperature
e. Chilled water setpoint
f. Compressor and unit state and input and output digital and analog values

4. A fault history shall be displayed using an easy to decipher, color coded set of messages that are date and time stamped. Time interval scale shall be user selectable as 20 mins, 2 hours, or 8 hours. The alarm history shall be downloadable from the unit's USB port. An operating and maintenance manual specific for the unit shall be viewable on the screen.

5. All setpoints shall be viewable and changeable (multi-level password protected) on the touch screen and include setpoint description and range of set values.

6. Automatic corrective action to reduce unnecessary cycling shall be accomplished through preemptive control of low evaporator or high discharge pressure conditions to keep the unit operating through abnormal transient conditions.

7. Chiller shall be capable of starting with entering condenser water temperatures as low as 55°F for short periods of time during startup, the chiller shall be able to operate with an entering condenser water temperature lower than the leaving chilled water temperature.

8. Chiller shall be capable of stable operation with varying evaporator flow rate down to 50% of design flow and flow variations of 30% of design flow per minute.

9. The factory mounted controller(s) shall support operation on a BACnet® network via one of the data link / physical layers listed below as specified by the successful Building Management System (BMS) supplier. All communication from the chiller unit controller as specified in the points list shall be via standard BACnet objects. Proprietary BACnet objects shall not be allowed. BACnet communications shall conform to the BACnet protocol (ANSI/ASHRAE135-2001). A BACnet Protocol Implementation Conformance Statement (PICS) shall be provided along with the unit

submittal.

a. BACnet MS/TP master (Clause 9)
b. BACnet IP, (Annex J)
c. BACnet ISO 8802-3, (Ethernet)

10. The information communicated between the BMS and the factory mounted unit controllers shall include the reading and writing of data to allow unit monitoring, control and alarm notification as specified in the unit sequence of operation and the unit points list.

11. The factory mounted controller shall include the following hardwired control and monitoring points for BMS interface(provide terminal strips for BMS interface):
    a. Remote chiller enable/disable.
    b. Chiller run status
    c. Chiller common alarm.
    d. Remote chiller setpoint adjustment.

B. VARIABLE FREQUENCY DRIVE

1. A variable speed drive (VFD) shall be factory-installed on the chiller.
2. The VFD shall vary the compressor motor speed by controlling the frequency and voltage of the electrical power to the motor. Motor adaptive capacity control logic shall automatically adjust motor speed and compressor pre-rotation vane position independently for maximum part load efficiency by analyzing information fed to it by sensors located throughout the chiller.
3. Enclosure: Unit mounted, NEMA-1, with all power and control wiring between the drive and chiller factory-installed including power to the chiller oil pump. Field power wiring shall be a single point connection and electrical lugs for incoming power wiring shall be provided. The entire package shall be U.L. listed.
4. Integral Disconnecting Means: Door-interlocked, NEMA AB 1, instantaneous-trip circuit breaker capable of being padlocked. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 65,000.
5. Drive: Pulse width modulated (PWM) output with insulated gate bipolar transistors (IGBT) with a power factor of 0.95 or better at all loads and speeds.
6. Technology: Pulse width modulated (PWM) output with insulated gate bipolar transistors (IGBT); suitable for variable torque loads.
7. Controller shall consist of a rectifier converter section, a digital/analog driver regulator section, and an inverter output section.

    a. Rectifier section shall be a full-wave diode bridge that changes fixed-voltage, fixed-frequency, ac line power to a fixed dc voltage. Silicon controller rectifiers, current source inverters, and paralleling of devices are unacceptable. Rectifier shall be insensitive to phase rotation of the ac line.

b. Regulator shall provide full digital control of frequency and voltage.
c. Inverter section shall change fixed dc voltage to variable-frequency, variable ac voltage, for application to a squirrel-cage motor. Inverter shall produce a sine-coded, pulse width modulated (PWM) output wave form and shall conduct no radio-frequency interference back to the input power supply.

8. Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.

9. Operating Requirements:

   a. Input AC Voltage Tolerance: 460-V ac, plus 10 percent or 506 V maximum.
   b. Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
   c. Capable of driving full load, without derating, under the following conditions:

      1) Ambient Temperature: 0 to 50 deg C.
      2) Relative Humidity: Up to 95 percent (noncondensing).
      3) Altitude: Sea level.

   d. Minimum Efficiency: 96 percent at 60 Hz, full load.
   e. Minimum Displacement Primary-Side Power Factor: 95 percent without harmonic filter, 98 percent with harmonic filter.
   f. Overload Capability: 1.05 times the full-load current for 7 seconds.
   g. Starting Torque: As required by compressor-drive assembly.
   h. Speed Regulation: Plus or minus 1 percent.
   i. Isolated control interface to allow controller to follow control signal over a 10:1 speed range.
   j. To avoid equipment resonant vibrations, provide critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.
   k. Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.

10. Internal Adjustability Capabilities:

   a. Minimum Output Frequency: 6 Hz.
   b. Maximum Output Frequency: 60 Hz.
   c. Acceleration: 2 seconds to a minimum of 60 seconds.
   d. Deceleration: 2 seconds to a minimum of 60 seconds.
   e. Current Limit: 30 percent to a minimum of 100 percent of maximum rating.

11. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or the need for replacement:

   a. Overtemperature.
   b. Short circuit at controller output.
   c. Ground fault at controller output. Variable frequency controller shall be able to start a grounded motor.
   d. Open circuit at controller output.

e. Input undervoltage.
f. Input overvoltage.
g. Loss of input phase.
h. Reverse phase.
i. AC line switching transients.
j. Instantaneous overload, line to line or line to ground.
k. Sustained overload exceeding 100 percent of controller rated current.
l. Starting a rotating motor.

12. Motor Protection:

a. UL listed ground fault protection.
b. Overvoltage and Undervoltage protection.
c. 3-phase sensing motor overcurrent protection.
d. Single phase protection.
e. Insensitive to phase rotation.
f. Overtemperature protection.
g. Phase loss protection.
h. Reverse phase protection.

13. Automatic Reset and Restart: Capable of three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Controller shall be capable of automatic restart on phase-loss and overvoltage and undervoltage trips.

14. Visual Indication: On face of controller enclosure or chiller control enclosure; indicating the following conditions:

a. Power on.
b. Run.
c. Overvoltage.
d. Line fault.
e. Overcurrent.
f. External fault.
g. Motor speed (percent).
h. Fault or alarm status (code).
i. DC-link voltage.
j. Motor output voltage.
k. Input kilovolt amperes.
l. Total power factor.
m. Input kilowatts.
n. Input kilowatt-hours.
o. Three-phase input voltage.
p. Three-phase output voltage.
q. Three-phase input current.
r. Three-phase output current.

s. Output frequency (Hertz).
t. Elapsed operating time (hours).
u. Self-Diagnostic and service parameters.

15. Operator Interface: At controller or chiller control panel; with start-stop and auto-manual selector with manual-speed-control potentiometer.

16. Control Signal Interface:

a. Electric Input Signal Interface: A minimum of two analog inputs (0 to 10 V or 0/4-20 mA) and six programmable digital inputs.

17. Cooling: Closed loop, fresh water circuit consisting of a water-to-water heat exchanger and circulating pump. All interconnecting water piping is factory installed and rated for 150 psig working pressure.

18. Accessories: Devices shall be factory installed in controller enclosure unless otherwise indicated.

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

3. Chiller Capacity Control Interface: Equip chiller with adaptive control logic to automatically adjust the compressor motor speed and the compressor pre-rotation inlet vane position independently to achieve maximum part-load efficiency in response to sensor inputs that are integral to the chiller controls.

2.7 ELECTRICAL

A. Factory installed and wired, and functionally tested at factory before shipment.

B. Power connection shall be single point to a factory mounted disconnect switch OR shall be multipoint to each compressor power panel on two-compressor units. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 65,000 A.

C. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.

D. Factory-installed wiring outside of enclosures shall be in metal raceway except make terminal connections with not more than a 24-inch length of liquidtight or flexible metallic conduit.

2.8 FINISH

A. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:

1. Provide at least one coat of primer with a total dry film thickness of at least 2 mils.

2. Provide at least two coats of alkyd-modified, vinyl enamel finish with a total dry film thickness of at least 4 mils.

3. Paint surfaces that are to be insulated before applying the insulation.

4. Paint installed insulation to match adjacent uninsulated surfaces.

5. Color of finish coat to be manufacturer's standard.

B. Provide Owner with quart container of paint used in application of topcoat to use in touchup applications after Project Closeout.

2.9 ACCESSORIES

A. Tool Kit: Chiller manufacturer shall assemble a tool kit specially designed for use in serving the chiller(s) furnished. Include special tools required to service chiller components not readily available to Owner service personnel in performing routine maintenance. Place tools in a lockable case with hinged cover. Provide a list of each tool furnished and attach the list to underside of case cover.

2.10 CAPACITIES AND CHARACTERISTICS – AS NOTED ON PLANS

2.11 SOURCE QUALITY CONTROL

A. Factory performance test chillers, before shipping, according to AHRI 550/590.

1. Test the following conditions:

   a. Design conditions indicated.
   b. Reduction in capacity from design to minimum load in steps of 25% with varying entering condenser-fluid temperature from design to minimum conditions in 5 deg F increments.

2. Allow Owner access to place where chillers are being tested. Notify Architect 14 days in advance of testing.

3. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

4. Performance Test Witnessing: Provide accommodations, including travel, meals and lodging expenses, for the Owner and Design Engineer to witness the chiller performance testing in the factory.

PART 3 - EXECUTION

3.1 GENERAL

A. The chillers will be delivered to the designated rigger's yard. Contractor shall coordinate shipment, receive, inspect and accept responsibility for equipment. Any damage or deficiency shall be resolved by Contractor directly with manufacturer and/or hauler, with no recourse to the Owner.

B. Delivery and rigging of chillers will be staged based on the construction schedule. Contractor shall protect equipment, transport to the site, rig into place, install, pipe, wire and test equipment in accordance with drawings, specifications and manufacturer's recommendations. Contractor shall coordinate any requirements directly with the manufacturer.

C. Consult equipment supplier regarding rigging requirements. If disassembly is required, both disassembly and reassembly shall be done by the Contractor in strict compliance with the manufacturer's instructions, under supervision of chiller manufacturer's representative, and shall not void any warranties.

3.2 EXAMINATION

A. Examine chillers before installation. Reject chillers that are damaged.

B. Examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, and electrical connections to verify actual locations, sizes, and other conditions affecting chiller performance, maintenance, and operations before equipment installation.

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

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

3.3 CHILLER INSTALLATION

A. Install chillers on support structure indicated. Level machine to within manufacturer's tolerances.

B. Equipment Mounting: Install chiller on concrete bases using elastomeric pads. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-Place Concrete." Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Minimum Deflection: 1/4 inch.

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 supported equipment.

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

D. Charge chiller with refrigerant and fill with oil if not factory installed.

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

F. Nameplates: In addition to the manufacturer’s standard nameplate, as specified in ASHRAE Standard 15, provide engraved brass nameplate with minimum 0.5-inch letters on each chiller to indicate the name and address of installer, horsepower or equivalent kW of prime mover, type and number of pounds of refrigerant and pressure applied for refrigerant leakage test.

3.4 CONNECTIONS

A. Comply with requirements for piping specified in Division 23 Section "Hydronic Piping" and Division 23 Section "Refrigerant Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Piping Connections: Piping connections to the nozzles of the evaporator and condenser shall have provisions for removal to provide unobstructed access for cleaning and replacing tubes.

C. Evaporator Fluid Connections: Connect to evaporator inlet with shutoff valve, flexible connector, thermometer, and plugged tee with pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, thermometer, plugged tee with shutoff valve, and pressure gage, and drain connection with valve. Make connections to chiller with a flange or mechanical coupling.

D. Condenser-Fluid Connections: Connect to condenser inlet with shutoff valve, flexible connector, thermometer, and plugged tee with pressure gage. Connect to condenser outlet with shutoff valve, balancing valve, flexible connector, thermometer, plugged tee with shutoff valve and pressure gage and drain connection with valve. Make connections to chiller with a flange or mechanical coupling.

E. Refrigerant Pressure Relief Device Connections: For chillers installed indoors, extend vent piping to the outdoors without valves or restrictions. Comply with ASHRAE 15. Connect to chiller pressure relief device with flexible connector and dirt leg with drain valve.

F. Miscellaneous Unit Water Piping: Provide a water supply manifold piped to the compressor oil cooler and the unit-mounted VFD unit. The supply manifold shall be complete and include valves, sight glasses, thermometers and other devices to verify sufficient water flow.

G. Miscellaneous Unit Refrigerant Piping: Provide all interconnecting refrigerant piping between the chiller, refrigerant recovery unit, compressor and condenser, and remote refrigerant storage vessel, if required.

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

3.5 SPARE PARTS

A. Maintenance Items: Provide to the Owner prior to final completion and in original packaging the following:

1. Replacement evaporator and condenser water barrel head gaskets, one for each removable head.
2. One jointed tube rodding brush with handle and sufficient sections to rod the full length of the chiller tubes.
3. Six each evaporator and condenser tube brushes, compatible with the joined rod above.

3.6 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. Verify that refrigerant charge is sufficient and chiller has been leak tested.
3. Verify that pumps are installed and functional.
4. Verify that thermometers and gages are installed.
5. Operate chiller for run-in period.
6. Check bearing lubrication and oil levels.
7. Verify that refrigerant pressure relief device is vented outside.
8. Verify proper motor rotation.

9. Verify and record performance of fluid flow and low-temperature interlocks for evaporator and condenser.
10. Verify and record performance of chiller protection devices.
11. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

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

C. Prepare test and inspection startup reports.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain chillers. Video record the training sessions.

3.8 FACTORY PERFORMANCE TESTS

A. Manufacturer shall conduct factory performance test for each chiller in accordance with AHRI 550/590-98, to verify design capacity and part load capacity points indicated on Bid form. Owner and/or Owner’s representative may elect to witness tests. Notify Owner and/or Owners representative of test date at least 2 weeks in advanced.

B. Before shipment of chillers, all records and certifications approving testing requirements shall be submitted to and approved by Owner.

C. Defective work or material shall be replaced or repaired, as necessary, and inspection and test repeated. Repairs shall be made with new materials. Run new performance test in accordance with AHRI standard.

D. If chiller assembly fails to meet any of part load performance data supplied by manufacturer with its bid, Owner may elect not to accept delivery until chiller is modified at manufacturer’s expense to meet all of design and part load performance data or to assess penalty charge equal to 10 years operating cost differential. This differential is to be determined by using part load data included in bid form and data obtained from performance test, subtracting bid data annual operating cost from test data annual operating cost, and multiplying difference by ten. Penalty charge shall apply to all chillers.

E. All design conditions and part load performance data shall be evaluated with 480 volt, 3-phase, 60 hertz power supplied to chiller.

F. Conduct test at approved AHRI certified test facility of the manufacturer.

G. Instrumentation used for testing must be calibrated within 6 months of test date and traceable to National Bureau of Standards. Documentation verifying NBS traceability shall be submitted to Engineer.

H. Performance test shall be four-point test per chiller. Points will be selected at time of test. Points will be selected from submitted performance from 25 to 100% of capacity.

I. See Factory Performance Verification under 1.12.

END OF SECTION 23 64 16

SECTION 23 64 16.01 - PCA CENTRIFUGAL WATER CHILLERS

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. Basic Requirements: Provisions of Section 23 00 10.01, Basic Pre-Conditioned Air Requirements, are a part of this Section.

C. Section includes design, performance criteria, refrigerants, controls, and installation requirements for water-cooled centrifugal chillers with variable speed drives.

D. Comply with requirements in Section 23 05 48 "Vibration Controls for HVAC" for equipment isolation.

1.2 SUMMARY

A. General: Provide hermetic, water chiller of type, size, capacities, and operating characteristics as indicated.

1.3 REFERENCES

A. Comply with the following codes and standards:

1. AHRI 550/590
2. AHRI 575
3. NEC
4. ANSI/ASHRAE 15
5. OSHA as adopted by the State
6. ETL
7. ASME Section VIII

1.4 DEFINITIONS

A. BAS: Building automation system.

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

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

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

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

F. NPLV: Nonstandard part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by AHRI 550/590 and intended for operating conditions other than the AHRI standard rating conditions.

1.5 SUBMITTALS

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

1. Manufacturer's certified performance data at full load plus IPLV or NPLV.
2. Performance at AHRI standard unloading conditions.
3. Minimum evaporator flow rate.
4. Refrigerant capacity of chiller.
5. Fluid capacity of evaporator, and condenser.
6. Characteristics of safety relief valves.
7. Minimum entering condenser-fluid temperature.
8. Performance at varying capacities with constant design condenser-fluid temperature. Repeat performance at varying capacities for different condenser-fluid temperatures from design to minimum in 5 deg F increments.

B. LEED Submittals:

1. Product Data for Credit EA 4: Documentation indicating that equipment and refrigerants comply.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, load distribution, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: Diagram of control system indicating points for field interface and field connection. Diagram shall fully depict field and factory wiring.

1.6 INFORMATIONAL SUBMITTALS

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

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

B. Performance Data:

1. NPLV calculation based on the values indicated in the paragraph entitled "NPLV CALCULATION PROCEDURE".

2. Maximum and minimum water flow allowed through the evaporator and the pressure drop in feet of water at each condition (maximum, minimum and design).
3. Pressure drop through the condenser in feet of water at the design water flow.
4. Speed/torque curve under the most severe starting conditions.
5. Maximum allowable voltage drop during starting.
6. Total maximum harmonic distortion (at any operating point), listed as a percentage at point of equipment connection.
7. Locked rotor current.
8. Waterside number of passes, arrangements and connections for the evaporator.
9. Waterside number of passes, arrangements and connections for the condenser.
10. Maximum sound pressure level (dBA) at operating conditions.
11. Performance at AHRI standard conditions and at conditions indicated.
12. Performance at AHRI standard unloading conditions and at unloading conditions indicated.
13. Refrigerant capacity of chiller.
14. Oil capacity of chiller.
15. Fluid capacity of evaporator, condenser.
16. Characteristics of safety relief valves.
17. Minimum entering condenser-fluid temperature.
18. Minimum evaporator flow rate.

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

D. Source quality-control reports.

E. Startup service reports.

F. Warranty: Sample of special warranty.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each chiller to include in emergency, operation, and maintenance manuals. See Division 01 Section for other closeout requirements.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Chillers shall be delivered to the job site completely assembled and charged with refrigerant R134a and be shipped on skids with a weather resistant cover. Charge each chiller with nitrogen if refrigerant is shipped in containers separate from chiller.

B. Comply with the manufacturer's instructions for rigging and handling equipment. Leave protective covers in place until installation.

1.9 QUALITY ASSURANCE

A. AHRI Certification: Certify chiller according to AHRI 550 certification program.

B. AHRI Rating: Rate chiller performance according to requirements in AHRI 550/590.

C. ASHRAE Compliance:

1. ASHRAE 15 for safety code for mechanical refrigeration.
2. ASHRAE 147 for refrigerant leaks, recovery, and handling and storage requirements.

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

E. Chiller manufacturer must be ISO Certified.

F. The Chiller shall be tested to job conditions at the manufacturer's plant.

G. ASME Compliance: Fabricate and label chillers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, as applicable to chiller design. For chillers charged with R-134a refrigerant, include an ASME U-stamp and nameplate certifying compliance.

H. Comply with NFPA 70.

I. Comply with requirements of UL/ETL and include label by a qualified testing agency showing compliance.

J. All major components of the chiller shall be produced and assembled within the United States of America.

1.10 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

1.11 WARRANTY

A. Provide a full parts and labor warranty for 60 months from start-up or 72 months from ship date, whichever is longer.

B. The warranty items include, but are not limited to the following:

1. Whole Units Parts Warranty
2. Whole Unit Labor Warranty
3. Pump Parts & Labor Warranty
4. Refrigerant Warranty

C. Provide an extended compressor parts only warranty for a total of 120 months that commences on the date that the general 60 or 72 month warranty expires.

D. Provide to the Owner an extended service warranty on the chillers (Quarterly Inspections/Preventative Maintenance) for the first 60 months from start-up or 72 months from ship date, whichever is longer, on all materials and labor. ~~The chiller manufacturer's warranty shall cover routine and regular maintenance, parts costs and labor costs for the repair or replacement of defects in material or workmanship, and include refrigerant for the entire unit, for a period of five (5) years from date of Substantial Completion.~~

B. Provide to the Owner a separate written refrigerant loss warranty for the lesser of 120 months from initial start-up or 126 months from date of shipment. During this period, manufacturer shall furnish (at its cost) replacement refrigerant which is lost due to a leak in the machine. Once a leak is determined, action must be taken to eliminate the source of the leak. Replacement parts and labor are not included.

~~B.~~ Provide to the Owner a separate written warranty that guarantees that the type of refrigerant included in the original chillers will be available for the lifespan of the chiller (20 years) for an agreed cost based upon the market price at the time of the announced phase-out or the Manufacturer shall replace or convert the chillers to obtain a substantially similar efficiency at no cost to the Owner. This warranty shall include a commitment from the Manufacturer to pay the Owner for any additional operation and maintenance costs as a result of the replacement refrigerant or replacement chillers.

~~C. Warranty support shall be provided by company direct or factory authorized service permanently located near the job site.~~

~~C. The Manufacturer shall also provide to the Owner a separate written refrigerant loss warranty for the lesser of 120 months from initial start-up or 126 months from date of shipment. During this period, manufacturer shall furnish (at its cost) replacement refrigerant which is lost due to a leak in the machine. Once a leak is determined, action must be taken to eliminate the source of the leak. Replacement parts and labor are not included.~~

C. ~~The Manufacturer shall also provide to the Owner a separate written warranty that guarantees that the type of refrigerant included in the original chillers will be available for the lifespan of the chiller (25 years) or the Manufacturer shall replace or convert the chillers to obtain a substantially similar efficiency at no cost to the Owner. This warranty shall include a commitment from the Manufacturer to pay the Owner for any additional operation and maintenance costs as a result of the replacement refrigerant or replacement chillers.~~

1.12 MAINTENANCE

A. Maintenance of the chillers in strict accordance with GOAA maintenance requirements and Manufacturer's recommendations as published in the operation and maintenance manuals shall be the responsibility of the Contractor prior to Substantial Completion of the STC Program. The chiller Manufacturer shall provide full maintenance coverage as required according to Manufacturer's recommendations to each chiller for the first 60 months from start-up or 72 months from ship date, whichever is longer, on all materials and labor. The extended services included in the warranty shall include, as a minimum, three quarterly inspections plus one annual inspection in which the condenser water tubes are cleaned, for a total of four annual visits.

~~A. Maintenance of the chillers in accordance with manufacturer's recommendations as published in the installation and maintenance manuals shall be the responsibility of the contractor prior to substantial completion The chiller manufacturer shall provide full maintenance coverage as required according to manufacturer's recommendations and the Maintenance Agreement in the attached Bid Form on each chiller for 5 years following substantial completion.~~

1.13 FACTORY PERFORMANCE VERIFICATION

A. General: Each chiller shall undergo a factory performance test in an ARI-certified test facility. The chiller manufacturer shall supply the certified original test report confirming specified performance. The factory tests shall be conducted in accordance with ARI Standard 550 procedures and tolerances (except as noted in 1.15.B), and the calibration of all instrumentation shall be traceable to a National Institute of Standards and Technology reference.

B. Performance Test Witnessing: Provide accommodations, including travel, meals and lodging expenses, for the Owner and Engineer to witness the chiller performance testing in the factory.

C. Acceptance: The chillers shall be accepted if the test procedures and results are within allowable tolerances of the testing standard; otherwise, the manufacturer shall make revisions to the equipment and retest as required, at no additional cost to the Owner.

D. Performance Penalties: In the event the chiller fails to achieve the submitted performance, the following penalties shall be imposed:

1. Capacity Test: For each ton below the allowable capacity for the unit, four thousand dollars per ton shall be assessed. Allowable capacity is [(1 - tolerance) * design capacity].
2. Power Consumption Penalty: The power consumption penalty shall be calculated as follows:

   Power Consumption Penalty = [Measured kW - (Measured tons x allowable kW/ton)] x $4000 /kW, where:

   Allowable kW/ton = (1 + Tolerance) x Design kW/ton.

3. Total Penalty: The total performance penalty shall be the sum of the capacity penalty and the power consumption penalty, for each chillers regardless if tested or not. Penalties shall be deducted from the contract price prior to submitting the invoice for the chillers.

E. Test Procedures: Factory performance tests shall be based on the design conditions as indicated in the paragraph entitled "NPLV CALCULATION PROCEDURE".

1.14 NPLV CALCULATION PROCEDURE

D. Chiller Efficiency: The chiller efficiency shall be established by computer algorithm simulation, and shall be verified through a factory test in accordance with the Non-Standard Part-Load Value methodology and criteria of AHRI Standard 550/590-2011. The NPLV variables shall be as follows:

Note 1: Adjust the evaporator and condenser water temperatures from the schedule to above freezing in order to simulate the same lift at the factory test as in the field condition.

1. Entering Chilled Water Temperature .... ~~As Scheduled~~65.4 Degrees F (Note 1)

~~1.~~2. Leaving Chilled Water Temperature .... 40 Degrees F (Note 1)
~~5.~~3. Chilled Water Flow Rate .... As Scheduled
~~6.~~4. Evaporator Fouling Factor.. 0.0001
~~7.~~5. Entering Condenser Water Temperature – 100% Load ... ~~As Scheduled~~67.15 Degrees F (Note 1)
~~8.~~6. Entering Condenser Water Temperature – 0% Load .... 67.15 Degrees F (Note 1)~~2.5 Degree F. Reset Linearly Per 10% Load Reduction~~
~~9.~~7. Condenser Water Flow Rate.. As Scheduled
~~10.~~8. Condenser Fouling Factor.. 0.00025

~~D.~~E. NPLV Evaluation: The NPLV shall be the weighted sum of the chiller performance at four operating points, with weighting factors as indicated:

1. NPLV = 1 divided by (0.05/A + 0.73/B + 0.21/C + 0.01/D) where:

   a. A = Chiller consumption/evaporator load (Kw/ton) at 100% full-load.
   b. B = Chiller consumption/evaporator load (Kw/ton) at 75% full-load.
   c. C = Chiller consumption/evaporator load (Kw/ton) at 50% full-load.
   d. D = Chiller consumption/evaporator load (Kw/ton) at 25% full-load.

~~E.~~F. NPLV Evaluation: The NPLV shall be the weighted sum of the chiller performance at the different operating points, as indicated in VFD Centrifugal Chiller Load Data within the Bid Form.

~~F.~~G. Table 1 –VFD Centrifugal Chiller Load Data will be the basis for NPLV testing at the factory. Factory witness testing shall be in accordance with AHRI 550/590-2011.

~~G.~~H. Testing tolerances will be based on Table 10: Definition of Tolerances of that AHRI 550/590-2011.

1.15 PERFORMANCE REQUIREMENTS

A. Condenser-Fluid Temperature Performance:
   1. Startup Condenser-Fluid Temperature: Chiller shall be capable of starting with an entering condenser-fluid temperature of 40 deg F and providing stable operation until the system temperature is elevated to the minimum operating entering condenser-fluid temperature
   2. Minimum Operating Condenser-Fluid Temperature: Chiller shall be capable of continuous operation over the entire capacity range indicated with an entering condenser-fluid temperature of 42 deg F.
   3. Make factory modifications to standard chiller design if necessary to comply with performance indicated.

B. Performance Tolerance: ~~Comply with the following: AHRI 550/590-2011~~.
   1. Allowable Capacity Tolerance: Zero percent.
   2. Allowable IPLV/NPLV Performance Tolerance: Zero percent.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. ~~Basis of Design~~Base Bid: Daikin Model WSC, including the standard product features and all special features as required per drawings and specifications.

B. Bid Alternate: Equipment manufactured by York (Johnson Control Company Model ~~-~~– YK, Trane (Model CVHF). These manufacturers with water-cooled condensers and variable-speed compressors are acceptable.
   1. Heat rejection penalty to be applied due to open drive. The Kw/Ton equal to the amount of heat rejection shall be added to the full load Kw/Ton in the NPLV calculation for each point of operation.

C. Other manufacturers with a similar product may be acceptable as an approved substitution provided they meet the following criteria:

1. Product is manufactured within the United States.
2. The product manufacturer has local representation within 50 miles of Orlando International Airport.
3. Manufacturer's representative must have been representing chiller product locally for a minimum of 2 year.
4. Equipment proposed "as an approved substitution", must meet the specifications including all architectural, mechanical, electrical, and structural details, all scheduled performance and the job design, plans and specifications.

2.2 UNIT DESCRIPTION

A. Base-Bid Chiller Description

1. Provide and install a factory assembled, charged, and tested water-cooled packaged centrifugal chiller. Factory assembled, single piece, liquid chiller shall consist of hermitically sealed compressor, motor, unit-mounted variable frequency drive, lubrication system, cooler, condenser, initial oil and refrigerant operating charges, microprocessor control system, and documentation required prior to start-up.

B. Each chiller shall be factory run-tested under load conditions for a minimum of one hour on an AHRI certified test stand with evaporator and condenser water flow at job conditions. Measure at the 4-points as scheduled on the plans per the efficiency calculations in the NPLV or CPLV. Operating controls shall be adjusted and checked. The refrigerant charge shall be adjusted for optimum operation and recorded on the unit nameplate. Any deviation in performance or operation shall be remedied prior to shipment and the unit retested if necessary to confirm repairs or adjustments. Manufacturer shall supply a certificate of completion of a successful run-test upon request.

2.3 DESIGN REQUIREMENTS

A. General: Provide a complete water-cooled, hermetic, centrifugal compressor water chiller utilizing traditional bearings and oil and is equipped with a variable speed drive as specified herein. The unit shall be provided according to standards indicated in Section 1.3.

B. Unit shall consist of one traditional bearing, with oil centrifugal compressors, refrigerant, condenser and evaporator, and control systems including integrated variable frequency drive, operating controls and equipment protection controls. Chiller shall be charged with refrigerant HFC-134A or HFC-514A. Manufacturers offering a chiller using any HCFC refrigerant, is not considered equivalent.

C. The entire chiller system, including all pressure vessels, shall remain above atmospheric pressure during all operating conditions and during shut down to ensure that non-condensables and moisture do not contaminate the refrigerant and chiller system.

D. Performance: Refer to chiller performance rating.

2.4 CHILLER COMPONENTS

A. Compressors:

1. The unit shall utilize hermetic centrifugal compressors. The compressor drive train shall be capable of coming to a controlled, safe stop in the event of a power failure.

2. The motor shall be of the hermetic type, of sufficient size to efficiently fulfill compressor horsepower requirements. It shall be liquid refrigerant cooled with internal thermal sensing devices in the stator windings. The motor shall be compatible with variable frequency drive operation.

   a. If the compressor design requires a shaft seal to contain the refrigerant, the manufacturer shall supply a 20 year parts and labor warranty on the shaft seal and a lifetime refrigerant replacement warranty if a seal failure leads to refrigerant loss, or the chiller manufacturer shall assume all costs to supply and install a self contained air conditioning system in the mechanical space sized to handle the maximum heat output the open drive motor. The energy required to operate this air conditioning system shall be added to the chiller power at all rating points for energy evaluation purposes.
   b. If the compressor/motor uses any form of antifriction bearing (roller, ball, etc), the chiller manufacturer shall provide the following at no additional charge:

      1) A 20-year bearing warranty and all preventative maintenance as specified by the manufacturer's published maintenance instructions.
      2) At start up a three-axis vibration analysis and written report to establish bearing condition baseline.
      3) An annual three-axis vibration analysis and written report indicating bearing condition.

3. The chiller shall be equipped with an integrated Variable Speed Drive (VSD) to automatically regulate compressor speed in response to cooling load and the compressor pressure lift requirement. Movable inlet guide vanes and variable compressor speed, shall provide unloading. The chiller controls shall coordinate compressor speed and guide vane position to optimize chiller efficiency.
4. Each compressor circuit shall be equipped with a line reactor to help protect against incoming power surges and help reduce harmonic distortion.
5. Chiller Motor: the chiller shall meet IEEE Standard 519 Total Demand Distortion limits at an Isc/IL ratio no greater than 20. Testing shall be performed and certified in accordance with IEEE per Manufacturer or an independent certified Electrical Testing Laboratory specialized in these tests.

B. Evaporator and Condenser:

1. The evaporator and condenser shall be separate vessels of the shell-and-tube type, designed, constructed, tested and stamped according to the requirements of the ASME Code, Section VIII. Regardless of the operating pressure, the refrigerant side of each vessel will bear the ASME stamp indicating compliance with the code and indicating a test pressure of 1.1 times the working pressure, but not less than 300 psig. For R-514a Pressure test fluid side of heat exchangers, including water boxes, to 1.5 times the rated pressure. Pressure proof test refrigerant side of heat exchangers, vacuum and pressure test for leaks. The tubes shall be individually replaceable and secured to the intermediate supports without rolling or expanding to facilitate replacement.
2. The evaporator shall be flooded type with 0.028 in. wall copper internally and externally enhanced tubes rolled into carbon steel tubesheets. The water side shall be designed for a minimum of 300 psig. The refrigerant side shall be designed for a minimum of 200 psi. ~~Provide intermediate tube supports at a maximum of 24 inch spacing~~ Tubes shall fit tightly into tubesheets and provide intermediate tube supports prevent crevice corrosion or chafing due to vibration. The heads shall be carbon steel and the tubes shall be ~~carbon steel~~copper. Water connections shall be grooved suitable for Victaulic couplings. The evaporator shall be equipped with marine waterboxes with ~~removable~~ hinged covers and vent and drain

connections. ~~The evaporator shall have right-hand connections when looking at the unit control panel~~Coordinate the evaporator connections with the plans and details.

3. The condenser shall have 0.028 in. wall copper internally and externally enhanced tubes rolled into carbon steel. Water connections shall be grooved suitable for Victaulic couplings. The water side shall be designed for a minimum of 150 psig. The refrigerant side shall be designed for a minimum of 200 psi. Tubes shall fit tightly into tubesheets and provide intermediate tube supports prevent crevice corrosion or chafing due to vibration.~~Provide intermediate tube supports at a maximum of 24 inch spacing.~~ The condenser shall be equipped with marine waterboxes with ~~removable~~ Hinged covers and vent and drain connections. Coordinate the evaporator connections with the plans and details.~~The condenser shall have right-hand connections when looking at the unit control panel.~~
4. The evaporator and condenser heads and tube sheets shall be epoxy coated, or be stainless steel construction, to meet the full life unit warranty.
5. Provide sufficient isolation valves and condenser volume to hold the full unit refrigerant charge in the condenser during servicing or the maintenance agreement shall include using ~~provide~~ a separate pumpout system and storage tank sufficient to hold the charge of the largest unit being furnished.
6. An electronic expansion valve shall control refrigerant flow to the evaporator. ~~Fixed orifice devices or float controls with hot gas bypass are not acceptable because of inefficient control at low load conditions.~~ Unit shall have stable control of machine capacity down to 20 percent of full load continuously without surge, cavitation, or undue vibration through the use of adjust valve position via control panel to optimize refrigerant level or speed reduction and without the use of hot gas bypass. The liquid line shall have moisture indicating sight glass.
7. Re-seating type spring loaded pressure relief valves according to ASHRAE-15 safety code shall be furnished. The evaporator shall be provided with single or multiple valves. The condenser shall be provided with dual relief valves equipped with a transfer valve so one relief valve can be removed for testing or replacement without loss of refrigerant or removal of refrigerant from the condenser. ~~Rupture disks are not acceptable.~~ If rupture disks are required on negative pressure units to prevent air and moisture ingress, then factory mounted spring loaded pressure relief valves shall be provided in series with the rupture disks to contain the remaining refrigerant in the event of vessel over-pressurization. The space between the rupture disk and the relief valve shall include a suitable telltale indicator integrated into the chiller control system to alert the operator that a potential safety issue exists in the pressure relief system.
8. The evaporator and condenser, including water heads, suction line, and any other component or part of a component subject to condensing moisture shall be insulated with UL recognized 2 inch closed cell insulation. All joints and seams shall be carefully sealed to form a vapor barrier.
9. The evaporator and condenser waterbox shall be insulated with UL recognized 2 inch closed cell insulation. All joints and seams shall be carefully sealed to form a vapor barrier.
10. Provide factory-mounted and wired, thermal-dispersion water flow switches on each vessel to prevent unit operation with no or low water flow. Paddle and pressure differential type switches are not acceptable due to high rates of failure and false indications from these types of flow indicators.

C. Vibration Isolation: Provide neoprene waffle-type vibration isolators for each corner of the unit.

D. Power Connections: Power connection shall be single point to a factory-mounted disconnect switch.

E. Chiller Control:

1. The unit shall have a microprocessor-based control system consisting of a 15-inch VGA touch-screen operator interface and a unit controller.

2. The touch-screen shall display the unit operating parameters, accept setpoint changes (multi-level password protected) and be capable of resetting faults and alarms. The following parameters shall be displayed on the home screen and also as trend curves on the trend screen:

   a. Entering and leaving chilled water temperatures
   b. Entering and leaving condenser water temperatures
   c. Evaporator saturated refrigerant Pressure
   d. Condenser saturated refrigerant pressure
   e. Percent of 100% speed (per compressor)
   f. % of rated load amps for entire unit

3. In addition to the trended items above, all other important real-time operating parameters shall also be shown on the touch-screen. These items shall be displayed on a chiller graphic showing each component. At a minimum, the following critical areas must be monitored:

   a. Compressor actual speed, maximum speed, percent speed
   b. Evaporator water in and out temperatures, refrigerant pressure and temperature
   c. Condenser water in and out temperatures, refrigerant pressure and temperature
   d. Liquid line temperature
   e. Chilled water setpoint
   f. Compressor and unit state and input and output digital and analog values

4. A fault history shall be displayed using an easy to decipher, color coded set of messages that are date and time stamped. Time interval scale shall be user selectable as 20 mins, 2 hours, or 8 hours. The alarm history shall be downloadable from the unit's USB port. An operating and maintenance manual specific for the unit shall be viewable on the screen.
5. All setpoints shall be viewable and changeable (multi-level password protected) on the touch screen and include setpoint description and range of set values.
6. Automatic corrective action to reduce unnecessary cycling shall be accomplished through preemptive control of low evaporator or high discharge pressure conditions to keep the unit operating through abnormal transient conditions.
7. Chiller shall be capable of starting with entering condenser water temperatures as low as 40°F (4.4°C). For short periods of time during startup, the chiller shall be able to operate with an entering condenser water temperature lower than the leaving chilled water temperature.
8. Chiller shall be capable of stable operation with varying evaporator flow rate down to the minimum value, and operate at a minimum capacity of 20%.
9. ~~Chiller plant optimization software for multiple chillers shall be provided including automatic control of: at least eight (8) chillers, evaporator and condenser pumps (primary and standby), up to 3 stages of cooling tower fan cycling control and a tower modulating bypass valve or cooling tower fan variable frequency drives.~~
9. Provide the Building Automation System contractor with performance points and parameters to operate Chiller Plant Optimization software. At no point shall the BAS override the chiller safeties or operate outside of the chiller manufacturer's selected design ranges.

10. The factory mounted controller(s) shall support operation on a BACnet® network via one of the data link / physical layers listed below as specified by the successful Building Automation System (BAS) supplier. All communication from the chiller unit controller as specified in the points list shall be via standard BACnet objects. Proprietary BACnet objects shall not be allowed. BACnet communications shall conform to the BACnet protocol (ANSI/ASHRAE135-2001). A BACnet Protocol Implementation Conformance Statement (PICS) shall be provided along with the unit submittal.

    a. BACnet MS/TP master (Clause 9)

b. BACnet IP, (Annex J)
c. BACnet ISO 8802-3, (Ethernet)

11. The information communicated between the BAS and the factory mounted unit controllers shall include the reading and writing of data to allow unit monitoring, control and alarm notification as specified in the unit sequence of operation and the unit points list.

F. VARIABLE SPEED DRIVE

1. A variable speed drive (VSD) shall be factory-installed on the chiller.
2. The VSD shall vary the compressor motor speed by controlling the frequency and voltage of the electrical power to the motor. Motor adaptive capacity control logic shall automatically adjust motor speed and compressor pre-rotation vane position independently for maximum part load efficiency by analyzing information fed to it by sensors located throughout the chiller.
3. Enclosure: Unit mounted, NEMA-1, with all power and control wiring between the drive and chiller factory-installed including power to the chiller oil pump. Field power wiring shall be a single point connection and electrical lugs for incoming power wiring shall be provided. The entire package shall be U.L. listed.
4. Integral Disconnecting Means: Door-interlocked, NEMA AB 1, instantaneous-trip circuit breaker capable of being padlocked. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 65,000.
5. Drive: Pulse width modulated (PWM) output with insulated gate bipolar transistors (IGBT) with a power factor of 0.95 or better at all loads and speeds.
6. Technology: Pulse width modulated (PWM) output with insulated gate bipolar transistors (IGBT); suitable for variable torque loads.
7. Controller shall consist of a rectifier converter section, a digital/analog driver regulator section, and an inverter output section.

   a. Rectifier section shall be a full-wave diode bridge that changes fixed-voltage, fixed-frequency, AC line power to a fixed dc voltage. Silicon controller rectifiers, current source inverters, and paralleling of devices are unacceptable. Rectifier shall be insensitive to phase rotation of the ac line.
   b. Regulator shall provide full digital control of frequency and voltage.
   c. Inverter section shall change fixed dc voltage to variable-frequency, variable ac voltage, for application to a squirrel-cage motor. Inverter shall produce a sine-coded, pulse width modulated (PWM) output wave form and shall conduct no radio-frequency interference back to the input power supply.

8. Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.
9. Operating Requirements:

   a. Input AC Voltage Tolerance: 460-V ac, plus 10 percent or 506 V maximum.
   b. Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
   c. Capable of driving full load, without derating, under the following conditions:

      1) Ambient Temperature: 0 to 50 deg C.
      2) Relative Humidity: Up to 95 percent (noncondensing).
      3) Altitude: Sea level.

d. Minimum Efficiency: 96 percent at 60 Hz, full load.
e. Minimum Displacement Primary-Side Power Factor: 95 percent without harmonic filter, 98 percent with harmonic filter.
f. Overload Capability: 1.05 times the full-load current for 7 seconds.
g. Starting Torque: As required by compressor-drive assembly.
h. Speed Regulation: Plus or minus 1 percent.
i. Isolated control interface to allow controller to follow control signal over a 10:1 speed range.
j. To avoid equipment resonant vibrations, provide critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.
k. Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.

10. Internal Adjustability Capabilities:

a. Minimum Output Frequency: 6 Hz.
b. Maximum Output Frequency: 60 Hz.
c. Acceleration: 2 seconds to a minimum of 60 seconds.
d. Deceleration: 2 seconds to a minimum of 60 seconds.
e. Current Limit: 30 percent to a minimum of 100 percent of maximum rating.

11. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or the need for replacement:

a. Overtemperature.
b. Short circuit at controller output.
c. Ground fault at controller output. Variable frequency controller shall be able to start a grounded motor.
d. Open circuit at controller output.
e. Input undervoltage.
f. Input overvoltage.
g. Loss of input phase.
h. Reverse phase.
i. AC line switching transients.
j. Instantaneous overload, line to line or line to ground.
k. Sustained overload exceeding 100 percent of controller rated current.
l. Starting a rotating motor.

12. Motor Protection:

a. UL listed ground fault protection.
b. Overvoltage and Undervoltage protection.
c. 3-phase sensing motor overcurrent protection.
d. Single phase protection.
e. Insensitive to phase rotation.
f. Overtemperature protection.
g. Phase loss protection.
h. Reverse phase protection.

13. Automatic Reset and Restart: Capable of three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Controller shall be capable of automatic restart on phase-loss and overvoltage and undervoltage trips.
14. Visual Indication: On face of controller enclosure or chiller control enclosure; indicating the following conditions:

a. Power on.
b. Run.
c. Overvoltage.
d. Line fault.
e. Overcurrent.
f. External fault.
g. Motor speed (percent).
h. Fault or alarm status (code).
i. DC-link voltage.
j. Motor output voltage.
k. Input kilovolt amperes.
l. Total power factor.
m. Input kilowatts.
n. Input kilowatt-hours.
o. Three-phase input voltage.
p. Three-phase output voltage.
q. Three-phase input current.
r. Three-phase output current.
s. Three-phase input voltage total harmonic distortion~~.~~ (when included in the drive).
t. Three-phase input current total harmonic distortion (when included in the drive).
u. Output frequency (Hertz).
v. Elapsed operating time (hours).
w. Self-Diagnostic and service parameters.

15. Operator Interface: At controller or chiller control panel; with start-stop and auto-manual selector with manual-speed-control potentiometer.
16. Control Signal Interface:

    a. Electric Input Signal Interface: A minimum of two analog inputs (0 to 10 V or 0/4-20 mA) and six programmable digital inputs.

17. Cooling: Closed loop, fresh water circuit consisting of a water-to-water heat exchanger and circulating pump. All interconnecting water piping is factory installed and rated for 150 psig working pressure.
18. Accessories: Devices shall be factory installed in controller enclosure unless otherwise indicated.

    a. 1. Control Relays: Auxiliary and adjustable time-delay relays.

19. Chiller Capacity Control Interface: Equip chiller with adaptive control logic to automatically adjust the compressor motor speed and the compressor pre-rotation inlet vane position independently to achieve maximum part-load efficiency in response to sensor inputs that are integral to the chiller controls.

B. ACTIVE HARMONIC FILTER FOR VARIABLE FREQUENCY DRIVE CHILLERS

1. A harmonic filter that limits electrical power supply distortion for the variable frequency drive to comply with the guidelines of IEEE Std. 519-1992 shall be provided if required to meet the standard. The filter shall be unit mounted within the same NEMA-1 enclosure and shall be UL listed. The following digital readouts shall be provided at the chiller unit control panel or at the filter control panel as part of the filter package; input KVA, total power factor, 3 phase input voltage, 3 phase input current, 3 phase input voltage total harmonic distortion (THD), 3 phase current total demand distortion (TDD), self diagnostic service parameters. Total Harmonic Current Distortion shall be less than 5% at the lugs of the VFD circuit breaker.

2. Acceptable Manufacturers: Power Correction Systems, Inc., Mesta Electronics, Inc., Toshiba Corporation, York International.

2.5. INSULATION

A. Where ~~Provide~~ factory installed thermal insulation is not available to meet the requirements of 2.4.B.8, ~~to prevent moisture condensation on all low temperature surfaces including the evaporator, compressor motor housing, water boxes, suction elbow, economizer, purge chamber and associated piping. Th~~provide field applied~~e~~ insulation ~~shall be 1 1/2 inch thick~~, cellular glass (~~elastomeric sheet insulation~~Foamglas), complying with the requirements listed in Section 23 07 00, HVAC Insulation.

2.6 FINISH

A. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:

1. Provide at least one coat of primer with a total dry film thickness of at least 2 mils.
2. Provide at least two coats of alkyd-modified, vinyl enamel finish with a total dry film thickness of at least 4 mils.
3. Paint surfaces that are to be insulated before applying the insulation.
4. Paint installed insulation to match adjacent uninsulated surfaces.
5. Color of finish coat to be manufacturer's standard.

B. Provide Owner with quart container of paint used in application of topcoat to use in touchup applications after Project Closeout.

2.7 SOURCE QUALITY CONTROL

A. Factory performance test chillers, before shipping, according to AHRI 550/590.

1. Test the following conditions:

a. Reduction in capacity from design to minimum load in steps of 25% with ~~varying entering~~constant condenser-fluid temperature. ~~from design to minimum conditions in 5 deg F increments.~~
   1) Use a reduction in entering evaporator temperature when minimum evaporator flow is met to match the percentage load reduction.

~~a.~~b. Reduction in capacity from design to minimum load, resetting leaving evaporator temperature up from design in increments of ~~2~~6 degrees F.

2. Allow Owner access to place where chillers are being tested. Notify Architect 30 days in advance of testing.
3. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.
4. Performance Test Witnessing: Provide accommodations, including travel, meals and lodging expenses, for the Owner and Design Engineer to witness the chiller performance testing in the factory.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine chillers before installation. Reject chillers that are damaged.

B. Examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, and electrical connections to verify actual locations, sizes, and other conditions affecting chiller performance, maintenance, and operations before equipment installation.

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

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

3.2 UNIT PLACEMENT

A. Field Verification: Locations shall be essentially as shown on drawings; however, actual placement shall be verified using field measurements and data relating to equipment used for actual installation.

B. Field Supplied Equipment: All field supplied wires, bus bars and fittings shall be copper only.

C. Install per manufacturer's requirements, shop drawings, and contract documents.

D. Adjust chiller alignment on foundations, or sub bases as called for on drawings.

E. Arrange piping to allow for dismantling to permit head removal and tube cleaning.

F. Coordinate electrical installation with electrical contractor.

G. Coordinate controls with control contractor.

H. Provide all material required for a fully operational and functional chiller.

3.3 EQUIPMENT SUPPORT

A. General: Refer to Section 23 00 10 Basic HVAC Requirements.

B. Equipment Mounting: Install chiller on concrete bases using elastomeric pads. Comply with requirements for concrete bases specified in Division 03 Section "Miscellaneous Cast-in-Place Concrete." Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration and Seismic Controls for HVAC."

1. Minimum Deflection: 1/4 inch.
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 supported equipment.

3.4 Provide mechanical equipment with vibration isolation according to Specification 23 05 48 Vibration Controls for HVAC, refer to the following schedule:

EQUIPMENT	ISOLATOR TYPE
Chiller	H

3.5 PIPING

A. Piping Connections: Piping connections to the nozzles of the evaporator and condenser shall have provisions for removal to provide unobstructed access for cleaning and replacing tubes.

B. Piping Auxiliaries: Install in the piping for each chiller:

1. Thermometers with separable sockets in entering and leaving water to the evaporator and condenser.
2. Pressure gauge with gauge valves in the entering and leaving water to the evaporator and condenser.
3. Valved 1/2 inch connections in the entering and leaving water to the evaporator and condenser for differential pressure switch connection.
4. Manual air vents and drains on all heads of water boxes.

C. Relief Connections: Pipe relief valve discharge full size of connections to the exterior. Connect the discharge from the relief valves to the relief line using Type PVT-1 flexible pipe connectors as specified in Section 230548 Vibration and Seismic Controls for HVAC.

3.6 REFRIGERANT

A. General: Provide initial charge of refrigerant, and any additional refrigerant and charging devices required to replace losses during checkout, startup, and system testing prior to final acceptance. Log all quantities of refrigerant or oil entered into the machines.

B. Moisture Indicators: Provide bulls-eye moisture indicators on each refrigerant liquid line to the filter/dryers.

3.7 SPARE PARTS

A. Maintenance Items: Provide to the Owner prior to final completion and in original packaging the following:

1. Replacement evaporator and condenser water barrel head gaskets, one for each removable head.
2. One jointed tube rodding brush with handle and sufficient sections to rod the full length of the chiller tubes.
3. Six each evaporator and condenser tube brushes, compatible with the joined rod above.

3.8 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. Verify that refrigerant charge is sufficient and chiller has been leak tested.
3. Verify that pumps are installed and functional.
4. Verify that thermometers and gages are installed.
5. Operate chiller for run-in period.
6. Verify proper motor rotation.
7. Verify static deflection of vibration isolators, including deflection during chiller startup and shutdown.
8. Verify and record performance of fluid flow and low-temperature interlocks for evaporator and condenser .
9. Verify and record performance of chiller protection devices.
10. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

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

C. Prepare test and inspection startup reports.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain chillers. Video record the training sessions.

END OF SECTION 23 64 16

SECTION 236423 - SCROLL WATER CHILLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

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

1.3 ACTION SUBMITTALS

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

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

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

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

1.4 INFORMATIONAL SUBMITTALS

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

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

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

C. Source quality-control test reports.

D. Startup service reports.

E. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

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

1.6 QUALITY ASSURANCE

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

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

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

D. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

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

F. Comply with NFPA 70.

1.7 DELIVERY, STORAGE, AND HANDLING

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

B. Package water chiller for export shipping.

1.8 COORDINATION

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

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

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.9 WARRANTY

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

1. Compressor Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PACKAGED AIR-COOLED WATER CHILLERS

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

1. Carrier Corporation; a United Technologies company.
2. Daikin Applied
3. McQuay International.
4. Trane.
5. York (Johnson Control Company)

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

C. Cabinet:

1. Base: Galvanized-steel base extending the perimeter of water chiller. Secure frame, compressors, and evaporator to base to provide a single-piece unit.
2. Frame: Rigid galvanized-steel frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components not directly supported from base.
3. Casing: Galvanized steel.
4. Finish: Coat base, frame, and casing with a corrosion-resistant coating capable of withstanding a 500-hour salt-spray test according to ASTM B 117.
5. Sound-reduction package consisting of the following:

    a. Acoustic enclosure around compressors.
    b. Reduced-speed fans with acoustic treatment.
    c. Designed to reduce sound level without affecting performance.

D. Compressors:

1. Description: Positive-displacement direct drive with hermetically sealed casing.
2. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.
3. Operating Speed: Nominal 3600 rpm for 60-Hz applications.
4. Capacity Control: On-off compressor cycling, plus hot-gas bypass.
5. Oil Lubrication System: Automatic pump with strainer, sight glass, filling connection, filter with magnetic plug, and initial oil charge.

E. Compressor Motors:

1. Hermetically sealed and cooled by refrigerant suction gas.
2. High-torque, two-pole induction type with inherent thermal-overload protection on each phase.

F. Compressor Motor Controllers:

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

G. Refrigeration:

1. Refrigerant: R-410a. Classified as Safety Group A1 according to ASHRAE 34.
2. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
3. Refrigerant Circuit: Each circuit shall include a thermal-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
4. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid-line to allow the isolation and storage of the refrigerant charge in the chiller condenser.

H. Evaporator:

1. Brazed Plate:

a. Direct-expansion, single-pass, brazed-plate design.
b. Type 316 stainless-steel construction.
c. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
d. Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.

2. Heater: Factory-installed and -wired electric heater with integral controls designed to protect the evaporator to minus 20 deg F (minus 29 deg C).
3. Remote Mounting: Designed for remote field mounting where indicated. Provide kit for field installation.

I. Air-Cooled Condenser:

1. Plate-fin coil with integral subcooling on each circuit, rated at 450 psig (3103 kPa).

a. Construct coils of copper tubes mechanically bonded to aluminum fins.
b. Coat coils with a baked epoxy corrosion-resistant coating after fabrication.
c. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.

2. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.
3. Fan Motors: Totally enclosed nonventilating (TENV) or totally enclosed air over (TEAO) enclosure, with permanently lubricated bearings, and having built-in overcurrent- and thermal-overload protection.
4. Fan Guards: Steel safety guards with corrosion-resistant coating.

J. Electrical Power:

1. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to water chiller.
2. Install factory wiring outside of an enclosure in a raceway.
3. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:

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

4. Provide each motor with overcurrent protection.
5. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.

6. Phase-Failure and Undervoltage: Solid-state sensing with adjustable settings.
7. Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.

   a. Power unit-mounted controls where indicated.

8. Control Relays: Auxiliary and adjustable time-delay relays.
9. Indicate the following for water chiller electrical power supply:

   a. Current, phase to phase, for all three phases.
   b. Voltage, phase to phase and phase to neutral for all three phases.
   c. Three-phase real power (kilowatts).
   d. Three-phase reactive power (kilovolt amperes reactive).
   e. Power factor.
   f. Running log of total power versus time (kilowatt hours).
   g. Fault log, with time and date of each.

K. Controls:

1. Stand-alone, microprocessor based.
2. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.
3. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, backlit, liquid-crystal display or light-emitting diodes. Display the following:

   a. Date and time.
   b. Operating or alarm status.
   c. Operating hours.
   d. Temperature and pressure of operating set points.
   e. Entering and leaving temperatures of chilled water.
   f. Refrigerant pressures in evaporator and condenser.
   g. Saturation temperature in evaporator and condenser.
   h. No cooling load condition.
   i. Elapsed time meter (compressor run status).
   j. Antirecycling timer status.
   k. Percent of maximum motor amperage.
   l. Current-limit set point.
   m. Number of compressor starts.

4. Control Functions:

   a. Manual or automatic startup and shutdown time schedule.
   b. Entering and leaving chilled-water temperatures, control set points, and motor load limit. Current limit and demand limit.
   c. External water chiller emergency stop.
   d. Antirecycling timer.

5. Manual-Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:

    a. Low evaporator pressure or high condenser pressure.
    b. Low chilled-water temperature.
    c. Refrigerant high pressure.
    d. High or low oil pressure.
    e. High oil temperature.
    f. Loss of chilled-water flow.
    g. Control device failure.

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

    a. ASHRAE 135 (BACnet) or LonTalk interface communication interface with building automation system shall enable building automation system operator to remotely control and monitor the water chiller from an operator workstation. Control features and monitoring points displayed locally at water chiller control panel shall be available through building automation system.

L. Insulation:

1. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I, for tubular materials and Type II, for sheet materials.
2. Thickness: 1-1/2 inches (38 mm).
3. Factory-applied insulation over cold surfaces of water chiller components.

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

4. Apply protective coating to exposed surfaces of insulation.

M. Accessories:

1. Factory-furnished, chilled-water flow switches for field installation.
2. Individual compressor suction and discharge pressure gages with shutoff valves for each refrigeration circuit.

2.2 SOURCE QUALITY CONTROL

A. Perform functional test of water chillers before shipping.

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

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

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

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

3.2 WATER CHILLER INSTALLATION

A. Install water chillers on support structure indicated.

B. Equipment Mounting:

1. Install water chillers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Division 03.
2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

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

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

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

3.3 CONNECTIONS

A. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 “Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

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

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

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

3.4 STARTUP SERVICE

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

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

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

1. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
2. Verify that pumps are installed and functional.
3. Verify that thermometers and gages are installed.
4. Operate water chiller for run-in period.
5. Check bearing lubrication and oil levels.
6. Verify proper motor rotation.
7. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
8. Verify and record performance of chilled-water flow and low-temperature interlocks.
9. Verify and record performance of water chiller protection devices.
10. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

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

3.5 DEMONSTRATION

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

END OF SECTION 236423

SECTION 236500 – PACKAGED COOLING TOWERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Requirements Division 01, Division 23 Specification Sections, and Common Work Requirements for HVAC apply to the work specified in this Section.

1.2 SUMMARY

A. Section Includes:
   1. Open-circuit, forced-draft, counterflow cooling towers.
   2. Open-circuit, induced-draft, counterflow cooling towers.
   3. Open-circuit, induced-draft, crossflow cooling towers.
   4. Basin water level controls.
   5. Winterization system.

1.3 DEFINITIONS

A. BMS: Building management system.

B. FRP: Fiber-reinforced polyester.

1.4 PERFORMANCE REQUIREMENTS

A. Structural Performance: Cooling tower support structure shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated according to SEI/ASCE 7.

B. Seismic Performance: Cooling towers shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.5 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, pressure drop, fan performance data, rating curves with selected points indicated, materials of construction, furnished specialties, and accessories.

   1. Maximum flow rate.
   2. Minimum flow rate.

3. Drift loss as percent of design flow rate.
4. Sound power levels in eight octave bands for operation with fans off, fans at minimum, and design speed.
5. Performance curves for the following:

    a. Varying entering-water temperatures from design to minimum.
    b. Varying ambient wet-bulb temperatures from design to minimum.
    c. Varying water flow rates from design to minimum.
    d. Varying fan operation (off, minimum, and design speed).

6. Fan airflow, brake horsepower, and drive losses.
7. Motor amperage, efficiency, and power factor at 100, 75, 50, and 25 percent of nameplate horsepower.
8. Electrical power requirements for each cooling tower component requiring power.

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

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

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

D. Seismic Qualification Certificates: For cooling towers, accessories, and components, from manufacturers.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Source quality-control reports.

F. Field quality-control reports.

G. Startup service reports.

H. Operation and Maintenance Data: For each cooling tower to include in emergency, operation, and maintenance manuals. Include start-up instructions, maintenance data, parts lists, controls, accessories, and trouble-shooting guide.

I. Warranty: Sample of special warranty.

1.6 CODES AND STANDARDS

A. American Society of Mechanical Engineers (ASME).

1. Boiler and Pressure Vessel Code, Section VIII, Division 1, "Rules for Construction of Pressure Vessels."
2. Performance Test Code PTC 23, "Atmospheric Water Cooling Equipment."

B. Cooling Technology Institute (CTI).

1. Standard 201, "Standard for the Certification of Water-Cooling Tower Thermal Performance."
2. Acceptance Test Code ATC 105, "Acceptance Test Code for Water Cooling Towers."

C. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).

1. Standard 90.1, "Energy Standard for Building Except Low-Rise Residential Buildings."

D. National Fire Protection Association (NFPA).

1. Standard 70, "National Electrical Code."

E. American National Standards Institute (ANSI).

F. American Society for Testing and Materials (ASTM).

G. Institute of Electrical and Electronics Engineers (IEEE).

H. National Electrical Manufacturers Association (NEMA).

I. Factory Mutual (FM).
1. Property Loss Prevention Data Sheet 1-6 with April 2017 Interim Revisions

J. Underwriters Laboratories (UL).

1.7 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

C. ASME Compliance: Fabricate and label heat-exchanger coils to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

D. CTI Certification: Cooling tower thermal performance according to CTI STD 201, "Certification Standard for Commercial Water-Cooling Towers Thermal Performance."

E. FMG approval and listing in the latest edition of FMG's "Approval Guide."

1.8 DELIVERY, STORAGE, AND HANDLING

A. Factory assemble entire unit. For shipping, disassemble into as large as practical sub-assemblies so that minimum amount of field work is required for reassembly.

B. Ship cooling towers equipped with gear drives with a full charge of oil.

C. Ship each cooling tower with a firmly attached stainless steel nameplate indicating name of manufacturer and model number.

D. Reject and damaged cooling tower equipment upon arrival at the site.

E. Store cooling tower equipment to prevent damage, and protect from weather, dirt, fumes, water and construction debris. Provide a clean, dry space for storage if one is not available at the site.

F. Handle cooling tower equipment according to the manufacturer’s rigging and installation instructions for unloading and transporting into the final location.

1.9 COORDINATION

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

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace the following components of cooling towers that fail in materials or workmanship within specified warranty period:
   1. All components of cooling tower.
   2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 OPEN-CIRCUIT, FORCED-DRAFT, COUNTERFLOW COOLING TOWERS

A. Products: Subject to compliance with requirements, provide one of the following products that may be incorporated into the Work include, but are not limited to, the following:

   1. Tower Tech, Inc.

B. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.

C. Cooling tower designed to resist wind load of 110 mph.

D. Casing and Frame:

   1. Casing Material: FRP with UV inhibitors or Stainless steel.
   2. Frame Material: FRP with UV inhibitors or Stainless steel.

3. Fasteners: Stainless steel.
4. Joints and Seams: Sealed watertight.
5. Welded Connections: Continuous and watertight.

E. Collection Basin:

1. Material: FRP with UV inhibitors or Stainless steel.
2. Strainer: Removable stainless-steel strainer with openings smaller than nozzle orifices.
3. Overflow and drain connections.
4. Makeup water connection.
5. Basin Sweeper Distribution Piping and Nozzles:

    a. Pipe Material: PVC.
    b. Nozzle Material: Plastic.
    c. Configure piping and nozzles to minimize sediment from collecting in the collection basin.

F. Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve:

1. Enclosure: NEMA 250, Type 4.
2. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to provide control of water makeup valve and low- and high-level alarms.
3. Electrode Probes: Stainless steel.
4. Water Stilling Chamber: Corrosion-resistant material.
5. Solenoid Valve: Slow closing, controlled and powered through level controller in response to water-level set point.
6. Electrical Connection Requirements: 120 V, single phase, 60 Hz.

G. Pressurized Water Distribution Piping: Main header and lateral branch piping designed for even distribution over heat-exchanger coil or fill throughout the flow range without the need for balancing valves and for connecting individual, removable, nonclogging spray nozzles.

1. Pipe Material: PVC.
2. Spray Nozzle Material: Plastic.
3. Piping Supports: Corrosion-resistant hangers and supports to resist movement during operation and shipment.

H. Fill:

1. Materials: PVC, with maximum flame-spread index of 5 according to ASTM E 84.
2. Fabrication: Fill-type sheets, fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.
3. Fill Material Operating Temperature: Suitable for entering-water temperatures up through 120 deg F.

I. Removable Drift Eliminator:

1. Material: FRP or PVC; with maximum flame-spread index of 5 according to ASTM E 84.
2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.

3. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.

J. Removable Air-Intake Screens: Stainless-steel wire mesh.

K. Axial Fan: Balanced at the factory after assembly.

1. Blade Material: FRP.
2. Hub Material: Aluminum.
3. Blade Pitch: Field adjustable.
4. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens complying with OSHA regulations.
5. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F. Bearings designed for an L-10 life of 50,000 hours.
6. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.

L. Direct Drive: Fan hub directly connected, and properly secured, to motor shaft.

M. Fan Motor:

1. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Division 23 Section "Common Motor Requirements for HVAC Equipment" and not indicated below.
2. Motor Enclosure: Totally enclosed air over (TEAO).
3. Energy Efficiency: Comply with ASHRAE/IESNA 90.1.
4. Service Factor: 1.15.
5. Insulation: Class F.
6. Variable-Speed Motors: Inverter-duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
7. Severe-duty rating with the following features:

   a. Rotor and stator protected with corrosion-inhibiting epoxy resin.
   b. Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and 300 deg F.
   c. Internal heater automatically energized when motor is de-energized.

8. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.

N. Vibration Switch: For each fan drive.

1. Enclosure: NEMA 250, Type 4X.
2. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
3. Provide switch for field connection to a BMS and hardwired connection to fan motor electrical circuit.
4. Switch shall, on sensing excessive vibration, signal an alarm through the BMS and shut down the fan.

O. Controls: Comply with requirements in Division 23 Section "Instrumentation and Control for HVAC."
   1. Factory-installed and -wired, collection basin electric/electronic level controller.
   2. Collection basin electric/electronic level controller complying with requirements in "Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve" Paragraph.
   3. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
   4. Single-point, field-power connection to a disconnect switch rated for system short circuit capacity.
      a. Branch power circuit to each motor and to controls with a disconnect switch or circuit breaker.
      b. NEMA-4X rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller with manual bypass and line reactors for each variable-speed motor indicated.
   5. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.
   6. Visual indication of status and alarm with momentary test push button for each motor.
   7. Cooling tower shall have hardware to enable BMS to remotely monitor and display the following:
      a. Operational status of each motor.
      b. Cooling tower leaving-fluid temperature.
      c. Fan vibration alarm.
      d. Collection basin high- and low-water-level alarms.

P. Capacities and Characteristics:
   1. As scheduled on drawings.

2.2 OPEN-CIRCUIT, INDUCED-DRAFT, COUNTERFLOW COOLING TOWERS

A. Products: Subject to compliance with requirements, provide one of the following products that may be incorporated into the Work include, but are not limited to, the following:
   1. Delta Cooling Towers, Inc.
   2. Evapco Inc.

B. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.

C. Cooling tower designed to resist wind load of 30 lbf/sq. ft..

D. Casing and Frame:
   1. Casing and Frame Material: 304 grade Stainless steel.
   2. Fasteners: 304 Grade Stainless steel.

3. Joints and Seams: Sealed watertight.
4. Welded Connections: Continuous and watertight.

E. Collection Basin:

1. Material: 316 Grade Stainless steel, fully welded.
2. Strainer: Removable stainless-steel strainer with openings smaller than nozzle orifices.
3. Overflow and drain connections.
4. Makeup water connection.
5. Outlet Connection: ASME B16.5, Class 150 flange.
6. Equalizer connection for field-installed equalizer piping.
7. Basin Sweeper Distribution Piping and Nozzles:

   a. Pipe Material: PVC.
   b. Nozzle Material: Plastic.
   c. Configure piping and nozzles to minimize sediment from collecting in the collection basin.

F. Electric/Electronic, Collection Basin Water-Level Controller:

1. Enclosure: NEMA 250, Type 4X.
2. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to provide low, low-low, high and high-high-level alarms to the BMS
3. Electrode Probes: Stainless steel.
4. Water Stilling Chamber: Corrosion-resistant material.
5. Electrical Connection Requirements: 120 V, single phase, 60 Hz.

G. Pressurized Water Distribution Piping: Main header and lateral branch piping designed for even distribution over heat-exchanger coil or fill throughout the flow range without the need for balancing valves and for connecting individual, removable, nonclogging spray nozzles.

1. Pipe Material: PVC.
2. Spray Nozzle Material: Plastic.
3. Piping Supports: 304 Grade stainless steel ~~Corrosion-resistant~~ hangers and supports to resist movement during operation and shipment.

H. Fill:

1. Materials: PVC, resistant to rot, decay, and biological attack; with maximum flame-spread index of 5 according to ASTM E 84.
2. Fabrication: Fill-type sheets, fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.
3. Fill Material Operating Temperature: Suitable for entering-water temperatures up through 120 deg F.

I. Removable Drift Eliminator:

1. Material: FRP or PVC; resistant to rot, decay, and biological attack; with maximum flame-spread index of 5 according to ASTM E 84.
2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.

3. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.
~~3.~~4. Maximum drift loss shall be 0.005% of circulating flow

J. Air-Intake Louvers:

1. Material: PVC.
2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
3. Louver Blades: Arranged to uniformly direct air into cooling tower, to minimize air resistance, and to prevent water from splashing out of tower during all modes of operation including operation with fans off.

K. Removable Air-Intake Screens: Stainless-steel wire mesh.

L. Axial Fan: Balanced at the factory after assembly.

1. Blade Material: FRP or heavy duty aluminum alloy.
2. Hub Material: FRP or heavy duty aluminum alloy.
~~2.~~3. Fan Shaft: 304 Grade stainless steel.
~~3.~~4. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens, complying with OSHA regulations.
~~4.~~5. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F. Bearings designed for an L-10 life of 50,000 hours.
~~5.~~6. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.

M. Belt Drive:

1. Service Factor: 1.5 based on motor nameplate horsepower.
2. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
   a. Belt: One-piece, multigrooved, solid-back belt.
   b. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
   c. Belt-Drive Guard: Comply with OSHA regulations.

N. Gear Drive: Right angle, reduced speed, and designed for cooling tower applications according to CTI STD 111. Motor and gear drive shall be aligned before shipment.

1. Gear Drive and Coupling Service Factor: 2.0 based on motor nameplate horsepower.
2. Housing: Cast iron, with epoxy or polyurethane finish, beveled high-strength steel gears continuously bathed in oil, and with lubrication to other internal parts at all operating speeds.
3. Mounting: Directly mounted to fan hub and connected to motor so motor shaft is in horizontal position.
4. Operation: Able to operate both forward and in reverse.
5. Drive-to-Motor Connection: Close coupled to motor using a flexible coupling.
6. Extend oil fill, drain, and vent to outside of cooling tower casing using galvanized-steel piping. Provide installation with oil-level sight glass.

~~N.~~O. Fan Motor:

1. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Division 23 Section "Common Motor Requirements for HVAC Equipment" and not indicated below.
2. Motor Enclosure: Totally enclosed air over (TEAO) or Totally enclosed fan cooled (TEFC).
3. Energy Efficiency: Comply with ASHRAE/IESNA 90.1.
4. Service Factor: 1.15.
5. Insulation: Class F.
6. Variable-Speed Motors: Inverter-duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
7. Severe-duty rating with the following features:
    a. Rotor and stator protected with corrosion-inhibiting epoxy resin.
    b. Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F.
    c. Internal heater automatically energized when motor is de-energized.
8. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.

~~O.~~P. Fan Discharge Stack: Material shall match casing,

1. Stack Termination: Wire-mesh, galvanized-steel screens; complying with OSHA regulations.

~~P.~~Q. Vibration Switch: For each fan drive.

1. Enclosure: NEMA 250, Type 4X.
2. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
3. Provide switch with manual-reset button for field connection to a BMS and hardwired connection to fan motor electrical circuit.
4. Switch shall, on sensing excessive vibration, signal an alarm through the BMS and shut down the fan.

~~Q.~~R. Controls: Comply with requirements in Division 23 Section "Instrumentation and Control for HVAC."

1. Collection basin level controller complying with requirements in "Electric/Electronic, Collection Basin Water-Level Controller" Paragraph.
2. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
3. Cooling tower shall have hardware to enable BMS to remotely monitor and display the following:
    a. Operational status of each motor.
    b. Cooling tower leaving-fluid temperature.
    c. Fan vibration alarm.
    d. Collection basin low-low, low, high, high-high-water-level alarms..

~~R.~~S. Personnel Access Components:

1. Doors: Large enough for personnel to access cooling tower internal components from both cooling tower end walls. Doors shall be operable from both sides of the door.

~~1.~~2. Access stairs and platforms to tower basin level and fan deck level is furnished and installed by contractor external to tower scope of supply.
~~2.~~3. ~~External Ladders with Safety Cages: Aluminum, galvanized- or stainless-steel, fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.~~
~~3. External Platforms with Handrails: Aluminum, FRP, or galvanized-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.~~
4. Handrail for fan deck perimeter only: Aluminum, galvanized steel, or stainless steel complete with kneerail and toeboard, around top of cooling tower. Comply with 29 CFR 1910.23.
5. Internal Platforms: Aluminum, FRP, or galvanized-steel bar grating.

   a. Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall be elevated so that all parts are above the high water level of the collection basin.
   b. Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach from collection basin platform.

~~S.~~T. Capacities and Characteristics:

1. As scheduled on drawings.

2.3 OPEN-CIRCUIT, INDUCED-DRAFT, CROSSFLOW COOLING TOWERS

A. Products: Subject to compliance with requirements, provide one of the following products that may be incorporated into the Work include, but are not limited to, the following:

1. Baltimore Aircoil Company.
2. Evapco, Inc.
3. Marley Cooling Technologies; an SPX Corporation.

B. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.

C. Cooling tower designed to resist wind load of 30 lbf/sq. ft..

D. Casing and Frame:

1. Casing and Frame Material: 304 Grade Stainless steel.
2. Fasteners: 304 Grade Stainless steel.
3. Joints and Seams: Sealed watertight.
4. Welded Connections: Continuous and watertight.

E. Collection Basin:

1. Material: 316 Grade Stainless steel, fully welded.
2. Strainer: Removable stainless-steel strainer with openings smaller than nozzle orifices.
3. Overflow and drain connections.
4. Makeup water connection.
5. Outlet Connection: ASME B16.5, Class 150 flange.
6. Equalizer connection for field-installed equalizer piping.
7. Basin Sweeper Distribution Piping and Nozzles:
   a. Pipe Material: PVC.
   b. Nozzle Material: Plastic.
   c. Configure piping and nozzles to minimize sediment from collecting in the collection basin.

F. Electric/Electronic, Collection Basin Water-Level Controller:

1. Enclosure: NEMA 250, Type 4X.
2. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to provide low, low-low, high and high-high-level alarms to the BMS
3. Electrode Probes: Stainless steel.
4. Water Stilling Chamber: Corrosion-resistant material.
5. Electrical Connection Requirements: 120 V, single phase, 60 Hz.

G. Pressurized Water Distribution Piping: Main header and lateral branch piping designed for even distribution over heat-exchanger coil or fill throughout the flow range without the need for balancing valves and for connecting individual, removable, nonclogging spray nozzles.

1. Pipe Material: PVC.
2. Spray Nozzle Material: Plastic.
3. Piping Supports: 304 Grade stainless steel~~Corrosion-resistant~~ hangers and supports to resist movement during operation and shipment.

H. Fill:

1. Materials: PVC, resistant to rot, decay, and biological attack; with maximum flame-spread index of 5 according to ASTM E 84.
2. Fabrication: Fill-type sheets, fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.
3. Fill Material Operating Temperature: Suitable for entering-water temperatures up through 120 deg F.

I. Removable Drift Eliminator:

1. Material: FRP or PVC; resistant to rot, decay, and biological attack; with maximum flame-spread index of 5 according to ASTM E 84.
2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
3. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.
~~3.~~4. Maximum drift loss shall be 0.005% of circulating flow.

J. Air-Intake Louvers:

1. Material: PVC.
2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
3. Louver Blades: Arranged to uniformly direct air into cooling tower, to minimize air resistance, and to prevent water from splashing out of tower during all modes of operation including operation with fans off.

K. Removable Air-Intake Screens: Stainless-steel wire mesh.

L. Axial Fan: Balanced at the factory after assembly.

1. Blade Material: FRP or heavy duty aluminum alloy.
2. Hub Material: FRP or heavy grade aluminum alloy.
~~2.~~3. Fan shaft: 304 Grade stainless steel.
~~3.~~4. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens, complying with OSHA regulations.
~~4.~~5. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F. Bearings designed for an L-10 life of 50,000 hours.
~~5.~~6. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.

M. Belt Drive:

1. Service Factor: 1.5 based on motor nameplate horsepower.
2. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
   a. Belt: One-piece, multigrooved, solid-back belt.
   b. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
   c. Belt-Drive Guard: Comply with OSHA regulations.

N. Gear Drive: Right angle, reduced speed, and designed for cooling tower applications according to CTI STD 111. Motor and gear drive shall be aligned before shipment.

1. Gear Drive and Coupling Service Factor: 2.0 based on motor nameplate horsepower.
2. Housing: Cast iron, with epoxy or polyurethane finish, beveled high-strength steel gears continuously bathed in oil, and with lubrication to other internal parts at all operating speeds.
3. Mounting: Directly mounted to fan hub and connected to motor so motor shaft is in horizontal position.
4. Operation: Able to operate both forward and in reverse.
5. Drive-to-Motor Connection: Close coupled to motor using a flexible coupling.
6. Extend oil fill, drain, and vent to outside of cooling tower casing using galvanized-steel piping. Provide installation with oil-level sight glass.

~~N.~~O. Fan Motor:

1. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Division 23 Section "Common Motor Requirements for HVAC Equipment" and not indicated below.

2. Motor Enclosure: Totally enclosed air over (TEAO) or Totally enclosed fan cooled (TEFC).
3. Energy Efficiency: Comply with ASHRAE/IESNA 90.1.
4. Service Factor: 1.15.
5. Insulation: Class F.
6. Variable-Speed Motors: Inverter-duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
7. Severe-duty rating with the following features:

   a. Rotor and stator protected with corrosion-inhibiting epoxy resin.
   b. Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F.
   c. Internal heater automatically energized when motor is de-energized.

8. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.

~~O.~~P. Fan Discharge Stack: Material shall match casing,
1. Stack Termination: Wire-mesh, galvanized-steel screens; complying with OSHA regulations.

~~P.~~Q. Vibration Switch: For each fan drive.

1. Enclosure: NEMA 250, Type 4X.
2. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
3. Provide switch with manual-reset button for field connection to a BMS and hardwired connection to fan motor electrical circuit.
4. Switch shall, on sensing excessive vibration, signal an alarm through the BMS and shut down the fan.

~~Q.~~R. Controls: Comply with requirements in Division 23 Section "Instrumentation and Control for HVAC."
1. Collection basin level controller complying with requirements in "Electric/Electronic, Collection Basin Water-Level Controller" Paragraph.
2. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
3. Cooling tower shall have hardware to enable BMS to remotely monitor and display the following:

   a. Operational status of each motor.
   b. Cooling tower leaving-fluid temperature.
   c. Fan vibration alarm.
   d. Collection basin low-low, low, high, high-high-water-level alarms..

~~R.~~S. Personnel Access Components:

1. Doors: Large enough for personnel to access cooling tower internal components from both cooling tower end walls. Doors shall be operable from both sides of the door.

~~1.~~2. Access stairs and platforms to tower basin level and fan deck level is furnished and installed by Contractor external to tower scope of supply.

~~2.~~3. ~~External Ladders with Safety Cages: Aluminum, galvanized- or stainless-steel, fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.~~

~~3.~~4. ~~External Platforms with Handrails: Aluminum, FRP, or galvanized-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.~~

~~4.~~5. Handrail (for fan deck perimeter only): Aluminum, galvanized steel, or stainless steel complete with kneerail and toeboard, around top of cooling tower. Comply with 29 CFR 1910.23.

~~5.~~6. Internal Platforms: Aluminum, FRP, or galvanized-steel bar grating.

a. Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall be elevated so that all parts are above the high water level of the collection basin.

b. Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach from collection basin platform.

~~S.~~T. Capacities and Characteristics:

1. As scheduled on drawings.

2.4 SOURCE QUALITY CONTROL

A. Verification of Performance: Test and certify cooling tower performance according to CTI STD 201, "Certification Standard for Commercial Water-Cooling Towers Thermal Performance."

PART 3 - EXECUTION

3.1 GENERAL

A. The cooling towers will be delivered to the designated rigger's yard. Contractor shall coordinate shipment, receive, inspect and accept responsibility for equipment. Any damage or deficiency shall be resolved by Contractor directly with manufacturer and/or hauler, with no recourse to the Owner.

B. Delivery and rigging of cooling towers will be stages based on the construction schedule. Contractor shall protect equipment, transport to the site, rig into place, install, pipe, wire and test equipment in accordance with drawings, specifications and manufacturer's recommendations. Contractor shall coordinate any requirements directly with the manufacturer.

C. Consult equipment supplier regarding rigging requirements. If disassembly is required, both disassembly and reassembly shall be done by the Contractor in strict compliance with the manufacturer's instructions, under supervision of cooling tower manufacturer's representative, and shall not void any warranties.

3.2 EXAMINATION

A. Before cooling tower installation, examine roughing-in for tower support, anchor-bolt sizes and locations, piping, and electrical connections to verify actual locations, sizes, and other conditions affecting tower performance, maintenance, and operation.

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

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

3.3 INSTALLATION

A. Install cooling towers on support structure indicated.

B. Install anchor bolts to elevations required for proper attachment to supported equipment.

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

D. Loose Components: Install electrical components, devices, and accessories that are not factory mounted.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to cooling towers to allow service and maintenance.

C. Provide drain piping with valve at cooling tower drain connections and at low points in piping.

D. Connect cooling tower overflows and drains, and piping drains to sanitary sewage system.

E. Supply and Return Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping." Connect to entering cooling tower connections with shutoff valve, balancing valve, thermometer, plugged tee with pressure gage, and drain connection with valve. Connect to leaving cooling tower connection with shutoff valve. Make connections to cooling tower with a flange or mechanical coupling.

F. Equalizer Piping: Piping requirements to match supply and return piping. Connect an equalizer pipe, full size of cooling tower connection, between tower cells. Connect to cooling tower with shutoff valve.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to perform field tests and inspections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections: Comply with CTI ATC 105, "Acceptance Test Code for Water Cooling Towers."

D. Cooling towers will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.6 STARTUP SERVICE

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

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

C. Obtain performance data from manufacturer.

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

    a. Clean entire unit including basins.
    b. Verify that accessories are properly installed.
    c. Verify clearances for airflow and for cooling tower servicing.
    d. Check for vibration isolation and structural support.
    e. Lubricate bearings.
    f. Verify fan rotation for correct direction and for vibration or binding and correct problems.
    g. Adjust belts to proper alignment and tension.
    h. Operate variable-speed fans through entire operating range and check for harmonic vibration imbalance. Set motor controller to skip speeds resulting in abnormal vibration.
    i. Check vibration switch setting. Verify operation.
    j. Verify water level in tower basin. Fill to proper startup level. Check makeup water-level control and valve.
    k. Verify that cooling tower air discharge is not recirculating air into tower or HVAC air intakes. Recommend corrective action.
    l. Replace defective and malfunctioning units.

D. Start cooling tower and associated water pumps. Follow manufacturer's written starting procedures.

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

3.7 ADJUSTING

A. Set and balance water flow to each tower inlet.

B. Adjust water-level control for proper operating level.

3.8 DEMONSTRATION

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

END OF SECTION 236500

SECTION 23 72 00 - AIR-TO-AIR ENERGY RECOVERY EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Requirements Division 01, Division 23 Specification Sections, and Common Work Requirements for HVAC apply to the work specified in this Section.

1.2 SUMMARY

A. Section Includes:

1. Heat wheels.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design vibration isolation details, using performance requirements and design criteria indicated.

1.4 SUBMITTALS

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

B. LEED V4 BD+C Submittals:

1. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
2. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2010, Section 5 - "Systems and Equipment."

C. Shop Drawings: For air-to-air energy recovery equipment. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.
3. Detail fabrication and assembly of air-to-air energy recovery 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.

5. Design Calculations: Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.

D. Coordination Drawings: Plans, elevations, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which equipment or suspension systems will be attached.

E. Field quality-control reports.

F. Operation and Maintenance Data: For air-to-air energy recovery equipment to include in maintenance manuals.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. AHRI Compliance: Capacity ratings for air-to-air energy recovery equipment shall comply with AHRI 1060, "Rating Air-to-Air Energy Recovery Equipment."

C. ASHRAE Compliance:

1. Applicable requirements in ASHRAE 62.1-2010, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
2. Capacity ratings for air-to-air energy recovery equipment shall comply with ASHRAE 84, "Method of Testing Air-to-Air Heat Exchangers."

D. NRCA Compliance: Roof curbs for roof-mounted equipment shall be constructed according to recommendations of NRCA.

E. UL Compliance: Packaged heat recovery ventilators shall comply with requirements in UL 1812, "Ducted Heat Recovery Ventilators"; or UL 1815, "Nonducted Heat Recovery Ventilators."

1.6 COORDINATION

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

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

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of air-to-air energy recovery equipment that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Packaged Energy Recovery Units: Two years.
2. Warranty Period for Fixed-Plate Total Heat Exchangers: 10 years.

PART 2 - PRODUCTS

2.1 HEAT WHEELS

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

1. TRANE.
2. Advanced Thermal Technologies.
3. Airxchange.
4. American Energy Exchange, Inc.
5. Loren Cook Company.
6. SEMCO Incorporated

B. The air handling unit shall be certified by AHRI to contain a rotary energy recovery wheel certified to ANSI/AHRI Standard 1060 and bears the AHRI 1060 label. Performance characteristics of the energy wheel shall be provided as defined by AHRI 1060 definitions. The energy wheel shall be a total energy wheel, with the sensible and latent effectiveness reported and within 5% of each other. The calculated total net effectiveness of the recovery wheel shall not be less than 70% when the specified ventilation flow rate equals the exhaust flow rate. The energy wheel's EATR shall be less than the value indicated in the schedule and drawings. Wheel face velocity and pressure drop shall not exceed performance as defined on schedule. The energy recovery cassette shall be an Underwriters Laboratories (UL) Recognized Component certified for mechanical, electrical, and fire safety in accordance with UL Standard 1812.

C. Casing: .

1. Steel with standard factory-painted finish

2. Integral purge section limiting carryover of exhaust air to between 0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg differential pressure.

3. Casing seals on periphery of rotor and on duct divider and purge section. Perimeter seals shall be self-adjusting; diameter seals shall be adjustable. Rim shall be continuous

rolled stainless steel to form an even concentric circle to prevent leakage around rim and to minimize wear of components

4. Support vertical rotors on grease-lubricated ball bearings having extended grease fittings or permanently lubricated bearings. Support horizontal rotors on tapered roller bearing. Permanently sealed and lubricated wheel bearings shall have minimum L-10 life of 400,000 hours.

5. Wheel casing to be removable to allow for servicing of heat wheel

6. Provide air bypass to allow for airside economizer.

7. Wheel drive motor shall be thermally protected and UL Component Recognized

D. Rotor: Polymer segmented wheel strengthened with radial spokes impregnated with nonmigrating, water-selective, molecular-sieve desiccant coating.

1. Maximum Solid Size for Media to Pass: 800 micrometer

2. Incorporate desiccant without the use of binders or adhesives

3. The absorbent shall not be applied as a glued on surface coating and not susceptible to erosion, abrasion, or delamination

4. Coated segments shall be washable using standard detergent or alkaline-based coil cleaners

5. The absorbent shall be selected for its high affinity for water vapor and shall not dissolve or deliquesce in the presence of water or high humidity

E. Bearing: Wheel bearings shall be permanently sealed and lubricated and have a minimum L-10 life of 400,000 hours.

F. Drive: Fractional horsepower motor and gear reducer and self-adjusting multilink belt around outside of rotor.

1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment".

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

3. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.

4. Drive belts shall not require belt tensioner

G. Controls:

1. Basis of design: Starting relay, factory mounted and wired, and manual motor starter for field wiring.

2. Energy recovery wheels shall be designed with variable effectiveness control, to vary the wheel's recovery capacity. Variable effective control shall be done by an internal bypass damper provided by the AHU Manufacturer. The wheel's variable effectiveness control shall have the ability to modulate the total energy recovery ability down to at least 40% of the initial recovery capacity. Variable frequency speed control is not an acceptable method for controlling variable effectiveness.

3. Pilot-Light Indicator: Display rotor rotation and speed.

4. Speed Settings: Adjustable settings for maximum and minimum rotor speed limits

H. Frost Protection: Frost prevention shall be achieved by outside air bypass, return air preheat, or outside air preheat, depending upon design conditions. Frost set point temperatures based on the scheduled design air conditions shall be provided by the AHU Manufacturer. Variable frequency speed control is not an acceptable method of frost control. Winter design supply and exhaust air conditions leaving the energy wheel shall be provided by the AHU Manufacturer and shall include any de-rate in performance due to frost prevention measures.

I. Control of energy wheels shall be incorporated and an integral part of the DOAS control systems and shall be as described under the DOAS control diagrams and control sequences shown on the BMS drawings. Secondary independent wheel controllers are not acceptable.

J. Access doors: Access doors shall be provided on all air entering and air leaving sides of wheel to allow for wheel maintenance, belt, bearing, or motor removal

2.2 CAPACITIES AND CHARACTERISTICS

A. As scheduled on drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

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

B. Examine casing insulation materials and filter media before air-to-air energy recovery equipment installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

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

3.2 INSTALLATION

A. Install heat wheels so supply and exhaust airstreams flow in opposite directions and rotation is away from exhaust side to purge section to supply side.

1. Install access doors in both supply and exhaust ducts, both upstream and downstream, for access to wheel surfaces, drive motor, and seals.

B. Install units with clearances for service and maintenance.

C. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

D. Pipe drains from units and drain pans as shown, same size as condensate drain connection.

3.3 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.

3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain air-to-air energy recovery units.

END OF SECTION 23 72 00

SECTION 23 73 13 - MODULAR INDOOR CENTRAL-STATION AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Requirements Division 01, Division 23 Specification Sections, and Common Work Requirements for HVAC apply to the work specified in this Section.

B. Basic Requirements: Provisions of Section 23 00 10, Basic HVAC Requirements are part of this Section.

1.2 SUMMARY

A. Section Includes:

1. Constant-air-volume, single-zone air-handling units.
2. Variable-air-volume, single-zone air-handling units.

1.3 PERFORMANCE REQUIREMENTS

A. Structural Performance: Casing panels shall be self-supporting and capable of withstanding 133 percent of internal static pressures indicated, without panel joints exceeding a deflection of L/240 where "L" is the unsupported span length within completed casings.

1.4 SUBMITTALS

A. Product Data: Manufacturer’s literature for each air-handling unit indicated.

1. Unit dimensions and weight.
2. Cabinet material, metal thickness, finishes, insulation, and accessories.
3. Fans:

   a. Certified fan-performance curves with system operating conditions indicated.
   b. Certified fan-sound power ratings.
   c. Fan construction and accessories.
   d. Motor ratings, electrical characteristics, and motor accessories.

4. Certified coil-performance ratings with system operating conditions indicated.

5. Coil description, rows and fins per inch and face velocity.
6. Airflow and airside pressure drop at design conditions.
7. Dampers, including housings, linkages, and operators.
8. Filters with performance characteristics.
9. Scaled drawings of unit assembly with construction details, field connection details and required clearances.
10. Wiring diagrams for interlock and control wiring, clearly indicating factory installed and field installed wiring.

B. Sustainable Design Documentation Submittals: Refer to section 01 81 13.14 "Sustainable Design Requirements – LEED V4 BD+C".
   1. Product Data: Documentation for Filter Media/Filter Log in accordance with spec~~t~~ification Section 01 35 46.

C. Delegated-Design Submittal: For vibration isolation indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

   1. 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.
   2. Design Calculations: Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.

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

   1. Mechanical-room layout and relationships between components and adjacent structural and mechanical elements.
   2. Support location, type, and weight.
   3. Field measurements.

E. Source quality-control reports.

F. Field quality-control reports.

G. Installation instructions: Manufacturer's printed instructions for the assembly and installation of each air handling unit including copies shipped with the equipment.

H. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals, including:

   1. Catalog cuts of equipment and all components.
   2. Instructions for lubrication, filter replacement, motor and drive replacement.
   3. Spare parts list.

4. Wiring diagrams.

I. CLOSEOUT SUBMITTALS: See Section 01 78 00 – Closeout Submittals for requirements.

J. MAINTENANCE MATERIAL SUBMITTALS: See Section 01 78 00 – Closeout Submittals for requirements.

1.5 QUALITY ASSURANCE

A. General: All equipment, material, accessories, methods of construction and reinforcement, finish quality, workmanship and installation shall be in compliance with Section 23 00 10.

B. 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.

C. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components. All materials and adhesives used shall conform to the requirements of NFPA 90A and NFPA 255 with flame spread not exceeding 25 and smoke developed ratings not exceeding 50.

D. ARI Certification: Air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.

E. ARI Certification: Coil capacities, pressure drops and selection procedure shall be certified in accordance with ARI Standard 410.

F. ASHRAE Compliance: Applicable requirements in the latest edition of ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

G. ASHRAE/IESNA 90.1 Latest Edition Compliance: Applicable requirements in the latest edition of ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

H. Comply with NFPA 70.

1.6 COORDINATION

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

B. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.

1.7 EXTRA 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. Filters: One set for each air-handling unit.
2. Gaskets: One set for each access door.
3. Fan Belts: One set for each air-handling unit fan.
4. Belt Pulleys: One fixed pitch pulley for each air-handling unit fan.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide product by one of the following:
1. Carrier Corporation; a member of the United Technologies Corporation Family.
2. Daikin Applied
3. Temptrol
4. Trane; American Standard Inc.
5. YORK International Corporation.

2.2 UNIT CASINGS

A. General Fabrication Requirements for Casings:
1. Casing Joints: Sheet metal screws or pop rivets.
2. Casings: Double wall insulated panel construction.

a. Panels and access doors shall be constructed as a 2-inch (50-mm) nominal thick; thermal broke double wall assembly, injected with foam insulation for an R-value of not less than R-13.
b. Outer wall: Galvanized or phosphatized cold rolled steel, reinforced and braced with angles.
c. Internal wall: Galvanized steel panel over 2 inch (50 mm) thick fibrous glass board insulation 1.5 lb/cu. ft. (24 kg./cu. m.) density, NFPA approved. Fan section internal wall shall be perforated galvanized steel in lieu of solid panel.
d. Factory finish for galvanized steel casing shall consist of factory applied standard two coat, baked on enamel finish consisting of prime coat and thermostting Casing finished to meet ASTM B117 500-hour salt-spray test.

3. Sealing: Seal all joints with permanently applied bulb-type gasket. Shipped loose gasketing is not allowed.
4. The casing leakage rate shall not exceed ASHRAE 111 CL 6 at design pressure up to positive or negative 8 inches, where casing leakage (cfm/100 ft2 of casing surface are) = CL × P0.65.

5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in the latest edition of ASHRAE 62.1.
6. Panel deflection shall not exceed L/240 ratio at 133% of design static pressure, maximum positive or negative 8 inches of static pressure. Deflection shall be measured at the midpoint of the panel height.
7. Module to module assembly shall be accomplished with an overlapping, full perimeter, insulated, internal splice joint sealed with bulb type gasketing on both mating modules.

B. Flooring :

1. Units shall have a 0.044” aluminum tread plate floor on access sections.

C. Inspection and Access Panels and Access Doors:

1. Panel and Door Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing. Doors shall be flush mounted to cabinetry.
2. Inspection and Access Panels:

    a. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.
    b. Gasket: Neoprene, applied around entire perimeters of panel frames.
    c. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.

3. Access Doors:

    a. Hinges: A minimum of two stainless-steel hinges and two wedge-lever-type latches, operable from outside. Latches shall be non self-latching. Arrange doors to be opened against air-pressure differential.
    b. Gasket: Neoprene, applied around entire perimeters of panel frames.
    c. Fabricate windows in fan section doors of double-glazed, safety glass with an air space between panes and sealed with interior and exterior rubber seals. Windows shall be shatterproof capable of withstanding unit operating pressures.
    d. Size: At least 18 inches wide by full height of unit casing up to a maximum height of 60 inches.
    e. View Port:

        1) View Port: view port shall be provided and installed at the UVGI section. View port shall be constructed of anodized aluminum framework and 1/4” thick laminated glass. Viewing area shall be 3” x 12”. Air handling unit insulation rating shall not be compromised. View port shall be constructed to prevent condensation from forming on the view port and access door.
        2) Caution sign (7” x 10”) shall be provided and installed on all access to UVGI section. Sign shall be caution yellow with bold black lettering.

f. Door Safety Sensor:

1) System shall incorporate sensor device on the UVGI compartment access door to disconnect power when access is required. Device shall consist of coded magnet and shall be tamper-resistant to prevent by-passing.
2) Sensor shall be shock resistant to 30g/11ms and vibration resistant, 10 to 55 Hz, amplitude 1 mm and conform to CE, UL, CSA, VDE and

3) IEC Standards as well as safety EN954-1, Category 1 with provided safety controller.

4. Locations and Applications:

a. Fan Section: Doors - Access door shall be 20” minimum for this section only.
b. Access Section: Doors.
c. Coil Section: Access doors before and After Coil Section(s) on both sides of the unit – Access door shall be 20” minimum for this section only.
d. Damper Section: Doors.
e. Filter Section: Doors large enough to allow periodic removal and installation of filters.
f. Mixing Section: Doors.
g. Humidifier Section: Doors.

5. Service Light: Provide marine light and GFI receptacle in fan section mounted and wired to a junction box and on-off switch mounted on the outside of the cabinet. Provide marine light in filter section wired to a junction box and on-off switch mounted on the outside of the cabinet.

D. Condensate Drain Pans:

1. Fabricated with two percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.

a. Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
b. Depth: A minimum of 2 inches deep.

2. Formed sections or Integral part of floor plating.
3. Double-wall, stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.
4. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Drain connection centerline shall be a minimum of 3" above the base rail to aid in proper condensate trapping. Drain connections that protrude from the base rail are not acceptable.
5. Terminate with stainless-steel threaded nipple on one end of pan.
6. Minimum Connection Size: NPS 1.

7. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil, and piped to lowest drain pan.

E. Air-Handling-Unit Mounting Frame: Formed galvanized-steel, designed for low deflection, welded with integral lifting lugs to provide true thermal break

2.3 FAN, DRIVE, AND MOTOR SECTION

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.

1. Shafts: Designed for continuous operation at maximum-rated fan speed and motor horsepower, and with field-adjustable alignment. Multiple fans shall be mounted on a common shaft.

a. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

B. Centrifugal Fan Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.

1. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
2. Horizontal-Flanged, Split Housing: Bolted construction.
3. Housing for Supply Fan: Attach housing to fan-section casing with metal-edged flexible duct connector.
4. Flexible Connector: Factory fabricated with a fabric strip 3-1/2 inches or 5-3/4 inches wide attached to 2 strips of 2-3/4-inch-wide, 0.028-inch-thick, galvanized-steel sheet or 0.032-inch-thick aluminum sheets; select metal compatible with casing.

a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.

1) Fabric Minimum Weight: 26 oz./sq. yd..
2) Fabric Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3) Fabric Service Temperature: Minus 40 to plus 200 deg F.

C. Plenum Fan Housings: Steel frame and panel; fabricated without fan scroll and volute housing.

D. Backward-Inclined, Centrifugal Fan Wheels: Single-width-single-inlet and double-width-double-inlet construction with curved inlet flange, backplate, backward-inclined blades welded or riveted to flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

E. Airfoil, Centrifugal Fan Wheels: Single-width – single-inlet and double-width – double-inlet construction with smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

F. Direct-drive airfoil plenum supply fan(s):

1. See construction schedules for the number of fans located in the unit. Unit shall have 9 or 12 blade airfoil type, direct-drive class II fans with 2" spring isolation.
2. Fan and motor shall be mounted internally on a steel base. Provide access to motor, drive, and bearings through hinged access door.
3. Fans wheels shall be constructed of all aluminum.
4. Provide inlet safety screen.
5. Provide fan safety screen.
~~6. Fan shall be provided with Peizometer flow sensor with transducer. One piezometer ring shall be supplied on each fan in the fan array~~
~~7.~~6. Manual block-off damper mounted upstream of fan for isolation of individual fans shall be provided for units with multiple fans.

G. Fan Shaft Bearings:

1. Prelubricated and Sealed, Ball Bearings: Self-aligning, pillow-block type with a rated L-50 life of 500,000 hours according to ABMA 9.
2. Grease-Lubricated, Tapered-Roller Bearings: Self-aligning, pillow-block type with double-locking collars and 2-piece, cast-iron housing with grease lines extended to outside unit and a rated L-50 life of 500,000 hours according to ABMA 11.
3. Grease-Lubricated Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing with grease lines extended to outside unit and a rated L-50 life of 500,000 hours according to ABMA 11.

H. Belt Drives: Factory mounted, with adjustable alignment and belt tensioning, and with 1.5 service factor based on fan motor, allow for one drive change on fan to attain desired flow rates for air balance.

1. Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
2. Motor pulleys:

   a. Adjustable pitch type for use with fans up to 7.5 hp motors and smaller and for fans 10 to 25 hp under 1000 rpm, except fans with variable inlet vanes or variable frequency drives.
   b. Fixed pitch type for use with fans larger than 10 hp to 25 hp and larger, and fans with variable inlet vanes or variable frequency drives.
   c. Select pulley sizes so pitch adjustment is at the middle of adjustment range at fan design conditions.

3. Belts: Oil resistant, nonsparking, and nonstatic; in matched sets for multiple-belt drives. Companion sheaves to maintain belts parallel.
4. Belt Guards: Comply with requirements specified by OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; 0.1046-inch- thick, 3/4-inch diamond-mesh wire screen, welded to steel angle frame; prime coated.

I. Internal Vibration Isolation: Fans shall be factory mounted with manufacturer's standard vibration isolation mounting devices. For deflection, see schedule.

J. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."

1. Enclosure Type: Open Drip-Proof (ODP) or totally enclosed, fan cooled.
2. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.
5. Motors must be “matched” with variable frequency drives, one (1) VFD per fan. Motors and fans shall be selected and furnished by the air-handling unit manufacturer to meet specified performance requirements. All VFD’s for equipment under this specifications shall be sourced from one single VFD manufacturer.
6. Each VFD shall come with integral disconnect. Provide separate unit service disconnect switch upstream of VFD(s).
7. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

K. Variable Frequency Controllers: See Section 23 05 14 "Variable Frequency Motor Controllers."
1. VFD for Modular Air Handling Units’ supply fans specified under this section shall be furnished without bypass controller.

2.4 ELECTRICAL

A. General Requirements for Electrical:

1. The air handling units shall be ETL or UL listed, as an entire assembly. Component listing is not an acceptable alternate. ETL-C is not an acceptable alternative.
2. Units shall conform to ANSI/UL Standard 1995/CSA Standard C22.2 No.236.

B. Wiring Termination:

1. Provide terminal lugs to match branch circuit conductor quantities, sizes and materials indicated. Enclosed terminal lugs in terminal box shall comply with NFPA 70.

2. Air Handling Unit manufacturer shall provide and mount conduit and wiring from each fan motor terminated at an exterior junction box.
3. Air handling unit manufacturer shall provide electrical connections as scheduled.

2.5 COIL SECTION

A. General Requirements for Coil Section:

1. Comply with ARI 410. Coil shall bear the AHRI label.
2. Manufacturer of coil shall be ISO 9002 certified.
3. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
4. For multizone units, provide air deflectors and air baffles to balance airflow across coils.
5. Coils shall not act as structural component of unit.
6. Provide access to coils from both sides of unit for service and cleaning.
7. Cooling and heating coils, including headers and return bends, shall be totally enclosed within the unit casing.
8. Unit shall be provided with coil connections that extend a minimum of 5" beyond unit casing for ease of installation.
9. Drain and vent connections shall be provided exterior to unit casing. Coil connections must be factory sealed with grommets on interior and exterior and gasket sleeve between outer wall and liner where each pipe extends through the unit casing to minimize air leakage and condensation inside panel assembly.
10. Headers shall consist of seamless copper tubing to assure compatibility with primary surface. Headers to have intruded tube holes to provide maximum brazing surface for tube to header joint, strength, and inherent flexibility. Header diameter should vary with fluid flow requirements.
11. Fins shall have a minimum thickness of 0.0075" of aluminum plate construction for mixed air units. Fins shall have a minimum thickness of 0.0075” of copper plate construction for 100% outside air units.

    a. Fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer.
    b. Tubes shall be mechanically expanded into the fins to provide a continuous primary to secondary compression bond over the entire finned length for maximum heat transfer rates. Bare copper tubes shall not be visible between fins.

12. Coil tubes shall be 5/8 inch OD seamless copper, 0.020" nominal tube wall thickness, expanded into fins, brazed at joints. Soldered U-bends shall be provided to minimize the effects of erosion and premature failure having a minimum tube wall thickness of 0.025".Coil connections shall be O.D. sweat copper with connection size to be determined by manufacturer based upon the most efficient coil circuiting. Vent and drain fittings shall be furnished on the connections, exterior

to the air handler. Vent connections provided at the highest point to assure proper venting. Drain connections shall be provided at the lowest point to insure complete drainage.

13. Cooling Coil casings shall be a formed channel frame of stainless steel and slide into a pitched track for fluid drainage.
14. Air Velocities:
    a. Units shall have a face velocity below 500 FPM on mixed air unit.
    b. Units shall have a face velocity below 400 FPM on 100% O.A. unit.
15. Cooling coil maximum height shall be 42 inches (10.5 cm). For units that require coils higher than 42 inches (10.5 cm), provide multiple coil sections of equal heights. Provide intermediate condensate drain pans and drain line to lower drain pan.
16. Provide factory installed electric resistance heat for unit. Unit shall include field-replaceable heat sections. All heat sections are to be sub-fused.
17. Electric resistance heaters shall be factory-installed, nichrome element type, open wire coils, insulated with ceramic bushings, and include operating and safety controls. Coil ends shall be staked and welded to terminal screw slots.
18. Heat sections shall feature multiple stage capacity.
19. Safety Features: All heat sections for said unit shall feature factory installed.
    a. Automatic discharge air limit Control.
    b. Air proving pressure switch.
    c. Color coded wiring and matching terminal blocks.
    d. Circuit breaker protected transformers.

2.6 AIR FILTRATION SECTION

A. General Requirements for Air Filtration Section: See Division 23 "Particulate Air Filtration."

1. Comply with NFPA 90A.
2. Provide minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
3. Filter media shall be UL 900 listed, Class I or Class II.
4. Provide filter holding frames arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.
5. Provide filter gauges for each filter type.

B. PHOTOCATALYTIC AIR CLEANER:

1. General Requirements: Photocatalytic air cleaner section shall be provided by air handling unit manufacturer as integral part of unit.
2. See Division 23, Section "Particulate Air Filtration" for specific requirements.

3. Air handling unit manufacturer shall coordinate with photocatalytic air cleaner system manufacturer to determine length of section required for proper installation and operation of the system. Section length shown on drawings is minimum length required.
4. Provide access doors. Coordinate with photocatalytic air cleaner system manufacturer for door placement within the section to not interfere with air cleaner installation or operation.

2.7 DAMPERS

A. Dampers: See Division 23 Section "Instrumentation and Control for HVAC."

B. General Requirements for Dampers: Leakage rate, according to AMCA 500, "Laboratory Methods for Testing Dampers for Rating," shall not exceed 2 percent of air quantity at 2000-fpm face velocity through damper and 4-inch wg differential pressure.

C. Damper Operators: Comply with requirements in Division 23 Section "Instrumentation and Control for HVAC."

D. Mixing Section: Multiple-blade, air-mixer assembly located immediately downstream of mixing section.

E. Combination Filter and Mixing Section:

1. Cabinet support members shall hold 2-inch-thick, pleated, flat, permanent or throwaway filters.
2. Multiple-blade, air-mixer assembly shall mix air to prevent stratification, located immediately downstream of mixing box.

2.8 AIR-TO-AIR ENERGY RECOVERY

A. General Requirements: The air-to-air energy recovery section shall be provided by air handling unit manufacturer as integral part of unit.

B. See Division 23, Section "Air-to-Air Energy Recovery Equipment" for specific requirements.

C. Air handling unit manufacturer shall coordinate with energy recovery system manufacturer to determine length of section required for proper installation and operation of the system. Section length shown on drawings is minimum length required.

D. Provide access doors. Coordinate with energy recovery system manufacturer for door placement within the section to not interfere with air cleaner installation or operation.

2.9 AIRFLOW MEASURING SYSTEMS

A. See Division 23 “Instrumentation and Control for HVAC” for airflow measuring devices.

B. Airflow measuring devices shall be furnished and installed by BMS Contractor and shall be integral to the AHU.

~~C. An airflow measurement systems shall be provided as indicated on the schedule and drawings to measure fan airflow directly or to measure differential pressure that can be used to calculate airflow. The accuracy of the devices shall be no worse than +/- 2 percent when operating within stable fan operating conditions. Devices shall not affect the submitted fan performance and acoustical levels. Devices that obstruct the fan inlet or outlet shall not be acceptable. Devices shall be connected to transducers with a 2-10 VDC output. Signal shall be proportional to air velocity.~~

2.10 CAPACITIES AND CHARACTERISTICS

A. See Mechanical Drawings and Schedules.

2.11 CONTROLS

A. Controls shall be provided by control contractor.

B. For control devices and operational sequences refer to Division 23 Sections "Instrumentation and Control for HVAC" and see the BMS drawings for the "Sequence of Operations for HVAC Controls.”

2.12 SOURCE QUALITY CONTROL

A. Fan Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.

B. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency. Rate performance according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating."

C. Water Coils: Factory tested to 300 psig according to ARI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.1 EXAMINATION

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

B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

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

3.2 INSTALLATION

A. Equipment Mounting: Install air-handling units on concrete bases using elastomeric pads. Secure units to anchor bolts installed in concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-Place Concrete." Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration Controls for HVAC."

1. Install stainless-steel plate to equally distribute weight over elastomeric pad.
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. 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 supported equipment.

B. Elevate units by means of structural channels or I-beams where necessary to accommodate cooling coil condensate drainage requirements as detailed. See details on drawings for minimum drain trap.

C. Suspended Units: Suspend and brace units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration Controls for HVAC."

D. Arrange installation of units to provide access space around air-handling units for service and maintenance.

E. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

F. Install filter-gage, static-pressure taps upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum in accessible position. Provide filter gages on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to air-handling unit to allow service and maintenance.

C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using NPS 1-1/4, ASTM B 88, Type M copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Chilled-Water Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

F. Connect duct to air-handling units with flexible connections. Comply with requirements in Division 23 Section "Air Duct Accessories."

3.4 FIELD QUALITY CONTROL

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

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Do not operate units for any purpose, temporary or permanent , until ductwork is clean, filters are in place, bearings lubricated, and fan as been test run under observation.
3. If operation is required before premises are thoroughly clean, cover all return and exhaust outlets with temporary filter pads.

C. Tests and Inspections:

1. Leak Test: After installation, fill water coils with water, and test coils and connections for leaks.
2. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Photocatalyctic air cleaner operational tests: Pressurize housing to a minimum of 3-inch w.g. or to design operating pressure, whichever is higher, and test housing joints, door seals, and sealing edges of filter with soapy water to check for air leaks.
4. Final-Filter Operational Test: Pressurize housing to a minimum of 3-inch wg or to designed operating pressure, whichever is higher; test housing joints, door seals, and sealing edges of filter with soapy water to check for air leaks.
5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
6. Charge heat pipes with refrigerant and test for leaks.

D. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

E. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that shipping, blocking, and bracing are removed.
3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
6. Verify that zone dampers fully open and close for each zone.
7. Verify that face-and-bypass dampers provide full face flow.
8. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
9. Comb coil fins for parallel orientation.
10. Verify that proper thermal-overload protection is installed for electric coils.
11. Install new, clean filters.
12. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

B. Starting procedures for air-handling units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace fan and motor pulleys as required to achieve design conditions.
2. Measure and record motor electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

3.6 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

3.7 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters. Refer to Section 01 74 23 for final cleaning requirements.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-handling units. Provide one 8-hour training session at site with equipment fully operational. Refer to Division 1 Section 01 91 13 for additional requirements.

END OF SECTION 23 73 13

SECTION 23 74 33 - DEDICATED OUTDOOR AIR UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Requirements Division 01, Division 23 Specification Sections, and Common Work Requirements for HVAC apply to the work specified in this Section.

B. Basic Requirements: Provisions of Section 23 00 10, Basic HVAC Requirements are part of this Section.

1.2 SUMMARY

A. Section Includes:

1. Variable-air-volume, multizone air-handling units.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design vibration isolation details, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

1.4 SUBMITTALS

A. Product Data: For each air-handling unit indicated.

1. Unit dimensions and weight.
2. Cabinet material, metal thickness, finishes, insulation, and accessories.
3. Fans:
   a. Certified fan-performance curves with system operating conditions indicated.
   b. Certified fan-sound power ratings.
   c. Fan construction and accessories.
   d. Motor ratings, electrical characteristics, and motor accessories.
4. Certified coil-performance ratings with system operating conditions indicated.
5. Dampers, including housings, linkages, and operators.
6. Filters with performance characteristics.
7. Scaled drawings of unit assembly with construction details, field connection details and required clearances.
8. Wiring diagrams for interlock and control wiring, clearly indicating factory installed and field installed wiring.
9. 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.
10. Design Calculations: Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.

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

1. Mechanical-room layout and relationships between components and adjacent structural and mechanical elements.
2. Support location, type, and weight.
3. Field measurements.

C. Source quality-control reports.

D. Field quality-control reports.

E. Operation and Maintenance Data: The contractor is to provide a copy of the Installation, Operations, and Maintenance (IOM) manual following approval of the submittal. IOM is to be delivered to the CM within 2 weeks, this manual shall be used in the finalizing of Cx start up, and pre-functional testing check lists. For air-handling units to include in emergency, operation, and maintenance manuals, including:

1. Catalog cuts of equipment and all components.
2. Instructions for lubrication, filter replacement, motor and drive replacement.
3. Spare parts list.
4. Wiring diagrams.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

C. AHRI Certification: Air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by AHRI.

D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2010, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Systems Startup."

E. ASHRAE/IESNA 90.1-2010 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2010, Section 6 - "Heating, Ventilating, and Air-Conditioning."

F. Comply with NFPA 70.

1.6 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement and formwork requirements are specified in Division 3.

B. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.

1.7 EXTRA 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. Filters: Two sets for each air-handling unit.
2. Gaskets: Two sets for each access door.
3. Fan Belts: Two sets for each air-handling unit fan.
4. Belt Pulleys: Two sets for each air handling unit fan.

1.8 WARRANTY

A. AHU manufacturer shall provide a parts and labor warranty that covers a period of two years from unit start-up or 30 months from shipment, whichever occurs first. This warrants that all products are free from defects in material and workmanship and shall meet the capacities and ratings set forth in the equipment manufacturer's catalog and bulletins.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Air Handling Units:
   a. Trane. (Custom)
   b. Buffalo Air Handling
   c. HAAKON
   d. MAFNA
   e. Temtrol
   f. Ventrol
   g. Daikin

2.2 UNIT CASING

A. Casing Performance

1. Unit air leakage shall not exceed 0.5% of design cfm at +12.0” w.g. in all positive-pressure sections and -12.0” w.g. in all negative-pressure sections. Leakage shall be calculated by totaling all leakage either in to or out of the unit
2. Casing deflection shall not exceed L/250 at +12.0” w.g. in all positive-pressure sections and -12.0” w.g. in all negative-pressure sections, where L is defined as the panel span.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2010.
4. Under scheduled supply air temperature and design conditions on the exterior of the unit of 77°F dry bulb and 72°F wet bulb, condensation shall not form on the casing exterior. The AHU Manufacturer shall provide tested casing thermal performance for the scheduled supply air temperature plotted on a psychrometric chart. The design condition on the exterior of the unit shall also be plotted on the chart. If tested casing thermal data is not available, AHU Manufacturer shall provide, in writing, a guarantee against condensation forming on the unit exterior

under the scheduled supply air temperature and design conditions on the exterior of the unit of 77°F dry bulb and 72°F wet bulb. The guarantee shall note that the AHU Manufacturer will cover all expenses associated with modifying units in the field should external condensate form on them. Copies of the guarantee shall be provided to the Engineer and the Owner.

5. Class “A” thermal break shall be provided throughout the entire casing assembly, including all door assemblies downstream of the cooling coil. A Class “A” thermal break shall be defined as a thermal break that ensures no member on the exterior of the unit, including fasteners, has through metal contact with any member on the interior of the unit, including fasteners.

6. Insulation that meets a minimum R-value of 18.8 shall be provided throughout all unit wall assemblies. Insulation shall be injected foam. Foam shall be closed cell to prevent wicking of moisture. If fiberglass insulation is provided, it shall be completely wrapped with long-strand fiberglass cloth to limit the entrainment of moisture into the insulation. The long-strand fiberglass cloth shall also incorporate an anti-microbial coating to suppress microbial growth. Insulation shall completely fill the panel cavity in all directions so that no voids exist and settling of insulation is prevented. Wall assemblies shall comply with NFPA 90 A. To ensure injected closed-cell foam is properly engineered for rigidity and thermal performance, is amply applied to fill all cavities within each assembly, and is correctly cured to yield strong adhesion to casing members, the AHU Manufacturer shall have experience using injected closed-cell foam as an insulation in AHUs for no less than 10 years.

7. Factory finish for galvanized steel casing shall consist of factory applied standard two coat, baked on enamel finish consisting of prime coat and thermosetting Casing finished to meet ASTM B117 500-hour salt-spray test.

B. Bases & Floors

1. Base shall be constructed of welded structural steel channels around the perimeter and welded structural steel cross members. Formed steel channels are not acceptable. The structural steel base shall be shot blasted, fully welded and then painted. The maximum cross-member spacing shall be 24" on center with members located adequately to support fan, coils, and other large components. The height of each base channel shall be no less than the height indicated in the drawings. Each shipping section shall be provided with removable lifting lugs. Structural framework shall fully support the unit casing and all components during installation such that no section deflects more than L/1000 during rigging of that section, where L is defined as the distance between lifting lugs.

2. Floor shall be double bottom construction, inner floor shall be a minimum of 10 ga, outer floor shall be a minimum of 16 ga galvanized steel, with 4” fiberglass or 2” foam insulation. The floor surface shall be continuously welded with 2” turned up lip around the base perimeter and all floor penetrations. Caulk is not an acceptable sealing method for the floor. Floor deflection shall not exceed L/350 under a point load of 350 pounds, where L is defined as the floor span. Insulation shall completely fill the panel cavity in all directions so that no voids exist. Base assemblies shall comply with NFPA 90 A.

3. Safety grates that provide a walking surface shall be provided across all bottom air openings. Safety grates shall support a minimum 300-pound load. Safety grates

shall be made of Type IWA welded rod with a cross flow pattern of 1.1875” x 4”. Grating shall be galvanized steel construction for units with galvanized or painted steel floors and shall be aluminum construction for units with aluminum floors. Safety grates shall be removable to ensure adequate access to the ductwork below

C. Walls

1. Wall and roof assemblies shall be double-wall construction with minimum 16ga galvanized steel solid exterior and 16ga galvanized steel interior. The entire unit shall have a solid wall liner on the interior. All spaces and joints of wall assemblies shall be completely sealed. Wall shall meet the casing deflection limits contained herein.
2. A Class “A” thermal break shall be provided throughout the entire wall assembly.
3. Minimum 2” fiberglass or foam insulation shall be provided throughout all unit wall assemblies. Insulation that meets a minimum installed R-value of 18.8 shall be provided throughout all assemblies. Insulation shall completely fill the panel cavity in all directions so that no voids exist and settling of insulation is prevented. Wall assemblies shall comply with NFPA 90 A.
4. Removable wall access panels shall be provided in coil sections for service removal of components. A Class “A” thermal break shall be provided throughout all removal wall access panels. Removable panels shall match the surrounding casing construction

D. Access Doors

1. Access doors shall be provided throughout units as indicated on the schedules and drawings. Access doors shall be double wall construction. Interior door panels shall be min 18 ga. and exterior door panels shall be of the same construction as the exterior wall panels.
2. A Class “A” thermal break shall be provided on all door assemblies throughout the unit.
3. Insulation that meets a minimum installed R-value of 18.8 shall be provided throughout all door assemblies. Insulation shall match casing insulation. Insulation shall completely fill the panel cavity in all directions so that no voids exist and settling of insulation is prevented. Door assemblies shall comply with NFPA 90 A.
4. All doors shall be a minimum of 60” high if sufficient height is available, or the maximum height allowed by the unit height. All doors shall open against pressure to ensure an airtight seal and to prevent a safety hazard. Access doors in fan sections that must open with internal pressure shall be provided with door safety stops.
5. Door test ports shall be provided by the AHU Manufacturer as indicated on the schedule and drawings. Test ports shall be designed to allow the test and balance contractor to validate pressure losses using a hand held instrument. Test ports shall have a removable cover that completely seals the door penetration when testing and balancing is not being conducted
6. Door hinges shall be stainless steel type. Door handles shall be Allegis design for minimized leakage and to provide a Class “A” thermal break. Handles shall fasten against the door frame with a roller cam to eliminate wear of the door frame. On

indoor units, if Allegis handles are not provided, Ventlok 310 handles shall be provided on all doors to ensure positive seal of the door and to avoid wear of the door frame. All door handles shall be operable from both the unit exterior and interior. Access doors shall be provided with two securing latches, operable from inside and outside the unit.

7. Windows shall be provided in all access doors. Windows shall be mounted in a metal frame and shall be a minimum of 8” x 8”, with wire-reinforced safety glass. For any instance where a window cannot fit in a door, a narrower window 8” tall may be provided. Windows in doors with a thermal break shall be thermal, double-pane type

E. Condensate Drain Pans:

1. Fabricated pans with slopes in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and to direct water toward drain connection.
    a. Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1-2010. Condensate drain pan shall extend min. 18 inches downstream from leaving face.
    b. Depth: A minimum of 2 inches deep.
2. Formed sections.
3. Double-wall, 18 ga 304 stainless steel with space between walls filled with foam insulation and moisture-tight seal.
4. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on both ends of pan.
5. Pan-Top Surface Coating: Asphaltic waterproofing compound.
6. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

2.3 FAN, DRIVE, AND MOTOR SECTION

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.

1. Shafts: Designed for continuous operation at maximum-rated fan speed and motor horsepower, and with field-adjustable alignment.
    a. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
    b. Designed to operate at no more than 75 percent of first critical speed at top of fan's speed range.

B. All fans shall have airfoil blades. Backward inclined and forward curved fans are not acceptable.

C. All fans shall be selected to provide a maximum fan rpm of 2000.

D. Plenum Fan Housings: Steel frame and panel; fabricated without fan scroll and volute housing.

E. Direct-Drive Plenum Fan: The fan type shall be provided as required for stable operations and optimum energy efficiency. The fan shall be single-width, single-inlet, multiblade-type. Plenum fans shall be equipped with self-aligning, antifriction, pillow-block bearings with an L-50 life of 200,000 hours as calculated per ANSI/AFBMA Standard 9. For any bearing requirement liberation, the great line shall be extended to the fan support bracket on the drive side. The fan blades shall be backward-inclined airflow. Fan sections shall be provided with an expanded-metal guard screen for the access door, mounted on the door opening, to deter unauthorized entry and incidental contact with rotating components.

F. Fan Shaft Bearings:

1. Grease-Lubricated Bearings: Self-aligning, anti-friction bearings selected for L-50 200,000-hour average life per ANSI/AFBMA Standard 9. Lubrication lines for both bearings shall be extended to the drive side of the AHU and rigidly attached to support bracket with zerk fittings. Lubrication lines shall be a clear, high pressure, polymer to aid in visual inspection.

G. Internal Vibration Isolation: Fans and motor shall be factory internally mounted on the same isolation base with spring vibration isolation devices having a minimum static deflection of 1 inch. See Specification Section 23 05 48.13 “Vibration Control for HVAC” for specific requirements.

H. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."

1. Enclosure Type: Totally enclosed, fan cooled.
2. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.
5. Mount unit-mounted disconnect switches on exterior interior of unit.
6. Motors must be “matched” with variable frequency drives, one (1) VFD per fan. Motors and fans shall be selected and furnished by the air-handling unit manufacturer to meet specified performance requirements. All VFD’s for equipment under this specifications shall be sourced from one single VFD manufacturer.
7. Each VFD shall come with integral disconnect. Provide separate unit service disconnect switch upstream of VFD(s).
8. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

I. The fan section shall be provided with a convenience outlet (120V/1Ø), housekeeping drain, and marine grade light with guard. Convenience outlet shall be on separate circuit.

J. Outdoor air section shall be provided with a housekeeping drain and marine grade light with guard.

K. Variable Frequency Drives: See Section 23 05 14 “Variable Frequency Motor Controllers.”

1. Fan VFD for Dedicated Outdoor Air Units specified under this section shall be furnished without bypass controller.

L. Fans shall be tested, rated and certified in accordance with ANSI/AMCA Standard 210 for air delivery and in accordance with AMCA Standard 300 for sound power levels and shall bear the AMCA seal. The fan balancing process, including vibration limits and documentation, shall be performed in accordance with ANSI/AMCA Standard 204.

2.4 COIL SECTION

A. General Requirements for Coil Section:

1.

2. Comply with AHRI 410. Coil shall bear the AHRI label.

3. Manufacturer of coil shall be ISO 9002 certified.

4. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).

5. Coils shall not act as structural component of unit.

6. Provide access to coils from both sides of unit for service and cleaning.

7. Cooling coils, including headers and return bends shall be totally enclosed in casing.

8. Unit shall be provided with coil connections that extend a minimum of 5" beyond unit casing for ease of installation.

9. Drain and vent connections shall be provided exterior to unit casing. Coil connections must be factory sealed with grommets on interior and exterior and gasket sleeve between outer wall and liner where each pipe extends through the unit casing to minimize air leakage and condensation inside panel assembly.

10. Headers shall consist of seamless copper tubing to assure compatibility with primary surface. Headers to have intruded tube holes to provide maximum brazing surface for tube to header joint, strength, and inherent flexibility. Header diameter should vary with fluid flow requirements.

11. Fins shall have a minimum thickness of 0.0075” of copper plate construction for 100% outside air units

    a. Fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer.

    b. Tubes shall be mechanically expanded into the fins to provide a continuous primary to secondary compression bond over the entire finned length for maximum heat transfer rates. Bare copper tubes shall not be visible between fins

12. Cooling coil maximum height shall be 42 inches. For units that require coils higher than 42 inches, provide multiple coil sections of equal heights. Provide intermediate condensate drain pans and drain line to lower drain pan.

13. Cooling Coil casings shall be a formed channel frame of stainless steel and slide into a pitched track for fluid drainage.

14. Air Velocities: Units shall have a face velocity below 400 FPM on 100% O.A. unit.

2.5 AIR FILTRATION SECTION

A. General Requirements for Air Filtration Section. See Division 23 “Particulate Air Filtration.”

1. Comply with NFPA 90A and NFPA 90B.
2. Provide minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) greater than 13, according to ASHRAE 52.2.
3. Provide filter holding frames arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.
4. Provide filter gauges for each filter type.

B. ULTRAVIOLET LIGHT GERMICIDAL IRRADIATION (UVGI) SECTION General Requirements:

1. The UVGI surface irradiation system shall consist of heavy duty, factory assembled and tested light fixtures that emit short wave UVC light (200 nm –270 nm).

2. Constructed and tested for HVAC environments: UL listed at 55°F to 135°F with airflow velocities up to 1000 FPM. Independently tested to verify output and performance. UVGI system shall have UL Approval per Category Code ABQK (Accessories, Air Duct Mounted) UL Standards: UL153, UL1598 & UL1995.

3. Assembly shall consist of double ended UVC florescent lamp and housing, power source and sockets shall be UL Drip proof construction.

4. The enclosure shall be made of drip-proof construction from galvanized steel. The ballast shall be a self-contained electronic type. The enclosure shall include safety mechanical interlocks which do not allow the UV assembly to light unless installed on its track. The multiple UV assemblies shall connect via interlock.

5. UVC Lamp shall be a standard output hot cathode, low pressure T8, double ended UVC lamp. Lamps shall be constructed with a thick wall glass of soda barium UV transparent glass with a base of metal. Lamps shall have 5.5 milligrams or less of mercury.

6. Lamps shall produce adequate UV output and operate in environments of temperatures between 55°F to 135°F. Lamps shall produce a minimum of 80% of initial UV output at end of life (9000 hours minimum).

7. Power source shall be 120 VAC 60hz. Power connections shall be via a provided j-box or line cord from one end of the UV fixture. UV fixtures shall electrically connect via interlocks.

8. Installation shall be such that the cumulative sum length of UV fixtures end-to-end shall equal the coil width +/- three (3) inches. Modular coil system shall be installed and wired so that the entire surface of the coil and drain pan is bathed by UVC. System shall be installed using “tracks” to allow UV fixture to slide into place, for ease of access during installation and annual maintenance. System shall be installed 8"-20" (14" ideal) from coil surface. System shall be installed utilizing one row of lamps for every 48" of coil height. System shall incorporate safety “cut-off” switches on access doors

9. Manufacturer to provide and mount ultraviolet lights on the leaving air side of the cooling coil(s) and over the drain pan to meet GSA 2003 Facilities Standard - 5.9 HVAC Systems and Components and agency approved to UL category Code ABQK specification, HVAC Accessories, Air Duct Mounted

2.6 DAMPERS (PROVIDED BY AHU MANUFACTURER)

A. Dampers: See Division 23 Section “Instrumentation and Control for HVAC.”

B. For Damper Operators: Provided by BMS Contractor and specified in Division 23 Section "Instrumentation and Control for HVAC."

C. Dampers shall be provided by AHU manufacturer and shall be integral to AHU.

2.7 AIR-TO-AIR ENERGY RECOVERY

A. General Requirements: The air-to-air energy recovery section shall be provided by air handling unit manufacturer as integral part of unit.

B. See Division 23, Section "Air-to-Air Energy Recovery Equipment" for specific requirements.

C. Air handling unit manufacturer shall coordinate with energy recovery system manufacturer to determine length of section required for proper installation and operation of the system. Section length shown on drawings is minimum length required.

D. Provide access doors. Coordinate with energy recovery system manufacturer for door placement within the section to not interfere with air cleaner installation or operation.

2.8 AIRFLOW MEASURING SYSTEMS

A. See Division 23 “Instrumentation and Control for HVAC” for airflow measuring device specification.

B. Airflow measuring devices shall be furnished by BMS Contractor and installed by the air handling unit manufacturer and shall be integral to the AHU.

2.9 CAPACITIES AND CHARACTERISTICS

A. See mechanical drawings and schedule.

2.10 CONTROLS

A. Controls shall be provided by BMS Contractor.

B. For control devices and operational sequences refer to Division 23 Sections "Instrumentation and Control for HVAC" and BMS drawings for the "Sequence of Operations for HVAC Controls."

2.11 SOURCE QUALITY CONTROL

A. Fan Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.

B. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency. Rate performance according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating."

C. Water Coils: Factory tested to 300 psig according to AHRI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.1 EXAMINATION

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

B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

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

3.2 INSTALLATION

A. Equipment Mounting: Install air-handling units on 4-inch high concrete bases with additional steel framing to allow for cooling coil drain pipe trap assembly. Secure units to anchor bolts installed in concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-Place Concrete." Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration Controls for HVAC."

1. Minimum Deflection: 2 inches.
2. Install galvanized-steel plate to equally distribute weight over elastomeric pad.
3. 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.
4. Install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
5. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
6. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Suspended Units: Suspend and brace units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration Controls for HVAC."

C. Arrange installation of units to provide access space around air-handling units for service and maintenance.

D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

E. Install filter-gage, static-pressure taps upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum in accessible position. Provide filter gages on all filter banks, installed with separate static-pressure taps upstream and downstream of filters.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to air-handling unit to allow service and maintenance.

C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using minimum NPS 1½, ASTM B 88, Type M copper tubing. See details on drawings and extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Hot- and Chilled-Water Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

F. Connect duct to air-handling units with flexible connections. Comply with requirements in Division 23 Section "Air Duct Accessories."

3.4 FIELD QUALITY CONTROL

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

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Air Leak Test: The leakage test shall be done by the manufacturer, onsite, after the units are fully assembled.
2. Water Leak Test: After installation, fill water coils with water, and test coils and connections for leaks.
3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Photocatalytic Air Cleaner Operational Test: Pressurize housing to a minimum of 3-inch wg or to designed operating pressure, whichever is higher; test housing joints, door seals, and sealing edges of filter with soapy water to check for air leaks.
5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

E. Prepare test and inspection reports.

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. Verify that shipping, blocking, and bracing are removed.

3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
6. Verify that zone dampers fully open and close for each zone.
7. Verify that face-and-bypass dampers provide full face flow.
8. Verify that outdoor- and exhaust-air dampers open and close, and maintain minimum outdoor-air setting.
9. Comb coil fins for parallel orientation.
10. Verify that proper thermal-overload protection is installed for electric coils.
11. Install new, clean filters.
12. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

B. Starting procedures for air-handling units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace fan and motor pulleys as required to achieve design conditions.
2. Measure and record motor electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

3.6 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

3.7 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-handling units. Refer to General and Supplemental General Requirements Section "Demonstration and Training."

3.9 COMMISSIONING

A. Comply with commissioning process procedures and requirements as specified in Division 23 08 00 “HVAC System Commissioning,” and Division 01 General Requirements, in addition to the commissioning requirements in each section.

END OF SECTION 23 7433

SECTION 23 81 23 - COMPUTER-ROOM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Requirements Division 01, Division 23 Specification Sections, and Common Work Requirements for HVAC apply to the work specified in this Section.

1.2 SUMMARY

A. Section Includes:

1. Floor-mounted computer-room air conditioners, 6 tons and larger.
2. Floor-mounted computer-room air conditioners, 5 tons and smaller.
3. Ceiling-mounted computer-room air conditioners.
4. Console computer-room air conditioners.
5. Water detection system.

1.3 DEFINITION

A. BMS: Building management system.

1.4 SUBMITTALS

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

B. LEED V4 BD+C Submittals:

1. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
2. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with the latest edition of ASHRAE 62.1, Section 5 - "Systems and Equipment."

C. Shop Drawings: For computer-room air conditioners. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, safety, and control wiring.
3. Provide list of all BACnet points, functions and alarms available via integration with BMS.

D. Color Samples: For unit cabinet, discharge grille, and exterior louver and for each color and texture specified.

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

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

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

G. Field quality-control reports.

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

I. Warranty: Sample of special warranty.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
2. ASHRAE Compliance: Applicable requirements in the latest edition of ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."

C. ASHRAE/IESNA Compliance: Applicable requirements in the latest edition of ASHRAE/IESNA 90.1.

D. ASME Compliance: Fabricate and label water-cooled condenser shell to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

E. Sound Ratings: Based on AHRI 270 Standard

F. Performance based on AHRI 210/240 test conditions.

G. UL, CSA approved.

1.6 COORDINATION

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

B. Coordinate installation of computer-room air conditioners with computer-room access flooring Installer.

C. Coordinate in-row computer room air conditioners with computer room rack installer.

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

E. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of computer-room air conditioners that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.
2. Warranty Period for Humidifiers: Manufacturer's standard, but not less than three years from date of Substantial Completion.
3. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

1.8 EXTRA 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. Fan Belts: One set for each belt-driven fan.
2. Filters: One set of filters for each unit.

PART 2 - PRODUCTS

2.1 FLOOR-MOUNTED UNITS 6 TONS AND LARGER

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

1. Liebert Corporation.
2. Stulz-ATS.

B. Description: Packaged, factory assembled, prewired, and prepiped; consisting of cabinet, fans, filters, humidifier, and controls. Units arranged for Down flow or Up flow configuration as scheduled or shown.

C. Cabinet and Frame: Welded tubular steel with corrosion inhibitor, braced for rigidity, and supporting compressors and other mechanical equipment and fittings.

1. Doors and Access Panels: Galvanized steel with polyurethane gaskets, hinges, and concealed fastening devices.
2. Insulation: Thermally and acoustically insulate cabinet interior with minimum 1-inch-thick duct liner.
3. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in the latest edition of ASHRAE 62.1.
4. Finish of Exterior Surfaces: Baked-on, textured vinyl enamel; color as selected from manufacturer's standard colors.
5. Floor Stand: Welded tubular steel, with adjustable legs and vibration isolation pads.

D. Supply-Air Fan(s):

1. Electronically commutated (EC) motor.

E. Refrigeration System:

1. Compressors: Semihermetic reciprocating; with suction-gas-cooled, 1750-rpm motors; thermal overloads; oil sight glass; suction-line strainer; and reversible oil pumps; with oil strainer, internal motor overload protection, resilient suspension system, crankcase heater, manual-reset high-pressure switch, and pump-down low-pressure switch.
2. Compressors: Hermetic reciprocating; with oil strainer, internal motor overload protection, resilient suspension system, crankcase heater, manual-reset high-pressure switch, and pump-down low-pressure switch.
3. Compressors: Hermetic scroll; with oil strainer, internal motor overload protection, resilient suspension system, crankcase heater, manual-reset high-pressure switch, and pump-down low-pressure switch.
4. Refrigeration Circuits: Two; each with hot-gas mufflers, thermal-expansion valve with external equalizer, liquid-line solenoid valve, liquid-line filter-dryer, sight glass with moisture indicator, service shutoff valves, charging valves, and charge of refrigerant.
5. Refrigerant: R-407C or R-410A.
6. Refrigerant Evaporator Coil: Alternate-row or split-face-circuit, direct-expansion coil of seamless copper tubes expanded into aluminum fins.

   a. Mount coil assembly over stainless-steel drain pan complying with the latest edition of ASHRAE 62.1 and having a condensate pump unit with integral float switch, pump-motor assembly, condensate reservoir, check valve and minimum 20 ft head.

   b. Dual float for condensate pump to alarm on high water level.

7. Integral, Water-Cooled Refrigerant Condenser: Shell-and-tube type fabricated and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII. Single pass, counter flow brazed plate heat exchanger, with integral subcooler, 316 stainless steel, 450 psig working pressure with liquid-line stop valve and head-pressure-actuated, two-way regulating valve (minimum 150 psi working pressure). Terminate fluid connections outside cabinet. Cooling Medium: Water.

8. Insulated piping.

F. Hydronic Cooling Coil: Seamless copper tubes (0.020" minimum thickness) expanded into aluminum fins with modulating two-way control valve. Certified as per ARI Standard 410.

1. Cooling Medium: Water.
2. Control Valve: 150 lb rating.

a. Maximum Pressure Drop: 5 psig at design flow rate.
b. Close-Off (Differential) Pressure Rating: 100 percent of pressure differential across valve or 100 percent of total system (pump) head.

3. Mount coil assembly over stainless-steel drain pan complying with the latest edition of ASHRAE 62.1 and having a condensate pump unit with integral float switch, pump-motor assembly, condensate reservoir, check valve and minimum 20 ft head capability. Dual float for condensate pump to alarm on high water level.

4. AHRI certified per current Standard 410.

G. Electric-Resistance Heating Coil: Enclosed finned-tube electric elements arranged for SCR, with thermal safety switches, manual-reset overload protection, and branch-circuit overcurrent protection.

H. Extended-Surface, Disposable, Panel Filter: Pleated, lofted, nonwoven, reinforced cotton fabric; supported and bonded to welded-wire grid; enclosed in cardboard frame.

1. Thickness: 4 inches.
2. MERV (ASHRAE 52.2): 8.

I. Infrared Humidifier: High-intensity quartz lamps mounted above stainless-steel evaporator pan, serviceable without disconnecting water, drain, or electrical connections; prepiped and located in bypass airstream; with flush-cycle timer and solenoid drain valve.

J. Integral Electrical Controls: Unit-mounted electrical enclosure with piano-hinged door, grounding lug, combination magnetic starters with overload relays, circuit breakers and cover interlock, and fusible control-circuit transformer.

K. Independent Disconnect Switches: Non-locking type, unit mounted, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.

L. Electronic-Control System: Solid state, with start button, stop button, temporary loss of power indicator, manual-reset circuit breakers, temperature control, humidity control, and monitor panel.

1. Monitor Panel: Backlighted, with no visible indicator lights until operating function is activated; indicators include cooling, humidification, loss of airflow, change filters, high temperature, low temperature, high humidity, low humidity, high head pressure (each compressor), and low suction pressure (each compressor).
2. Temperature- and Humidity-Control Modules: Solid state, plug-in; with adjustable set point, push-to-test calibration check button, and built-in visual indicators to show mode of operation.
3. Location: Behind hinged door in front of unit; isolated from conditioned airstream to allow service while system is operating.

M. Microprocessor-Control System: Continuously monitors operation of process cooling system; continuously displays room temperature and room relative humidity; sounds alarm on system malfunction and simultaneously displays problem. If more than one malfunction occurs, system displays fault in sequence with room temperature and continues to display fault when malfunction is cleared until system is reset.

1. Malfunctions:

a. Power loss.
b. Loss of airflow.
c. Clogged air filter.
d. High room temperature.
e. Low room temperature.
f. High humidity.
g. Low humidity.
h. Smoke/fire.
i. Water under floor.
j. Supply fan overload.
k. Compressor No. 1 - Overload.
l. Compressor No. 1 - Low Pressure.
m. Compressor No. 1 - High Pressure.
n. Compressor No. 2 - Overload.
o. Compressor No. 2 - Low Pressure.
p. Compressor No. 2 - High Pressure.

2. Digital Display:

a. Control power on.
b. Humidifying.
c. Dehumidifying.
d. Compressor No. 1 - Operating.
e. Compressor No. 2 - Operating.

f. Heat operating.
g. Economy cooling.

3. Push buttons shall stop and start process cooling system, silence audible alarm, test indicators, and display room's relative humidity.
4. BMS Interface: Factory-installed hardware and software to enable the BMS to monitor, control, and display unit status and alarms.

a. Hardwired Points:

1) Monitoring: On-off status, common trouble alarm space temperature space relative humidity.
2) Control: On-off operation, space temperature set-point adjustment space relative humidity set-point adjustment.

b. Communication interface with the BMS shall enable the BMS operator to remotely control and monitor the unit from an operator workstation. Control features and monitoring points displayed locally at unit control panel shall be available through the BMS via BACnet integration protocol.

N. Added Control and Safety Functions: Integrated into unit control systems.

1. Automatic restart after power sags or outages to include programmable time delay on restart.
2. Smoke detector shall immediately shutdown units with local alarm dry contacts.
3. Firestat should immediately shutdown systems on high temperature alarm conditions.
4. Common Alarm terminals: Two sets to be wired to automatic switchover panel
5. Remote shutdown terminals: Two sets to be wired to automatic switchover panel and BMS.
6. Furnish leak detection for field installation hardwired to factory mounted controller with spare contacts for interface with BMS.

2.2 FLOOR-MOUNTED UNITS 5 TONS AND SMALLER

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following**:**
1. Liebert Corporation.
2. Stulz-ATS.

B. Description: Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, fan, filters, and controls; for vertical floor mounting in upflow or downflow configuration.

C. Cabinet and Frame: Welded tubular-steel frame with removable steel panels with baked-enamel finish, insulated with 1-inch-thick duct liner.

1. Floor Stand: Welded tubular steel, with adjustable legs and vibration isolation pads.

2. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in the latest edition of ASHRAE 62.1.

D. Supply-Air Fan:

1. Electronically commutated (EC) motor.

E. Refrigeration System:

1. Compressor: Hermetic, with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.
2. Refrigeration Circuit: Low-pressure switch, manual-reset high-pressure switch, thermal-expansion valve with external equalizer, sight glass with moisture indicator, service shutoff valves, charging valves, and charge of refrigerant.
3. Refrigerant: R-407C or R-410A.
4. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins, with two circuits, each with solenoid valve.

   a. Mount coil assembly over stainless-steel drain pan complying with the latest edition of ASHRAE 62.1 and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir. Dual float for condensate pump to alarm on high water level.

5. Integral, Water-Cooled Refrigerant Condenser: Shell-and-tube type fabricated and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII. Single pass, counter flow brazed plate heat exchanger, with integral subcooler, 316 stainless steel, 450 psig working pressure with liquid-line stop valve and head-pressure-actuated, two-way regulating valve (minimum 150 psi working pressure). Terminate fluid connections outside cabinet.
6. . Cooling Medium: Water

F. Hydronic Cooling Coil: Seamless copper tubes expanded into aluminum fins with modulating three-way control valve.

1. Cooling Medium: Water.

2. Mount coil assembly over stainless-steel drain pan complying with the latest edition of ASHRAE 62.1 and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir. Dual float for condensate pump to alarm on high water level.

3. Control Valve: 150 lb rating.

G. Electric-Resistance Heating Coil: Finned-tube electric elements with contactor and high-temperature-limit switches SCR controller.

H. Filter: 2-inch-thick, disposable, glass-fiber media.

1. MERV (ASHRAE 52.2): 8.

I. Infrared Humidifier: High-intensity quartz lamps mounted above stainless-steel evaporator pan, serviceable without disconnecting water, drain, or electrical connections; prepiped and located in bypass airstream; with flush-cycle timer and solenoid drain valve.

J. Disconnect Switch: Automatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.

K. Control System: Unit-mounted panel with main fan contactor, compressor contactor, compressor start capacitor, control transformer with circuit breaker, solid-state temperature and humidity control modules, time-delay relay, heating contactor, and high-temperature thermostat. Provide solid-state, wall-mounted control panel with start-stop switch, adjustable humidity set point, and adjustable temperature set point.

L. BMS Interface: Factory installed hardware and software to enable BMS to monitor, control and display unit status and alarms.

a. Hardwired Points Monitoring: On-off status, common trouble alarm space temperature and space humidity.

b. Control: On-off operation, space temperature set-point adjustment, space relative humidity set-point adjustment.

M. Communication interface with BMS shall enable the BMS operator to remotely control and monitor the unit from an operator workstation. Control features and monitoring points displayed locally at unit control panel shall be available through the BMS via BACnet integration protocol.

N. Furnish leak detection for field installation hardwired to factory mounted controller with spare contacts for interface with BMS.

2.3 CEILING-MOUNTED UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Liebert Corporation.
2. Stulz-ATS.

B. Description: Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, fan, filters, and controls; for horizontal ceiling mounting to fit T-bar ceiling opening of 24 by 48 inches.

C. Cabinet: Galvanized steel with baked-enamel finish, insulated with 1/2-inch-thick duct liner.

1. Integral factory-supplied aluminum supply and return grille to fit ceiling grid kit of 24 by 48 inches, with filter.
2. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in the latest edition of ASHRAE 62.1.

D. Supply-Air Fan: Forward curved, centrifugal, and directly driven by two-speed motor.

E. Refrigeration System:

1. Compressor: Hermetic, with oil strainer, internal motor overload protection, resilient suspension system, force feed lubrication, and crankcase heater.
2. Refrigeration Circuit: Low-pressure switch, manual-reset high-pressure switch, thermal-expansion valve with external equalizer, sight glass with moisture indicator, service shutoff valves, charging valves, and charge of refrigerant.
3. Refrigerant: R-407C or R-410A.
4. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins.

   a. Mount coil assembly over stainless-steel drain pan complying with the latest edition of ASHRAE 62.1 and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir. Dual float for condensate pump to alarm on high water level.

5. Remote Air-Cooled Refrigerant Condenser: Integral, copper-tube aluminum-fin coil with propeller fan, direct driven.
6. Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.

F. Hydronic Cooling Coil: Seamless copper tubes expanded into aluminum fins with two-way control valve.

1. Cooling Medium: Water.

2. Mount coil assembly over stainless-steel drain pan complying with the latest edition of ASHRAE 62.1 and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir. Dual float for condensate pump to alarm on high water level.

3. Control Valve: 150 lb rating.

G. Electric-Resistance Heating Coil: Finned-tube electric elements with contactor, dehumidification relay, and high-temperature-limit switches.

H. Filter: 2-inch-thick, disposable, glass-fiber media.

1. MERV (ASHRAE 52.2): 8.

I. Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders, and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.

1. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain with integral air gap.

2. Control: Fully modulating to provide gradual 0 to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.
3. Drain Cycle: Field-adjustable drain duration and drain interval.

J. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.

K. Control System: Unit-mounted panel with main fan contactor, compressor contactor, compressor start capacitor, control transformer with circuit breaker, solid-state temperature and humidity control modules, humidity contactor, time-delay relay, heating contactor, and high-temperature thermostat. Provide solid-state, wall-mounted control panel with start-stop switch, adjustable humidity set point, and adjustable temperature set point.

L. Communication interface with BMS shall be via BACnet protocol.

M. Furnish leak detection for field installation hardwired to factory mounted controller with spare contacts for interface with BMS.

2.4 CONSOLE UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Liebert Corporation.
2. Stulz-ATS.

B. Description: Split system consisting of evaporator section for floor or wall mounting and remote condensing section.

C. Evaporator Cabinet: Furniture-grade steel with baked-enamel finish; with front access and containing direct-drive centrifugal fans and two-speed motor.

1. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in the latest edition of ASHRAE 62.1.

D. Condenser Cabinet: Steel with baked-enamel finish and containing compressor and condenser.

E. Refrigeration System:

1. Compressor: Hermetic, with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.
2. Refrigeration Circuit: Filter/dryer, manual-reset high-pressure switch, thermal-expansion valve with external equalizer, sight glass with moisture indicator, service shutoff valves, charging valves, and charge of refrigerant.
3. Refrigerant: R-407C or R-410A.
4. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins.
5. Mount coil assembly over stainless-steel drain pan complying with the latest edition of ASHRAE 62.1 and having a condensate pump unit with integral float

switch, pump-motor assembly, and condensate reservoir. Dual float for condensate pump to alarm on high water level.

6. Remote Air-Cooled Refrigerant Condenser: Integral, copper-tube aluminum-fin coil with propeller fan, direct driven.
7. Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.

F. Hydronic Cooling Coil: Seamless copper tubes expanded into aluminum fins with modulating control valve.

1. Cooling Medium: Water.
2. Mount coil assembly over stainless-steel drain pan complying with the latest edition of ASHRAE 62.1 and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir. Dual float for condensate pump to alarm on high water level.

3. Control Valve: 150 lb rating.

G. Electric-Resistance Heating Coil: Finned-tube electric elements with contactor and high-temperature-limit switches.

H. Filter: 1-inch-thick, disposable, glass-fiber media.

1. MERV (ASHRAE 52.2): 8.

I. Electrode Steam Humidifier: Self-contained and microprocessor controlled; with replaceable cylinder.

J. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.

K. Control System: Unit-mounted panel with contactors, control transformer with circuit breaker, and solid-state temperature and humidity control modules. Provide solid-state, unit-mounted control panel with start-stop switch, adjustable humidity set point, and adjustable temperature set point.

L. Communication interface with BMS shall be via BACnet Protocol.

M. Furnish leak detectors for field installation hardwired to factory mounted controller with spare contacts for interface with BMS.

2.5 FAN MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."

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

2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.

2.6 WATER DETECTION SYSTEM

A. Basics of Design Product: Subject to compliance with requirements, provide a Liebert Corporation water detection system or an equivalent product by the manufacturer of the units being supplied.

B. Description: Complete water detection location and alarm system and display into its location and sound audible alarm.

C. Cable: plenum rated water detection cable installed below raised floor of computer room area. Include end cap terminator to complete circuit.

1. No single section of detection cable shall exceed 50 feet for ease of installation, or replacement if necessary.
2. Provide hold-down clips, attached to cables and installed 6 feet apart.

D. Display Panel: Wall mounted digital display panel, powered by 120 volts AC, with relay output activated on detection of water or cable fault.

1. Detect Water leak and/or cable fault and display its location and sound alarm (1 foot increments) up to 2000 feet away form start of cable run
2. Provide leader cable from display panel to first water detection cable segment with connector.

E. Site Location Map: Provide a graphic reference map showing actual cable layout with distance indications and room landmarks from beginning point of water detection cable run.

1. Indicate icon location points and distance increments.
2. Maps shall be made after actual testing for distance reading is completed
3. Map shall be framed under glass or otherwise enclosed and secured alongside display panel

F. Enter water detection system installation shall be serviced by the installing contractor for a period of one year from date of recorded startup.

2.7 CAPACITIES AND CHARACTERISTICS

A. As scheduled on drawings

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

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

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

3.2 INSTALLATION

A. Install computer-room air conditioners level and plumb, maintaining manufacturer's recommended clearances. Install according to AHRI Guideline B.

B. Computer-Room Air-Conditioner Mounting: Install using elastomeric pads. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

C. Suspended Computer-Room Air Conditioners: Install using continuous-thread hanger rods and spring hangers with vertical-limit stop of size required to support weight of computer-room air conditioner.

1. Comply with requirements for vibration isolation devices specified in ~~Division 23~~ Section 23 05 48 "Vibration ~~and Seismic~~ Controls for HVAC ~~Piping and Equipment~~." Fabricate brackets or supports as required.
2. Comply with requirements for hangers and supports specified in ~~Division 23~~ Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment.
3. Coordinate installation with ceiling construction."

D. Air-Cooled Refrigerant Condenser Mounting: Install using elastomeric mounts. Comply with requirements for vibration isolation devices specified in ~~Division 23~~ Section 23 05 48 "Vibration ~~and Seismic~~ Controls for HVAC ~~Piping and Equipment~~."

1. Minimum Deflection: 1/4 inch.

E. Install water detection system cables below raised floor of computer room area in accordance with the manufacturer’s recommendations.

F. Install water detection system display panel where indicated on drawings or where directed by the Architect / Engineer.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Water and Drainage Connections: Comply with applicable requirements in Division 22 Sections. Provide adequate connections for water-cooled units, condensate drain, and humidifier flushing system.

D. Chilled water Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping." Provide shutoff valves in water inlet and outlet piping on water-cooled units.

E. Refrigerant Piping: Comply with applicable requirements in Division 23 Section "Refrigerant Piping." Provide shutoff valves and piping.

3.4 FIELD QUALITY CONTROL

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

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
2. After installing computer-room air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Computer-room air conditioners will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

F. After startup service and performance test, change filters and flush humidifier.

G. Water Detection System: Perform a complete functional test of the system after installation.

1. Ascertain that equipment has suffered no impairment of performances since tested in factory and that installation is in accordance with the manufacturer's specifications.
2. Tests shall include manufacturer's routine site acceptance tests.
3. The manufacturer shall be responsible for any damage to equipment resulting from his own testing.
4. Engage Factory-authorized technicians for sufficient time to carry out component acceptance, start-up, on-site testing and one (1) day of operational training. Training shall be scheduled at the owner's convenience at any time after acceptance of the equipment.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

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

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

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain computer-room air conditioners.

3.7 RELATED WORK TO BE INCLUDED BY VENDOR FOR A.C. EQUIPMENT

A. The Commissioning Specifications contain additional vendor and contractor requirements regarding factory and on-site testing, warrantees, submittals, operation and maintenance manuals, start-up responsibilities and operator training. If there is a discrepancy, the more stringent requirement shall apply.

END OF SECTION 23 81 23

SECTION 23 81 26 - SPLIT SYSTEM AIR CONDITIONERS

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. Basic Requirements: Provisions of Section 23 00 10, “Basic ~~Mechanical~~ HVAC Requirements” are part of this Section.

1.2 WORK INCLUDED

A. Packaged Split System Air Conditioning Unit, Air Cooled.

1.3 QUALITY ASSURANCE

A. All electrical components shall be UL listed or labeled.

B. All direct expansion coils shall be ARI certified.

C. All components in the air stream shall conform to the NFPA 90A Flame/Smoke/Fire contribution of 25/50/0.

D. All electrical devices shall conform to NEMA standards.

E. All wiring shall conform to the NEC.

F. After installation, the manufacturer's representative of all equipment provided in this section shall certify in writing to the Owner's representative that the equipment has been assembled and installed within the guidelines of the manufacturer's written installation instructions and that its performance meets or exceeds the operating characteristics specified and/or scheduled.

G. Starting of Mechanical Systems:

1. Provide material and labor to perform start-up of each respective item of equipment and system prior to beginning of test, adjust and balance procedures.
2. Provide labor to assist the Owner's Representative in acceptance review.

3. Provide point by point system check-out. Submit results in tabulated form by system. Include this data as part of Operation and Maintenance Manuals.
4. Provide information and assistance and cooperate with test, adjust and balance services.
5. Comply strictly with manufacturer's recommended procedures in starting up mechanical systems.
6. Provide such periodic continuing adjustment services as necessary to ensure proper functioning of mechanical systems until acceptance and up to 1 full year after date of Owner acceptance.

1.4 SUBMITTALS

A. Submit dimension drawings, performance and product data for acceptance. Include fan curves with the system design point plotted, and clearly indicate fan efficiency.

B. Product data, along with installation operation and maintenance instructions, shall be included in the operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Packaged Split System Air Conditioning Unit, Air Cooled:

1. Carrier
2. Daikin Applied
3. Lennox

2.2 EQUIPMENT

A. Packaged Split System Air Conditioning Unit, Air Cooled:

1. Provide an air-to-air electric condensing unit (outdoor unit) in combination with a direct expansion fan coil (indoor unit), fully piped, wired and operational. Condensing unit shall be designed, tested, and fully charged for use with R-410A refrigerant. The system shall have a minimum SEER rating of 16. Combination unit shall be designed certified by UL and ARI, and complete package to have one (1) year limited parts warranty and compressor to have a ten (10) year extended parts warranty.

2. Outdoor Section:

   a. Cabinet shall be constructed of commercial grade galvanized steel, primed and painted to manufacturer's standard color. Access doors with neoprene gaskets shall be provided to allow access to coil, fan, motor and controls. Mounting legs shall be provided.
   b. Compressor shall be high efficiency hermetic reciprocating type or scroll type equipped with a crankcase heater, automatically reversible oil pump, internal high pressure protection, and internal vibration isolation. Compressor motor shall have both thermal and current sensitive overload protection.
   c. Outdoor coil shall be constructed of copper tubing with mechanically bonded aluminum fins having all joints brazed, factory installed coil refrigerant metering device to be mounted on unit liquid service valve, with device internal components to be removable for cleaning or replacement. Coil to be protected by a vinyl coated grille.
   d. Outdoor fan shall be propeller type, direct driven, balanced statically and dynamically, and arranged for vertical air discharge. Fan shall be weatherproofed and approved for outdoor use. Fan motor shall be factory lubricated and internally protected.
   e. Controls shall provide compressor short cycle protection and shall prevent compressor restart for a minimum of five minutes after shutdown. Liquid line low pressure switch, suction line accumulator with positive oil return, pressure relief switch and a loss of pressure indicator shall be provided.
   f. Unit shall be equipped with filter drier, schrader access valves, refrigerant check valves in the refrigerant line, hot gas piping connection and valving, and expansion devices with interconnecting tubing to provide proper refrigerant flow control.
   g. Low refrigerant and high refrigerant cut-outs to be arranged in lock out circuit for manual reset. Control wiring terminal board and 24 volt control circuit transformer to be provided. Terminal board shall be designed to match indoor unit terminal board and furnished complete with factory wiring from board to all internal components and accessory thermostat terminals for standardized point-to-point connectors.
   h. Units with multiple compressors shall have independent refrigerant circuiting.
   i. Comply with the latest edition of ASHRAE/IESNA 90.1, "Energy Standard for Buildings except Low-Rise Residential Buildings."

3. Indoor Section:

   a. Cabinet shall be constructed of commercial grade galvanized steel, primed and painted to manufacturer's standard color, and insulated with fireproof, permanent, odorless glass fiber material. Access to be all components shall be provided with neoprene gasketed access panel(s).
   b. Indoor coil shall be constructed of copper tubing with mechanically bonded

aluminum fins having all joints brazed. Factory installed refrigerant metering device, refrigerant line fittings which permit mechanical connection on the liquid line and female sweat or mechanical connection on the gas line, and condensate pan with primary and auxiliary drain connections shall be provided. Unit shall also be equipped with hot gas reheat coil installed in the unit.

c. Fan shall be forward curved, centrifugal type, driven by factory lubricated single speed, three phase fan motor complete with internal overload protection, and resiliently mounted. Fan shall have horizontal air discharge or vertical air discharge as shown on the Contract Documents.

d. Unit shall be provided with factory installed electric heater for supplemental heating to mount in discharge air passage. Elements to be of heavy duty nichrome internally delta-connected on three phase. Heater to have line break high limit controls.

e. Certain units require multiple power connections for energy management purposes and are indicated on the schedules. Coordinate this requirement.

f. Unit shall be provided with 1 inch medium efficiency throwaway filters. Initial and one replacement set to be provided with unit. Filter retaining rack to be arranged for removal and replacement in space allotted.

4. Unit Accessories:

a. Control equipment and sequence of operation are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."

b. Thermostat: Low voltage with subbase to control compressor and evaporator fan.

c. Automatic-reset timer to prevent rapid cycling of compressor.

d. Refer to Schedules shown on the Contract Documents.

PART 3 - EXECUTION

3.1 GENERAL

A. Packaged Split System Air Conditioning Unit, Air Cooled:

1. Install in accordance with manufacturer's recommendations.
2. All openings made in walls or the roof the piping/electrical shall be patched and sealed completely, using materials of similar to existing type construction, to the Owner's satisfaction.
3. All refrigerant piping shall follow refrigerant piping techniques.
4. Condensate traps shall be minimum 4 inches deep and shall be field installed. Install plug in condensate drain on opposite side of unit from traps. Condensate drain connection shall be not less than 3/4".
5. All wiring shall comply with applicable local and national codes. Final connections shall be made with Liquid-tight Flexible Metal Conduit (LFMC) for ease in removal.
6. Maintain necessary access space for filter change and normal maintenance. Piping and electrical connections shall be so located as to eliminate any interference with removal and replacement of filter.
7. Maintain space clearances around heat pump per manufacturer's recommendation.
8. After installation of unit, all interconnecting piping, controls and wiring, check each unit for satisfactory operation of fan on continuous and automatic control setting, unit operation on cooling, change over and heating and so indicate on tag pasted on unit indicating: "Checked for proper operation on __Date___ by __Name__."
9. Insert installation and maintenance instructions and parts lists in a one inch ring binder marked "OPERATION AND MAINTENANCE INSTRUCTIONS" and furnish to Owner. (See Section 01 78 00 – Closeout Submittals for other requirements.)
10. Manufacturer shall review the drawings for piping distances. Contractor shall provide pipe sizes and any necessary accessories required by the Manufacturer as the result of their review.

END OF SECTION 23 81 26

SECTION 23 81 26.13 - SMALL CAPACITY SPLIT SYSTEM AIR CONDITIONERS

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. Basic Requirements: Provisions of Section 23 00 10, Basic Mechanical Requirements are part of this Section.

1.2 SYSTEM DESCRIPTION

A. The air conditioning system shall be a ductless split system series. The system shall consist of a slim silhouette, compact, wall mounted indoor fan coil section with wireless remote controller and a slim silhouette horizontal discharge outdoor unit which shall be of an inverter driven air conditioner design. The system shall have a minimum SEER rating of 18.

B. Manufacturers

1. Mitsubishi Mr. Slim
2. Daikin Applied

1.3 QUALITY ASSURANCE

A. The units shall be tested by a Nationally Recognized Testing Laboratory (NRTL) and shall bear the ETL label.

B. All wiring shall be in accordance with the National Electrical Code (N.E.C.).

C. The units shall be rated in accordance with Air-conditioning Refrigeration Institute's (ARI) Standard 210 and bear the ARI Certification label.

D. The units shall be manufactured in a facility registered to ISO 9001 and ISO 14001, which is a set of standards applying to environmental protection set by the International Standard Organization (ISO).

E. A dry air holding charge shall be provided in the indoor section.

F. System efficiency shall meet or exceed 18 SEER when part of a 1:1 (indoor/outdoor) system.

G. Delivery, Storage and Handling

1. Unit shall be stored and handled according to the manufacturer’s recommendations.
2. The wireless controller shall be shipped inside the carton with the indoor unit and able to withstand 105°F storage temperatures and 95% relative humidity without adverse effect.

H. Warranty

1. The units shall have a manufacturer’s parts and defects warranty for a period one (1) year from date of Substantial Completion. The compressor shall have a warranty of ten (10) years from date of Substantial Completion. If, during this period, any part should fail to function properly due to defects in workmanship or material, it shall be replaced or repaired at the discretion of the manufacturer. This warranty does not include labor.

PART 2 – PRODUCTS

2.1 INDOOR UNIT

A. General: The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, an emergency operation function and a test run switch. Indoor unit shall be charged with dry air before shipment from factory.

B. Unit Cabinet:

1. The casing shall have a white finish.
2. Multi directional drain and refrigerant piping, offering three (3) direction pipe alignment for all refrigerant piping and two (2) direction pipe alignment for condensate draining shall be standard.
3. There shall be a separate back plate that secures the indoor unit firmly to the wall.

C. Fan:

1. The evaporator fan shall be an assembly with a line-flow fan direct driven by a single motor.
2. The fan shall be statically and dynamically balanced and run on a motor with permanently lubricated bearing.

3. A manual adjustable guide vane shall be provided with the ability to change the airflow from side to side (left to right).
4. An integral, motorized air sweep flow louver shall provide for uniform air distribution.
5. The indoor fan shall consist of three (3) speeds: High, Medium and Low.

D. Filter

1. Return air shall be filtered by means of easily removed, washable, Catechin Antioxidant Pre-filter and an anti-allergy enzyme filter – blue

E. Coil

1. The evaporator coil shall be of nonferrous construction with smooth plate fins on copper tubing.
2. The tubing shall have inner groves for high efficiency heat exchange
3. All tube joints shall be brazed with phoscopper or silver alloy.
4. The coils shall be pressure tested at the factory.
5. A condensate pan and drain shall be provided under the coil.

F. Electrical:

1. The unit electrical power shall be 208-230 volts, 1-phase, 60 hertz.
2. The system shall be equipped with A-Control – a system allowing the indoor unit to be powered directly from the outdoor unit using a 3-wire connection plus ground.
3. The indoor unit shall not have any supplemental electrical heat elements.
4. The outdoor unit shall be equipped with Pulse Amplitude Modulation (PAM) control for efficiency.

G. Control:

1. The unit shall have a wireless controller to perform input functions necessary to operate the system.
2. The indoor unit shall have the option of a field installed hard-wired remote controller.
3. The controller shall consist of a Power On/Off switch, Mode Selector, Temperature Setting, Timer Control, Fan Speed Select and Auto Vane selector.
4. The indoor unit shall perform Self-diagnostic Function, Test Run switching and Check Mode switching.
5. Temperature changes shall be by 1ºF increments with a range of 65-87ºF.
6. The microprocessor located in the indoor unit shall have the capability of sensing return air temperature and indoor coil temperature, receiving and processing commands from the wireless or wired controller, providing emergency operation and controlling the outdoor unit.
7. The indoor units shall be capable of working with single-zone or multi-zone outdoor units

8. The system shall be capable of automatically restarting when the power is restored after power interruption.
9. Control system shall control the continued operation of the air sweep louvers, as well as provide On/Off, System/Mode function.

2.2 OUTDOOR UNIT

A. General: The outdoor units are specifically designed to work with the MSY indoor units. The units must have a powder coated finish. The outdoor unit shall be completely factory assembled, piped and wired. Each unit shall be run tested at the factory.

B. Unit Cabinet: The casing shall be fabricated of galvanized steel, bondenized, finished with an electrostatically applied, thermally fused acrylic or polyester powder coating for corrosion protection.

C. Coil:

1. The condenser coil shall be of nonferrous construction with lanced or corrugated plate fins on copper tubing.
2. The coil shall be protected with an integral metal guard.
3. Refrigerant flow from the condenser shall be controlled by means of a metering orifice.

D. Compressor:

1. The compressor motor shall be direct current (DC).
2. The compressor shall be of a high performance hermetic, inverter driven, variable speed rotary type.
3. The outdoor unit shall have an accumulator.
4. The compressor will be equipped with an internal thermal overload.
5. The outdoor unit must have the ability to operate with a maximum height difference of 35 feet and have refrigerant tubing length of 65 feet between indoor and outdoor units without the need for line size changes, traps or additional oil.
6. The compressor shall be mounted to avoid the transmission of vibration.

E. Electrical:

1. The unit electrical power shall be 208/230 volts, 1 phase, 60 hertz.
2. The unit shall be capable of satisfactory operation within voltage limits of 198 volts to 253 volts.
3. The outdoor unit shall be controlled by the microprocessor located in the indoor unit and outdoor unit.

PART 3 – EXECUTION

3.1 GENERAL

A. Each system shall perform in accordance to the ratings shown on the drawing schedule and as per manufacturers latest installation instructions.

END OF SECTION 23 81 26.13

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. This Section includes the following types of water-source heat pumps:
   1. Concealed horizontal or vertical units, larger than 6 tons.

1.3 ACTION SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each model.

B. LEED Submittals:

   1. Product Data for Credit EA 4: Documentation indicating that equipment and refrigerants comply.

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

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

D. Samples for Initial Selection: For units with factory-applied color finishes.

E. Samples for Verification: For each type of unit indicated.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

   1. Structural supports.
   2. Piping rough-in requirements.
   3. Wiring rough-in requirements, including spaces reserved for electrical equipment.

B. Product Certificates: For each type of water-source heat pump, signed by product manufacturer.

C. Field quality-control test reports.

D. Warranty: Special warranty specified in this Section.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For water-source heat pumps to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of water-source heat pumps and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

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

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

C. ASHRAE Compliance:

1. ASHRAE 15.
2. Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. Comply with NFPA 70.

F. Comply with safety requirements in UL 484 for assembly of free-delivery water-source heat pumps.

1.7 COORDINATION

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

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of water-source 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 MANUFACTURERS

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

1. Carrier Corporation.
2. ClimateMaster, Inc.
3. FHP Manufacturing Inc.
4. McQuay International.
5. Trane.

2.2 CONCEALED WATER-SOURCE HEAT PUMPS, LARGER THAN 6 TONS (21 kW)

A. Description: Packaged water-source heat pump with temperature controls; factory assembled, tested, and rated according to ARI-ISO-13256-1.

B. Cabinet and Chassis: Galvanized-steel casing with the following features:

1. Access panel for access and maintenance of internal components.
2. Knockouts for electrical and piping connections.
3. Cabinet Insulation: Glass-fiber liner, 1/2 inch thick, complying with UL 181.

C. Water Circuit:

1. Refrigerant-to-Water Heat Exchanger:

   a. Coil-in-shell heat exchanger with copper water tube with enhanced heat-transfer surfaces inside a steel shell; both shell and tube leak tested to 450 psig on refrigerant side and 400 psig on water side. Factory mount heat exchanger in unit on resilient rubber vibration isolators.

2. Water Regulating Valves: Limit water flow through refrigerant-to-water heat exchanger, and control head pressure on compressor during cooling and heating. Valves shall close when heat-pump compressor is not running.
3. Motorized Water Valve: Stop water flow through the unit when compressor is off.

D. Refrigerant Circuit Components:

1. Sealed Refrigerant Circuit: Minimum of 2 circuits required for units 10 tons (35 kW) and larger. Intertwine circuits in refrigerant to air coil.

    a. Charge with R-410A refrigerant.

2. Filter-Dryer: Factory installed to clean and dehydrate each refrigerant circuit.
3. Charging Connections: Service fittings on suction and liquid for charging and testing on each circuit.
4. Reversing Valve: Pilot-operated sliding-type valve designed to be fail-safe in heating position with replaceable magnetic coil.
5. Compressor: Hermetic scroll compressor installed on vibration isolators housed in an acoustically treated enclosure with factory-installed safeties as follows:

    a. Antirecycle timer.
    b. High-pressure cutout.
    c. Low-pressure cutout or loss of charge switch.
    d. Internal thermal-overload protection.
    e. Freezestat to stop compressor if water-loop temperature in refrigerant-to-water heat exchanger falls below 35 deg F.

6. Refrigerant Piping Materials: ASTM B 743 copper tube with wrought-copper fittings and brazed joints.
7. Pipe Insulation: Refrigerant minimum 3/8-inch- thick, flexible elastomeric insulation on piping exposed to airflow through the unit. Maximum 25/50 flame-spread/smoke-development indexes per ASTM E 84.
8. Refrigerant Metering Device: Capillary tube.
9. Refrigerant Metering Device: Thermal expansion valve to allow specified operation with entering-water temperatures from 25 to 125 deg F.
10. Hot-Gas Reheat Valve: Pilot-operated sliding-type valve with replaceable magnetic coil.

E. Hot-Gas Reheat: Reheat valve diverts refrigerant hot gas to reheat coil when remote humidistat calls for dehumidification.

F. Hot-Gas Bypass: Include constant pressure expansion valve, solenoid valve, and controls to maintain continuous refrigeration system operation at 10 percent of full load on lead compressor.

G. Control equipment and sequence of operation are specified in Division 23 Sections "Instrumentation and Controls for HVAC" and "Sequence of Operations for HVAC Controls."

H. Controls:

1. Basic Unit Controls:

    a. Low- and high-voltage protection.
    b. Overcurrent protection for compressor and fan motor.
    c. Random time delay, three to ten seconds, start on power-up.
    d. Time delay override for servicing.

e. Control voltage transformer.

2. Terminal Controller:

a. Scheduled operation for occupied and unoccupied periods on [**7**] [**365**]-day clock with minimum 4 programmable periods per day.
b. Remote control panel to contain programmable timer and LED for fault condition.
c. Compressor disable relay to stop compressor operation for demand limiting or switch to unoccupied operation.
d. Automatic restart after five minutes if fault clears. Lockout after three attempts to restart following fault. Indicate fault for service technician.
e. Backup for volatile memory.

3. BAS interface requirements as further described in Division 23 Sections "Instrumentation and Controls for HVAC" and "Sequence of Operations for HVAC Controls."

a. Interface relay for scheduled operation.
b. Interface relay to provide indication of fault at central workstation.
c. Provide BAC-net interface for central BAS workstation for the following functions:

1) Set-point adjustment for set points identified in this Section.
2) Start/stop and operating status of heat-pump unit.
3) Occupied and unoccupied schedules.

I. Electrical Connection: Single electrical connection with fused disconnect.

2.3 HOSE KITS

A. General: Hose kits shall be designed for minimum 400 psig working pressure, and operating temperatures from 33 to 211 deg F. Tag hose kits to equipment designations.

B. Hose: Minimum diameter, equal to water-source heat-pump connection size.

C. Isolation Valves: Two-piece bronze-body ball valves with stainless-steel ball and stem and galvanized-steel lever handle. Provide valve for supply and return. If balancing device is combination shutoff type with memory stop, the isolation valve may be omitted on the return.

D. Strainer: Y-type with blowdown valve in supply connection.

E. Balancing Device: Mount in return connection. Include meter ports to allow flow measurement with differential pressure gage.

1. Automatic balancing valve, factory set to operate within 10 percent of design flow rate over a 40:1 differential pressure range of 2 to 80 psig.

2. Manual, calibrated-orifice balancing valve.
3. Manual, venturi-type balancing valve.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of water-source heat pumps.

B. Examine roughing-in for piping and electric installations for water-source heat pumps to verify actual locations of piping connections and electrical conduit before installation.

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

3.2 INSTALLATION

A. Equipment Mounting: Install water-source heat pumps on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases specified in Division 03 Section "Cast-in-Place Concrete".

1. Coordinate sizes and locations of concrete bases with actual equipment provided.
2. Construct concrete bases 4 inches high and extend base not less than 6 inches in all directions beyond the maximum dimensions of water-source heat pump unless otherwise indicated.
3. 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.
4. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
5. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
6. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Install wall-mounting thermostats, humidistats, and switch controls in electrical outlet boxes at heights to match lighting controls or as required in Division 23 Section "Instrumentation and Control for HVAC."

3.3 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Connect supply and return hydronic piping to heat pump with unions and shutoff valves.

B. Install electrical devices furnished by manufacturer but not specified to be factory mounted.

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

D. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

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

B. Perform the following field tests and inspections and prepare test reports:

1. After installing water-source heat pumps and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.5 STARTUP SERVICE

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

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

1. Inspect for visible damage to unit casing.
2. Inspect for visible damage to compressor, coils, and fans.
3. Inspect internal insulation.
4. Verify that labels are clearly visible.
5. Verify that clearances have been provided for servicing.
6. Verify that controls are connected and operable.
7. Adjust vibration isolators.
8. Start unit according to manufacturer's written instructions.
9. Complete startup sheets and attach copy with Contractor's startup report.

10. Inspect and record performance of interlocks and protective devices; verify sequences.
11. Operate unit for an initial period as recommended or required by manufacturer.
12. Inspect controls for correct sequencing of refrigeration and normal and emergency shutdown.

3.6 ADJUSTING

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

3.7 CLEANING

A. After completing installation of exposed, factory-finished water-source heat pumps, inspect exposed finishes and repair damaged finishes.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain water-source heat pumps. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 238146

SECTION 23 81 46.01 - WATER SOURCE UNITARY HEAT PUMPS

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. This Section includes the following types of water-source heat pumps:
   1. Concealed horizontal or vertical units, larger than 6 tons.

1.3 ACTION SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each model.

B. LEED Submittals:

   1. Product Data for Credit EA 4: Documentation indicating that equipment and refrigerants comply.

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

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

D. Samples for Initial Selection: For units with factory-applied color finishes.

E. Samples for Verification: For each type of unit indicated.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

   1. Structural supports.
   2. Piping rough-in requirements.
   3. Wiring rough-in requirements, including spaces reserved for electrical equipment.

B. Product Certificates: For each type of water-source heat pump, signed by product manufacturer.

C. Field quality-control test reports.

D. Warranty: Special warranty specified in this Section.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For water-source heat pumps to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of water-source heat pumps and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

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

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

C. ASHRAE Compliance:

1. ASHRAE 15.
2. Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. Comply with NFPA 70.

F. Comply with safety requirements in UL 484 for assembly of free-delivery water-source heat pumps.

1.7 COORDINATION

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

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of water-source 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 MANUFACTURERS

A. Available manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified:
1. Carrier Corporation.
2. ClimateMaster, Inc.
3. FHP Manufacturing Inc.
4. McQuay International.
5. Trane.

2.2 CONCEALED WATER-SOURCE HEAT PUMPS, LARGER THAN 6 TONS (21 kW)

A. Description: Packaged water-source heat pump with temperature controls; factory assembled, tested, and rated according to ARI-ISO-13256-1.

B. Cabinet and Chassis: Galvanized-steel casing with the following features:

1. Access panel for access and maintenance of internal components.
2. Knockouts for electrical and piping connections.
3. Cabinet Insulation: Glass-fiber liner, 1/2 inch thick, complying with UL 181.

C. Water Circuit:

1. Refrigerant-to-Water Heat Exchanger:

a. Coil-in-shell heat exchanger with copper water tube with enhanced heat-transfer surfaces inside a steel shell; both shell and tube leak tested to 450 psig on refrigerant side and 400 psig on water side. Factory mount heat exchanger in unit on resilient rubber vibration isolators.

2. Water Regulating Valves: Limit water flow through refrigerant-to-water heat exchanger, and control head pressure on compressor during cooling and heating. Valves shall close when heat-pump compressor is not running.
3. Motorized Water Valve: Stop water flow through the unit when compressor is off.

D. Refrigerant Circuit Components:

1. Sealed Refrigerant Circuit: Minimum of 2 circuits required for units 10 tons (35 kW) and larger. Intertwine circuits in refrigerant to air coil.

a. Charge with R-410A refrigerant.

2. Filter-Dryer: Factory installed to clean and dehydrate each refrigerant circuit.
3. Charging Connections: Service fittings on suction and liquid for charging and testing on each circuit.
4. Reversing Valve: Pilot-operated sliding-type valve designed to be fail-safe in heating position with replaceable magnetic coil.

5. Compressor: Hermetic scroll compressor installed on vibration isolators housed in an acoustically treated enclosure with factory-installed safeties as follows:

    a. Antirecycle timer.
    b. High-pressure cutout.
    c. Low-pressure cutout or loss of charge switch.
    d. Internal thermal-overload protection.
    e. Freezestat to stop compressor if water-loop temperature in refrigerant-to-water heat exchanger falls below 35 deg F.

6. Refrigerant Piping Materials: ASTM B 743 copper tube with wrought-copper fittings and brazed joints.
7. Pipe Insulation: Refrigerant minimum 3/8-inch- thick, flexible elastomeric insulation on piping exposed to airflow through the unit. Maximum 25/50 flame-spread/smoke-development indexes per ASTM E 84.
8. Refrigerant Metering Device: Capillary tube.
9. Refrigerant Metering Device: Thermal expansion valve to allow specified operation with entering-water temperatures from 25 to 125 deg F.
10. Hot-Gas Reheat Valve: Pilot-operated sliding-type valve with replaceable magnetic coil.

E. Hot-Gas Reheat: Reheat valve diverts refrigerant hot gas to reheat coil when remote humidistat calls for dehumidification.

F. Hot-Gas Bypass: Include constant pressure expansion valve, solenoid valve, and controls to maintain continuous refrigeration system operation at 10 percent of full load on lead compressor.

G. Control equipment and sequence of operation are specified in Division 23 Sections "Instrumentation and Controls for HVAC" and "Sequence of Operations for HVAC Controls."

H. Controls:

1. Basic Unit Controls:

    a. Low- and high-voltage protection.
    b. Overcurrent protection for compressor and fan motor.
    c. Random time delay, three to ten seconds, start on power-up.
    d. Time delay override for servicing.
    e. Control voltage transformer.

2. Terminal Controller:

    a. Scheduled operation for occupied and unoccupied periods on [**7**] [**365**]-day clock with minimum 4 programmable periods per day.
    b. Remote control panel to contain programmable timer and LED for fault condition.
    c. Compressor disable relay to stop compressor operation for demand limiting or switch to unoccupied operation.
    d. Automatic restart after five minutes if fault clears. Lockout after three attempts to restart following fault. Indicate fault for service technician.
    e. Backup for volatile memory.

3. BAS interface requirements as further described in Division 23 Sections "Instrumentation and Controls for HVAC" and "Sequence of Operations for HVAC Controls."

    a. Interface relay for scheduled operation.

b. Interface relay to provide indication of fault at central workstation.
c. Provide BAC-net interface for central BAS workstation for the following functions:

1) Set-point adjustment for set points identified in this Section.
2) Start/stop and operating status of heat-pump unit.
3) Occupied and unoccupied schedules.

I. Electrical Connection: Single electrical connection with fused disconnect.

2.3 HOSE KITS

A. General: Hose kits shall be designed for minimum 400 psig working pressure, and operating temperatures from 33 to 211 deg F. Tag hose kits to equipment designations.

B. Hose: Minimum diameter, equal to water-source heat-pump connection size.

C. Isolation Valves: Two-piece bronze-body ball valves with stainless-steel ball and stem and galvanized-steel lever handle. Provide valve for supply and return. If balancing device is combination shutoff type with memory stop, the isolation valve may be omitted on the return.

D. Strainer: Y-type with blowdown valve in supply connection.

E. Balancing Device: Mount in return connection. Include meter ports to allow flow measurement with differential pressure gage.

1. Automatic balancing valve, factory set to operate within 10 percent of design flow rate over a 40:1 differential pressure range of 2 to 80 psig.
2. Manual, calibrated-orifice balancing valve.
3. Manual, venturi-type balancing valve.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of water-source heat pumps.

B. Examine roughing-in for piping and electric installations for water-source heat pumps to verify actual locations of piping connections and electrical conduit before installation.

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

3.2 INSTALLATION

A. Equipment Mounting: Install water-source heat pumps on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases specified in Division 03 Section "Cast-in-Place Concrete".

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

2. Construct concrete bases 4 inches high and extend base not less than 6 inches in all directions beyond the maximum dimensions of water-source heat pump unless otherwise indicated.
3. 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.
4. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
5. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
6. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Install wall-mounting thermostats, humidistats, and switch controls in electrical outlet boxes at heights to match lighting controls or as required in Division 23 Section "Instrumentation and Control for HVAC."

3.3 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Connect supply and return hydronic piping to heat pump with unions and shutoff valves.

B. Install electrical devices furnished by manufacturer but not specified to be factory mounted.

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

D. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

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

B. Perform the following field tests and inspections and prepare test reports:

1. After installing water-source heat pumps and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.5 STARTUP SERVICE

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

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

1. Inspect for visible damage to unit casing.
2. Inspect for visible damage to compressor, coils, and fans.
3. Inspect internal insulation.
4. Verify that labels are clearly visible.
5. Verify that clearances have been provided for servicing.
6. Verify that controls are connected and operable.
7. Adjust vibration isolators.
8. Start unit according to manufacturer's written instructions.
9. Complete startup sheets and attach copy with Contractor's startup report.
10. Inspect and record performance of interlocks and protective devices; verify sequences.
11. Operate unit for an initial period as recommended or required by manufacturer.
12. Inspect controls for correct sequencing of refrigeration and normal and emergency shutdown.

3.6 ADJUSTING

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

3.7 CLEANING

A. After completing installation of exposed, factory-finished water-source heat pumps, inspect exposed finishes and repair damaged finishes.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain water-source heat pumps. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 238146

SECTION 23 81 46.01 - WATER SOURCE UNITARY HEAT PUMPS

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. This Section includes the following types of water-source heat pumps:
   1. Concealed horizontal or vertical units, larger than 6 tons.

1.3 ACTION SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each model.

B. LEED Submittals:

   1. Product Data for Credit EA 4: Documentation indicating that equipment and refrigerants comply.

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

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

D. Samples for Initial Selection: For units with factory-applied color finishes.

E. Samples for Verification: For each type of unit indicated.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

   1. Structural supports.
   2. Piping rough-in requirements.
   3. Wiring rough-in requirements, including spaces reserved for electrical equipment.

B. Product Certificates: For each type of water-source heat pump, signed by product manufacturer.

C. Field quality-control test reports.

D. Warranty: Special warranty specified in this Section.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For water-source heat pumps to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of water-source heat pumps and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

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

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

C. ASHRAE Compliance:

1. ASHRAE 15.
2. Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. Comply with NFPA 70.

F. Comply with safety requirements in UL 484 for assembly of free-delivery water-source heat pumps.

1.7 COORDINATION

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

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of water-source 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 MANUFACTURERS

A. Available manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified:
1. Carrier Corporation.
2. ClimateMaster, Inc.
3. FHP Manufacturing Inc.
4. McQuay International.
5. Trane.

2.2 CONCEALED WATER-SOURCE HEAT PUMPS, LARGER THAN 6 TONS (21 kW)

A. Description: Packaged water-source heat pump with temperature controls; factory assembled, tested, and rated according to ARI-ISO-13256-1.

B. Cabinet and Chassis: Galvanized-steel casing with the following features:

1. Access panel for access and maintenance of internal components.
2. Knockouts for electrical and piping connections.
3. Cabinet Insulation: Glass-fiber liner, 1/2 inch thick, complying with UL 181.

C. Water Circuit:

1. Refrigerant-to-Water Heat Exchanger:

   a. Coil-in-shell heat exchanger with copper water tube with enhanced heat-transfer surfaces inside a steel shell; both shell and tube leak tested to 450 psig on refrigerant side and 400 psig on water side. Factory mount heat exchanger in unit on resilient rubber vibration isolators.
2. Water Regulating Valves: Limit water flow through refrigerant-to-water heat exchanger, and control head pressure on compressor during cooling and heating. Valves shall close when heat-pump compressor is not running.
3. Motorized Water Valve: Stop water flow through the unit when compressor is off.

D. Refrigerant Circuit Components:

1. Sealed Refrigerant Circuit: Minimum of 2 circuits required for units 10 tons (35 kW) and larger. Intertwine circuits in refrigerant to air coil.

   a. Charge with R-410A refrigerant.

2. Filter-Dryer: Factory installed to clean and dehydrate each refrigerant circuit.
3. Charging Connections: Service fittings on suction and liquid for charging and testing on each circuit.
4. Reversing Valve: Pilot-operated sliding-type valve designed to be fail-safe in heating position with replaceable magnetic coil.

5. Compressor: Hermetic scroll compressor installed on vibration isolators housed in an acoustically treated enclosure with factory-installed safeties as follows:

    a. Antirecycle timer.
    b. High-pressure cutout.
    c. Low-pressure cutout or loss of charge switch.
    d. Internal thermal-overload protection.
    e. Freezestat to stop compressor if water-loop temperature in refrigerant-to-water heat exchanger falls below 35 deg F.

6. Refrigerant Piping Materials: ASTM B 743 copper tube with wrought-copper fittings and brazed joints.
7. Pipe Insulation: Refrigerant minimum 3/8-inch- thick, flexible elastomeric insulation on piping exposed to airflow through the unit. Maximum 25/50 flame-spread/smoke-development indexes per ASTM E 84.
8. Refrigerant Metering Device: Capillary tube.
9. Refrigerant Metering Device: Thermal expansion valve to allow specified operation with entering-water temperatures from 25 to 125 deg F.
10. Hot-Gas Reheat Valve: Pilot-operated sliding-type valve with replaceable magnetic coil.

E. Hot-Gas Reheat: Reheat valve diverts refrigerant hot gas to reheat coil when remote humidistat calls for dehumidification.

F. Hot-Gas Bypass: Include constant pressure expansion valve, solenoid valve, and controls to maintain continuous refrigeration system operation at 10 percent of full load on lead compressor.

G. Control equipment and sequence of operation are specified in Division 23 Sections "Instrumentation and Controls for HVAC" and "Sequence of Operations for HVAC Controls."

H. Controls:

1. Basic Unit Controls:

    a. Low- and high-voltage protection.
    b. Overcurrent protection for compressor and fan motor.
    c. Random time delay, three to ten seconds, start on power-up.
    d. Time delay override for servicing.
    e. Control voltage transformer.

2. Terminal Controller:

    a. Scheduled operation for occupied and unoccupied periods on [**7**] [**365**]-day clock with minimum 4 programmable periods per day.
    b. Remote control panel to contain programmable timer and LED for fault condition.
    c. Compressor disable relay to stop compressor operation for demand limiting or switch to unoccupied operation.
    d. Automatic restart after five minutes if fault clears. Lockout after three attempts to restart following fault. Indicate fault for service technician.
    e. Backup for volatile memory.

3. BAS interface requirements as further described in Division 23 Sections "Instrumentation and Controls for HVAC" and "Sequence of Operations for HVAC Controls."

    a. Interface relay for scheduled operation.

b. Interface relay to provide indication of fault at central workstation.
c. Provide BAC-net interface for central BAS workstation for the following functions:

1) Set-point adjustment for set points identified in this Section.
2) Start/stop and operating status of heat-pump unit.
3) Occupied and unoccupied schedules.

I. Electrical Connection: Single electrical connection with fused disconnect.

2.3 HOSE KITS

A. General: Hose kits shall be designed for minimum 400 psig working pressure, and operating temperatures from 33 to 211 deg F. Tag hose kits to equipment designations.

B. Hose: Minimum diameter, equal to water-source heat-pump connection size.

C. Isolation Valves: Two-piece bronze-body ball valves with stainless-steel ball and stem and galvanized-steel lever handle. Provide valve for supply and return. If balancing device is combination shutoff type with memory stop, the isolation valve may be omitted on the return.

D. Strainer: Y-type with blowdown valve in supply connection.

E. Balancing Device: Mount in return connection. Include meter ports to allow flow measurement with differential pressure gage.

1. Automatic balancing valve, factory set to operate within 10 percent of design flow rate over a 40:1 differential pressure range of 2 to 80 psig.
2. Manual, calibrated-orifice balancing valve.
3. Manual, venturi-type balancing valve.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of water-source heat pumps.

B. Examine roughing-in for piping and electric installations for water-source heat pumps to verify actual locations of piping connections and electrical conduit before installation.

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

3.2 INSTALLATION

A. Equipment Mounting: Install water-source heat pumps on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases specified in Division 03 Section "Cast-in-Place Concrete”.

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

2. Construct concrete bases 4 inches high and extend base not less than 6 inches in all directions beyond the maximum dimensions of water-source heat pump unless otherwise indicated.
3. 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.
4. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
5. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
6. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Install wall-mounting thermostats, humidistats, and switch controls in electrical outlet boxes at heights to match lighting controls or as required in Division 23 Section "Instrumentation and Control for HVAC."

3.3 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Connect supply and return hydronic piping to heat pump with unions and shutoff valves.

B. Install electrical devices furnished by manufacturer but not specified to be factory mounted.

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

D. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

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

B. Perform the following field tests and inspections and prepare test reports:

1. After installing water-source heat pumps and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.5 STARTUP SERVICE

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

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

1. Inspect for visible damage to unit casing.
2. Inspect for visible damage to compressor, coils, and fans.
3. Inspect internal insulation.
4. Verify that labels are clearly visible.
5. Verify that clearances have been provided for servicing.
6. Verify that controls are connected and operable.
7. Adjust vibration isolators.
8. Start unit according to manufacturer's written instructions.
9. Complete startup sheets and attach copy with Contractor's startup report.
10. Inspect and record performance of interlocks and protective devices; verify sequences.
11. Operate unit for an initial period as recommended or required by manufacturer.
12. Inspect controls for correct sequencing of refrigeration and normal and emergency shutdown.

3.6 ADJUSTING

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

3.7 CLEANING

A. After completing installation of exposed, factory-finished water-source heat pumps, inspect exposed finishes and repair damaged finishes.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain water-source heat pumps. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 238146

SECTION 23 82 16 - AIR COILS

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. Basic Requirements: Provisions of Section 23 00 10, Basic HVAC Requirements are part of this Section.

1.2 SUMMARY

A. Section includes electric resistance air coils, also referred as electric duct heaters.

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 air coil.
2. Include rated capacities, operating characteristics, and pressure drops for each air coil.

B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which coil location and ceiling-mounted access panels are shown and coordinated with each other.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air coils to include in operation and maintenance manuals.

PART 2 – PRODUCTS

2.1 DESCRIPTION

A. ASHRAE Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

2.2 ELECTRIC RESISTANCE AIR COILS

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

1. Neptronic
2. Brasch Manufacturing Co., Inc.
3. Chromalox.
4. Indeeco.

B. Testing Agency Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Coil Assembly: Comply with UL 1995.

D. Heating Elements: Open coil type, coiled resistance wire of 80 percent nickel and 20 percent chromium.

E. High-Temperature Coil Protection: Disk-type, automatically reset, thermal-cutout, safety device; serviceable through terminal box without removing heater from duct or casing.

1. Secondary Protection: Load-carrying, manually reset or manually replaceable, thermal cutouts; factory wired in series with each heater stage.

F. Frames: Galvanized-steel channel frame, minimum 0.064 inch thick for slip-in mounting.

G. Control Panel: Unit mounted with disconnecting means and overcurrent protection. Include the following controls:

1. BACnet/Modbus controller
    a. Select MAC address
    b. Remote monitoring (status, alarms, diagnostics and trending)
    c. Realtime feedback of heater’s output capacity
    d. Real-time temperature measures and power consumption data
2. Magnetic contactor.
3. SCR controller
4. Stage fuse
5. Supply and discharge temperature sensors
6. Contact delay
7. Electronic airflow sensor
8. Control fuse
9. Disconnect switch
10. NEMA 1 Control Panel
11. Pressure differential switch

12. Transformer

H. Heater to be controlled by designated remote thermostat via the building management system (BMS).

I. Capacities and Characteristics:

1. See schedule on Drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.

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

3.2 INSTALLATION

A. Install coils level and plumb.

B. Install coils in ducts according to SMACNA's "Ducted Electric Heat Guide for Air-Handling Systems and strict manufacturer's instructions

C. Maintain manufacturer's recommended minimum distance to avoid flow obstruction and maintain clearance to access control panel.

D. Install coils in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

E. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

3.3 CONNECTIONS

A. Ground equipment according to Section 26 05 26 "Grounding and Bonding~~ for Electrical Systems~~."

B. Connect wiring according to Section 26 05 19 "~~Low-Voltage Electrical Power Conductors and Cables~~Building Wire and Cable."

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After electrical circuitry has been energized, operate electric coils to confirm proper unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Prepare test and inspection reports.

END OF SECTION 23 82 16

SECTION 23 82 19 - FAN COIL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Requirements Division 01, Division 23 Specification Sections, and Common Work Requirements for HVAC apply to the work specified in this Section.

1.2 SUMMARY

A. This Section includes fan-coil units and accessories.

1.3 ABBREVIATIONS

A. BAS: Building automation system.

1.4 SUBMITTALS

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

B. LEED V4 BD+C Submittals:

1. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment complies.
2. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."

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

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

D. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Ceiling suspension components.
2. Structural members to which fan-coil units will be attached.
3. Method of attaching hangers to building structure.

4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:

   a. Lighting fixtures.
   b. Air outlets and inlets.
   c. Speakers.
   d. Sprinklers.
   e. Access panels.

6. Perimeter moldings for exposed or partially exposed cabinets.

E. Samples for Initial Selection: For units with factory-applied color finishes.

F. Samples for Verification: For each type of fan-coil unit indicated.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For fan-coil units to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

   1. Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.

I. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

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

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2010, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IESNA 90.1-2010 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2010, Section 6 - "Heating, Ventilating, and Air-Conditioning."

D. AHRI Compliance: Rated and tested in accordance with AHRI Standard 440 “Room Fan Coil Units.”

E. UL listed and labeled in accordance with ANSI/UL Standard 880- “Safety Standard for Fan Coil Units.”

1.6 COORDINATION

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

B. Coordinate size and location of wall sleeves for outdoor-air intake.

C. Specific configuration of the supply and return ductwork and piping at each unit has been indicated on the drawings. If the configuration of the units furnished on the project differs from that indicated on the drawings (whether or not the units furnished are the specific units or an acceptable substitute), it shall be the contractor's responsibility to modify ductwork, piping, etc., as required to accommodate the actual the actual configuration of units furnished on the project.

1.7 WARRANTY

A. Warranty Period: One year from date of Substantial Completion.

1.8 EXTRA MATERIALS

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

1. Fan-Coil-Unit Filters: Furnish one spare filter for each filter installed.
2. Fan Belts: Furnish one spare set of fan belts for each unit installed.

PART 2 - PRODUCTS

2.1 GENERAL

A. Manufacturer shall be responsible for examining applications of each type of unit to assure that each will operate properly in the intended application.

B. Unit sizes are shown as selected in accordance with the principles set worth in the ASHRAE Guide and Manufacturer's literature.

C. All items of a given type shall be the products of the same manufacturer.

2.2 MANUFACTURERS

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

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

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

2.3 FAN-COIL UNITS

A. Manufacturers:

1. Airtherm; a Mestek Company.
2. Carrier Corporation.
3. Environmental Technologies, Inc.
4. McQuay International.
5. Trane.
6. USA Coil & Air.
7. YORK International Corporation.
8. IEC

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

C. Coil Section Insulation: 1/2-inch thick, 1-1/2 lb density coated glass fiber complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.

1. Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2010.

D. Main and Auxiliary Drain Pans: Plastic, Insulated Stainless or galvanized steel with plastic liner. Fabricate pans and drain connections to comply with ASHRAE 62.1-2010. Drain pans shall be removable.

E. Chassis: Galvanized steel where exposed to moisture. Floor-mounting units shall have leveling screws.

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

1. Vertical Unit Front Panels: Removable, steel, with integral stamped steel discharge grille and channel-formed edges, cam fasteners, and insulation on back of panel.
2. Horizontal Unit Bottom Panels: Fastened to unit with cam fasteners and hinge and attached with safety chain; with integral stamped steel or cast-aluminum discharge grilles.

3. Stack Unit Discharge and Return Grille: Aluminum double-deflection discharge grille, and louvered- or panel-type return grille; color as selected by Architect from manufacturer's standard colors. Return grille shall provide maintenance access to fan-coil unit.
4. Steel recessing flanges for recessing fan-coil units into ceiling or wall.

G. Outdoor-Air Wall Box: Minimum 0.1265-inch-thick, aluminum, rain-resistant louver and box with integral eliminators and bird screen.

1. Louver Configuration: Horizontal, rain-resistant louver.
2. Louver Material: Aluminum.
3. Bird Screen: 1/2-inch mesh screen on interior side of louver.
4. Decorative Grille: On outside of intake.
5. Finish: Anodized aluminum, Baked enamel, color as selected by Architect from manufacturer's standard colors.

H. Outdoor-Air Damper: Galvanized-steel blades with edge and end seals and nylon bearings; with electronic modulating actuators.

I. Filters: Minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

1. Pleated Cotton-Polyester Media: 7 MERV.

J. Hydronic Coils: 3/8 in. diameter, copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.

K. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.

1. Provided with automatic reset high limit control operating through heating element contactors.

2. U.L. listed and equipped with unit mounted disconnect switch.

3. Provide mercury contactor to provide scheduled steps of heating.

L. Fan and Motor Board: Removable.

1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

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

M. Unit Control Box: Integral unit cabinet to include:

1. Fan starter and electric heating coil circuit breakers.
2. Disconnect switches
3. Control circuit transformer for 24-volt control circuit, fused on primary and secondary sides.
4. Single point power entry
5. Numbered Terminal strips.

N. Control devices are specified in Division 23 Sections "Instrumentation and Control for HVAC". Control sequences as indicated on the Drawings.

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

P. Capacities and Characteristics: As scheduled on drawings.

2.4 DUCTED FAN-COIL UNITS

A. Manufacturers:

1. Carrier Corporation.
2. Environmental Technologies, Inc.
3. McQuay International.
4. Trane.
5. USA Coil & Air.
6. YORK International Corporation.

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

C. Coil Section Insulation: 1/2-inch thick coated glass fiber complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.

1. Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2010.

D. Drain Pans: Plastic, Insulated Stainless or galvanized steel with plastic liner. Fabricate pans and drain connections to comply with ASHRAE 62.1-2010.

E. Chassis: Galvanized steel, with baked-enamel finish and removable access panels.

F. Cabinets: Steel with baked-enamel finish in manufacturer's standard paint color.

1. Supply-Air Plenum: Sheet metal plenum finished and insulated to match the chassis with mill-finish, aluminum, double-deflection grille.
2. Return-Air Plenum: Sheet metal plenum finished to match the chassis.
3. Mixing Plenum: Sheet metal plenum finished and insulated to match the chassis with outdoor- and return-air, formed-steel dampers.
4. Dampers: Galvanized steel with extruded-vinyl blade seals, flexible-metal jamb seals, and interlocking linkage.

G. Filters: Minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

1. Pleated Cotton-Polyester Media: 7 MERV.

H. Hydronic Coils: 3/8 in. diameter copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain.

I. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection of heaters. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.

1. Provided with automatic reset high limit control operating through heating element contractors.

2. UL listed and equipped with unit and mounted disconnect switch.

3. Provide mercury contractor to provide scheduled steps of heating.

J. Direct-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.

K. Belt-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, single-speed motor installed on an adjustable fan base resiliently mounted in the cabinet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.

1. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

L. Control devices and operational sequence are specified in Division 23 Section 23 09 00 "Instrumentation and Control for HVAC~~" and "Sequence of Operations for HVAC Controls."~~

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

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive fan-coil units for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping and electrical connections to verify actual locations before fan-coil-unit installation.

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

3.2 STORAGE AND HANDLING

A. Comply with manufacturer’s installation instructions for rigging, unloading and transporting units.

B. All fan coil units shall be received and stored on the job site with the wooden shipping skids in place. Under no condition shall the units be stored on such a way that metal components are in direct contact with the ground.

C. Unit delivery shall be coordinated with building construction and units shall be delivered to the job site just prior to their installation. Cover air handling units stored on the job site with 6 mil polyethylene sheet, taped in place, to protect the units from damage and the weather. Units that receive water damage due to improper handling or storage shall be removed from the site and new ones furnished at no additional charge to the Owner.

3.3 INSTALLATION

A. Install fan-coil units level and plumb.

B. Install fan-coil units to comply with NFPA 90A.

C. Suspend fan-coil units from structure with elastomeric hangers and at least four 3/8 inch galvanized threaded support rods. Vibration isolators are specified in Division 23 Section "Vibration ~~and Seismic~~ Controls for HVAC ~~Piping and Equipment~~."

D. Verify locations of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above finished floor.

E. Install new filters in each fan-coil unit within two weeks after Substantial Completion.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Install piping adjacent to machine to allow service and maintenance.
2. Connect piping to fan-coil-unit factory hydronic piping package. Install piping package if shipped loose.
3. Connect condensate drain to full size but not less than 3/4 inch indirect waste.

   a. Install condensate trap of adequate depth to seal against the pressure of fan. Install cleanouts in piping at changes of direction.

B. Connect supply and return ducts to fan-coil units with flexible duct connectors specified in Division 23 Section "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.

C. Ground equipment according to Division 26 Section 26 05 26 "Grounding and Bonding ~~for Electrical Systems~~."

D. Connect wiring according to Division 26 Section 26 05 19 "~~Low-Voltage Electrical Power Conductors and Cables~~Building Wire and Cable."

3.5 FIELD QUALITY CONTROL

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

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.6 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. 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.

3.7 DEMONSTRATION

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

END OF SECTION 23 82 19

SECTION 238239 - UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Requirements Division 01, Division 23 Specification Sections, and Common Work Requirements for HVAC apply to the work specified in this Section.

1.2 SUMMARY

A. Section Includes:

1. Propeller unit heater with electric-resistance heating coils.

1.3 DEFINITIONS

A. BAS: Building automation system.

B. CWP: Cold working pressure.

C. PTFE: Polytetrafluoroethylene plastic.

D. TFE: Tetrafluoroethylene plastic.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, dimensions, materials, operating characteristics, furnished specialties, and accessories for each product indicated.

B. LEED V4 BD+C Submittals:

1. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment complies.
2. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."

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

1. Plans, elevations, sections, and details.
2. Location and size of each field connection.
3. Details of anchorages and attachments to structure and to supported equipment.

4. Equipment schedules to include rated capacities, operating characteristics, furnished specialties, and accessories.
5. Location and arrangement of integral controls.
6. Wiring Diagrams: Power, signal, and control wiring.

D. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which unit heaters will be attached.
3. Method of attaching hangers to building structure.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:

    a. Lighting fixtures.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.

6. Perimeter moldings for exposed or partially exposed cabinets.

E. Samples for Initial Selection: Finish colors for units with factory-applied color finishes.

F. Samples for Verification: Finish colors for each type of cabinet unit heater and wall and ceiling heaters indicated with factory-applied color finishes.

G. Manufacturer Seismic Qualification Certification: Submit certification that cabinet unit heaters, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

    a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
    b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

H. Field quality-control test reports.

I. Operation and Maintenance Data: For cabinet unit heaters to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

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

B. ASHRAE Compliance: Applicable requirements in the latest edition of ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IESNA 90.1 Latest Edition Compliance: Applicable requirements in the latest edition of ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

PART 2 - PRODUCTS

2.1 PROPELLER UNIT HEATERS

A. Manufacturers:

1. McQuay International.
2. Modine Manufacturing Company
3. Sterling Heating Products
4. Trane.

B. Description: An assembly including casing, heating coil, fan, and motor in horizontal discharge configuration with adjustable discharge louvers.

C. Comply with UL 2021.

D. Comply with UL 823.

E. Cabinet: Removable panels for maintenance access to controls.

F. Cabinet Finish: Manufacturer's standard baked enamel applied to factory-assembled and -tested propeller unit heater before shipping.

G. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in the latest edition of ASHRAE 62.1.

H. Electric-Resistance Heating Elements: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in steel or corrosion-resistant metallic sheath with fins no closer than 0.16 inch. Element ends shall be enclosed in terminal box. Fin surface temperature shall not exceed 550 deg F at any point during normal operation. Provide stages of electric control as required.

1. Circuit Protection: One-time fuses in terminal box for overcurrent protection and limit controls for high-temperature protection of heaters.
2. Wiring Terminations: Stainless-steel or corrosion-resistant material.

I. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi. Provide fan guard.

J. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

1. Motor Type: Permanently lubricated.

K. Control Devices:

1. Unit-mounted thermostat.

L. Capacities and Characteristics

1. As scheduled on drawings:

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for electrical connections to verify actual locations before unit heater installation.

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

3.2 INSTALLATION

A. Install cabinet unit heaters to comply with NFPA 90A. Coordinate to assure correct size openings for recessed units.

B. Install propeller unit heaters level and plumb. Mount as high as possible to maintain maximum headroom.

C. Suspend propeller unit heaters from structure with all-thread hanger rods and spring hangers with vertical-limit stop. Hanger rods and attachments to structure are specified in Division 23 Section "Vibration Controls for HVAC." Vibration hangers are specified in Division 23 Section "Vibration Controls for HVAC."

D. After construction, including painting is completed, clean exposed surfaces of units. Vacuum clean coils and inside of cabinets prior to running the equipment.

E. Touch-ups marred or scratched surfaces of factory finished cabinets, using finish materials furnished by the manufacturer.

3.3 CONNECTIONS

A. Ground equipment according to Division 26 Section 260526 "Grounding and Bonding”.

B. Connect wiring according to Division 26 Section 260519 "Building Wire and Cable."

3.4 FIELD QUALITY CONTROL

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

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.5 ADJUSTING

A. Adjust initial temperature set points.

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

3.6 DEMONSTRATION

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

END OF SECTION 238239

SECTION 26 01 00 - OPERATION AND MAINTENANCE MANUALS

PART 1- GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Contractual Conditions and Division 01 Specification sections apply to this section.

B. General: Refer to Section 01 78 00, Closeout Submittals for requirements related to the preparation and contents of Operation and Maintenance manuals/CDs.

1.2 OPERATION AND MAINTENANCE MANUALS

A. The various specification sections of Division 26 contain specific information to be included in the O&M manuals/CDs in addition to the general requirements outlined in Section 01 78 00.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 26 01 00

SECTION 26 05 00 – COMMON WORK RESULTS FOR ELECTRICAL

PART 1- GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Contractual Conditions and other Division 01 Specification sections apply to this section.

1.2 SUMMARY

A. This section includes Basic Electrical Requirements specifically applicable to Division 26 Sections.

1.3 DESCRIPTION

A. Provide and install all equipment, labor, material and accessories, and mounting hardware for a complete and operating system as described within these Division 26 Specification Sections.

B. Furnish, perform, or provide all labor including planning, purchasing, transporting, storing, installing, testing, cutting and patching, trenching, excavating, backfilling, coordination, field verification, equipment (installation and safety), supplies, and materials necessary for the installation of complete electrical systems (as described or implied by these specifications and the applicable drawings) in strict accordance with applicable codes, which may not be repeated in these specifications, but are expected to be common knowledge of qualified Bidders.

C. All work shall comply with all applicable codes as a minimum and with the additional requirements called for in these Contract Documents.

D. Only trained and licensed personnel shall perform work. No Work shall be performed which violates applicable Codes, even if called for in the Contract Documents.

E. Coordinate requirements with Utility Company and all applicable GOAA Testing, Certification and repair contractor prior to bid. Bid to include all work required.

F. Make connections of all items in the Work using electric power including wire, conduit, circuit protection, disconnects and accessories. Securing of roughing-in drawings and connection information for equipment involved shall also be included under this division. See other divisions for specifications for electrically operated equipment.

G. The Contractor shall provide and install panic hardware on all electrical room doors where the electrical room houses switchboards or MCC's rated ~~1200~~800 amps or more per NEC 110.26. All electrical room doors shall open in the direction of egress.

1.4 QUALITY ASSURANCE

A. Install Work in locations shown or described in the Contract Documents, unless prevented by Project conditions.

B. Install all equipment so that all Code and Manufacturer recommended working and servicing clearances are maintained. Properly arrange and install all equipment within designated spaces. If a departure from the Contract Documents is necessary, submit to the OAR for approval, detailed drawings of the proposed changes with written reasons for the changes. No change shall be implemented without the issuance of a change order or other directive permitted by the General Conditions.

C. The Contractor shall verify finish dimensions at the project site in preference to using dimensions noted on Contract Documents.

1.5 INVESTIGATION OF SITE

A. Investigate the site and existing conditions thoroughly before bidding. Advise OAR of discrepancies or questions noted.

B. During the course of the site visit, electrical bidder shall become familiar with all aspects of the proposed work and existing field conditions of the work. No compensation or reimbursement for additional expenses for failure to investigate the existing facilities will be authorized. This shall include rerouting around existing obstructions.

C. Submission of a proposal will be construed as evidence that such examination has been made and later claims for labor, equipment or materials required because of difficulties encountered will not be recognized.

D. Existing conditions and utilities indicated are taken from existing construction documents, surveys, and field investigations. Unforeseen conditions probably exist and existing conditions shown on drawings may differ from the actual existing installation with the result being that new work may not be field located exactly as shown on the drawings. Notify OAR if deviations are found.

E. All existing electrical is not shown. The Contractor shall become familiar with all existing conditions prior to bidding, and include in his bid the removal of all electrical equipment, wire, conduit, devices, fixtures, etc. that is abandoned due to renovation.

F. Protect all existing electrical raceways within concrete slabs, below concrete slabs, overhead raceways, equipment, etc. from damage due to renovation. Repair or replacement of utilities or other property damaged by operations in conjunction with the work will be at no cost to the Owner.

G. Remove existing power, lighting, systems, material and equipment which are made obsolete or which interfere with the construction of the project. Reinstall power, lighting, systems, materials and equipment which are required to remain active for the facility to be fully functional.

H. Reroute conduit and wiring in area of construction remaining active. Include temporary connections necessary to maintain continuity of existing circuitry required to remain active during renovation. Existing conduits indicated in Contract Documents are approximate locations only. Determine routing of existing conduits and pipes prior to any excavation, cutting or demolition.

I. Occupied existing buildings must remain in operation while work is being performed. Schedule work for a minimum outage to Owner. Notify the OAR appropriately for any shut-down of existing systems.

J. Bid shall include all removal and relocation of all piping, fixtures or other items required for completion of alterations and new construction.

K. Refer to Section 26 01 03 Minor Electrical Demolition for Remodeling for additional requirements associated with existing conditions.

1.6 CONTRACT DOCUMENTS

A. The drawings are diagrammatic and are not intended to include every detail of construction, materials, methods, and equipment. They indicate the result to be achieved by an assemblage of various systems. Coordinate equipment locations with Architectural and Structural drawings. Layout equipment before installation so that all trades may install equipment in spaces available. Coordinate installation in a neat and workmanlike manner. Provide 1/4" scale coordination drawings per specifications prior to start of work.

B. Contractor shall provide 1/4" scale coordination drawings for all electrical, mechanical and communications rooms during the shop drawing submittal phase, utilizing detailed dimensions from equipment actually submitted (all disciplines) and field-measured/verified existing conditions. These drawings are also required for any room where conduits equal to or over 1-1/4" in size, equipment (panels, HVAC, disconnects, comm. racks) or other large objects are being installed. Drawings shall show all electrical, mechanical, plumbing, fire protection, structural, etc. coordinated so that problems are discovered/prevented prior to installation. Claims during construction for additional funding in rooms where properly coordinated drawings were not submitted will not be considered.

C. Wiring arrangements for equipment shown on the drawings are intended to be diagrammatic and do not show all required conductors and functional connections. All such items incidental to a complete and operating system shall be provided.

D. Submit specific shop drawings which indicate the fabrication, assembly, installation, and erection of particular systems' components. Drawings that are part of the Contract Documents shall not be considered a substitute for required shop drawings, field installation drawings, code requirements, or applicable standards.

E. Locations indicated for outlets, switches, and equipment are approximate and shall be coordinated with the Contract Documents. Where instructions or notes are insufficient to locate the item, notify the OAR.

1.7 MATERIALS AND EQUIPMENT

A. Unless otherwise noted, all material shall be new and UL listed or labeled. In lieu of UL listing or labeling, a statement or data demonstrating compliance with contract documents from a nationally recognized testing agency shall be submitted to the OAR.

B. All materials shall comply with the requirements for Low Emitting Materials. This shall include:

1. Low Emitting Materials for Paints and Coatings
2. Low Emitting Materials for Adhesives and Sealants
3. Low Emitting Composite Wood

C. Reference section 01 8113.14 "Sustainable Design Requirements – LEED V4 BD+C for additional information.

~~B.~~D. Where Contract Documents list design selection, manufacturer or type, this model shall set the standard of quality and performance required. Where no brand name is specified, the source and quality shall be subject to Designers/OAR review and approval. Where Contract Documents list approved substitutions, these items shall comply with Division 01 requirements for substitutions.

~~C.~~E. When a product is specified to be in accordance with a trade association or government standard and at the request of Designers/OAR the Contractor shall furnish a certificate that the product complies with the referenced standard and supporting test data to substantiate compliance.

~~D.~~F. Where multiple items of the same equipment or materials are required, they shall be the product of the same Manufacturer.

~~E.~~G. Prior to placing equipment orders, verify the physical size of specified equipment to fit spaces allotted on the drawings and with NEC working clearances. Internal access for proposed equipment substitutions shall be provided. Provide 1/4" scale drawings showing that this coordination has taken place.

~~F.~~H. Electrical equipment shall be protected from the weather, during shipment, storage, and construction per manufacturer's recommendations. Should any apparatus be subjected to possible damage by water, it shall be thoroughly dried and put through a dielectric test, at the expense of the Contractor, to ascertain the suitability of the apparatus, or it shall be replaced without additional cost to the Owner.

~~G.~~I. Inspect all electrical equipment and materials prior to installation. Damaged equipment and materials shall not be installed or placed in service. Replace or repair and test damaged equipment in compliance with industry standards at no additional cost to the Owner. Equipment required for the test shall be provided by the Contractor.

~~H.~~J. Material and equipment shall be provided complete and shall function up to the specified capacity/function. Should any material or equipment as a part or as a whole fail to meet performance requirements, replacements shall be made to bring performance up to specified requirements. Damages to finish by such replacements, alterations, or repairs shall be restored to prior conditions, at no additional cost to the Owner.

~~I.~~K. Where tamperproof screws are specified or required, Phillips head or Allen head devices shall not be accepted. For each type used, provide OAR with three tools. OAR will designate the specific hardware design to correspond with existing devices elsewhere in the building, to limit special tool requirements.

~~J.~~L. Communications backboards shall be 3/4" A/B grade, Class A, flame spread, painted with light gray fire retardant paint. Neatly mask off a minimum of one (1) plywood ~~Manufactures~~manufactures pre-printed certified fire rating stamp per section of board prior to application of paint. Remove masking after paint has cured. Plywood shall comply with the requirements of Low Emitting Materials for composite wood.

1.8 SUPERVISION OF THE WORK

A. Reference the General Conditions for additional requirements.

B. A qualified and experienced electrical superintendent shall be in charge of the work in progress at all times. If, in the judgement of the OAR, the electrical superintendent is not performing his duties satisfactorily, the Contractor shall immediately replace him upon receipt of a letter of request from the OAR. Once a satisfactory electrical superintendent has been assigned to the work, he shall not be withdrawn by the Contractor without the written consent of the OAR.

C. Provide field superintendent who has had a minimum of four (4) years previous successful experience on projects of comparable sizes and complexity. Superintendent shall be present at all times that work under this Division is being installed or affected. All work performed by a non-licensed Journeyman shall be under the direct supervision (in the presence of) of a Licensed

Journeyman as specified herein. Increase the quantity of licensed Journeymen as required for supervision of all areas where direct contact is not possible. Project Superintendent and supervising Journeyman shall have passed a proctored H.H. Block Journeyman Exam with 75% grade or better and shall be a licensed Journeyman within the State of Florida. A resume of the Project superintendent's experience shall be submitted to OAR before starting work. At least one member of the electrical contracting firm shall hold a State Master Certificate of Competency. Each Journeyman shall have possession of licensing documentation at all times during work. Display to designer/OAR when requested.

D. Superintendent shall be employed by a State Registered (Type "E.R." License) or State certified (Type "E.C." License) electrical contractor.

1.9 COORDINATION

A. Provide all required coordination and supervision where work connects to or is affected by work of others, and comply with all requirements affecting this Division. Work required under other divisions, specifications or drawings to be performed by this Division shall be coordinated with the Contractor and such work performed at no additional cost to Owner including but not limited to electrical work required for:

1. Door hardware
2. Roll-up doors
3. Roll-up grilles
4. Signage
5. Fire shutters
6. Elevators
7. Escalators
8. Sliding doors
9. Mechanical Division of the Specifications
10. Landscape Architect drawings
11. Lifts
12. Lift Station
13. Kitchen equipment
14. Conveyors
15. Flight information display systems
16. Interior design drawings
17. Fountains
18. Millwork design drawings and shop drawings
19. Parking control equipment

B. Provide electrical subcontractor a set of Contract Documents for all areas of Electrical Work.

C. Installation studies shall be made to coordinate the electrical work with other trades. Work shall be preplanned. Unresolved conflicts shall be referred to the OAR prior to installation of the equipment.

D. Coordination drawings shall be prepared prior to the start of work. Drawings shall show the actual physical dimension required for the installation to assure proper integration of equipment with building systems and NEC required clearances. Location of conduit racking, etc., shall be provided. Coordination drawings shall be provided for all areas. Comply with the requirements of Division 01.

E. Secure approved shop drawings from all required disciplines and verify final electrical characteristics before roughing power feeds to any equipment. When electrical data on approved shop drawings differs from that shown or called for in Construction Documents, make adjustments to the wiring, disconnects, and branch circuit protection to match that required for the equipment installed. Adjustments to contract value will not be considered due to lack of coordination.

F. Damage from interference caused by inadequate coordination shall be corrected at no additional cost to the Owner.

G. Coordinate the exact location of floor outlets, floor ducts, floor stub-ups, etc. with OAR and Designer (and receive their approval) prior to rough-in. Locations indicated in Contract Documents are only approximate locations.

H. The Contract Documents describe specific sizes of switches, breakers, fuses, conduits, conductors, motor starters and other items of wiring equipment. These sizes are based on specific items of power consuming equipment (heaters, lights, motors for fans, compressors, pumps, etc.). Coordinate the requirements of each load with each load's respective circuitry shown and with each load's requirements as noted on its nameplate data and manufacturer's published electrical criteria. Adjust circuit breaker, fuse, conduit, and conductor sizes to meet the actual requirements of the equipment being provided and installed and change from single point to multiple points of connection (or vice versa) to meet equipment requirements. Changes shall be made at no additional cost to the Owner.

1.10 PROVISION FOR OPENINGS

A. Locate openings required for work. Provide sleeves, guards or other approved methods to allow passage of items installed.

B. Coordinate with roofing Contractor on installation of electrical items which penetrate the roof. Roof penetrations shall be installed so as to not void roof warranty.

C. Where work pierces waterproofing, it shall maintain the integrity of the waterproofing. Coordinate roofing materials which pierce roof for compatibility with membrane or other roof types with Contractor.

1.11 CONCRETE PADS

A. Furnish and install reinforced concrete pads for transformers, switchgear, generators, motor control centers, and other free-standing equipment. Unless otherwise noted, pads shall be four (4) inches high and shall exceed dimensions of equipment being set on them, including future sections, by six (6) inches each side, except when equipment is flush against a wall where the side against the wall shall be flush with the equipment. Pads shall be reinforced with W1.4 x 1.4 6 x 6 welded wire mesh. Chamfer top edges 1/2". Trowel all surfaces smooth. Provide 3000 psi concrete.

1.12 SURFACE MOUNTED EQUIPMENT

A. Surface mounted fixtures, outlets, cabinets, conduit, panels, etc. shall have finish or shall be painted as directed by designer. Paint shall be in accordance with applicable sections and/or divisions of these specifications.

1.13 CUTTING AND PATCHING

A. Reference Division 01 - General Requirements.

B. New Construction:

1. Cutting of work in place shall be cut, drilled, patched and refinished by trade responsible for initial installation.
2. Backfill new grades to match adjacent undisturbed surface.

C. Remodeling:

1. See Section 26 01 03 Minor Electrical Demolition.

1.14 INSTALLATION

A. Erect equipment to minimize interference and delays with the execution of the Work.

B. Take care in erection and installation of equipment and materials to avoid marring finishes or surfaces. Any damage shall be repaired or replaced as determined by the designer/OAR at no additional cost to the Owner.

C. Equipment requiring electrical service shall not be energized or placed in service until OAR is notified and is present or have waived their right to be present. Where equipment to be placed in service involves service or connection from another Contractor or the OAR, notify the OAR in writing as appropriate when the equipment will be ready.

D. Equipment supports shall be secured and supported from structural members unless written approval is granted by OAR.

E. Plywood material shall not be used as a backboard for mounting panel boards, disconnects, motor starters, and dry type transformers. Provide "cast in place" type inserts or install expansion type anchor bolts. Electrical equipment shall not be mounted directly to dry wall for support without additional channels as anchors. Channels shall be anchored to the floor and structure above. Panelboards and terminal cabinets shall be provided with structural framing located within drywall partitions.

F. Inserts, pipe sleeves, supports, and anchorage of electrical equipment shall be provided. Where items are to be set or embedded in concrete or masonry, the items shall be furnished and layout made for setting or embedment thereof so as to cause no delay.

G. Conduit or piping systems that contain water or liquid of any kind shall not be installed over the top of any electrical equipment, transformers, racks, cabinets, or enclosures without prior written approval from the OAR.

1.15 AS-BUILT DOCUMENTS

A. As-Built Documents: As-built Documents include Drawings, Shop Drawings, Specifications, Addenda, Change Orders, and other modifications permitted by the General Conditions.

B. Comply with all requirements of Division 01

C. Verify aspects of redlined as-builts for accuracy. As-Built Documents shall show all components including but not limited to:

1. All raceways 1-1/4" and above, cable tray systems, and grouped raceway racking as installed, including dimensions from fixed building lines such as column lines.
2. All site underground raceways and duct banks indicating burial depths and distances from fixed building lines or global tracking coordinates.
3. Underground pull boxes and manholes including elevations. Detail manhole and pull boxes, conduit terminations (butterfly layout) including conduit sizes, designated systems and cabling description.
4. General conduit routing from receptacle to receptacle, fixture to fixture, device to device. (Exact routing is not required for raceways 1" and smaller.)
5. Lighting: Diagrammatically show junction boxes that are located above accessible ceiling with flexible conduit connections to luminaries.
6. All junction boxes for Sections 28 31 11, 27 13 00 / 27 15 00, 27 13 00 / 27 15 00 and 27 51 16 shall be shown exactly where installed.
7. Junction box splices shall be shown in exact location and clearly noted referring to the written authorization by the OAR.
8. The first junction box within each homerun, regardless of size shall be shown in the installed location.
9. All junction boxes and pull boxes located above non-accessible ceilings shall be shown in exact location. All junction boxes 6"X6" and larger shall be shown in exact location.
10. Any combining of circuits (which is only allowed by specific permission) or change in homerun outlet box shall be indicated.
11. Any circuit number changes.
12. All conductors and cables, conductors and cable sizes, raceway sizes, etc not shown on contract documents and any changes from the documents.
13. Any switchboard, panelboard, motor control center, relay panel, or dimming control panel schedule changes, including load changes.
14. All access panels.
15. All existing conditions.
16. Location of lighting control devices such as photocell controls, space occupancy sensors, etc.
17. Exact quantity of conductors and cables shall be shown for all raceway systems.
18. All devices, wall outlet boxes, and control components.
19. All wireway and cable tray systems.
20. Exact location of all driven grounding electrodes including burial depths and dimensions from fixed building lines. Location of all grounding system busbars.
21. All building automation system (BAS) control panels and associated electrical devices, connections, power supplies, and dampers.
22. Riser diagrams exactly as installed.
23. Motor control devices, terminal cabinets, equipment racks, disconnects and switches and surge protection devices.
24. Change the equipment schedules (i.e. symbol legends, light fixture schedule, etc) to agree with items actually furnished.
25. Change plan notes to agree with items actually furnished, actual installation methods, etc. respectfully.
26. Cross-out all items, circuitry, devices, etc. not applicable.

D. As-Built red line information shall not compromise the clarity of the Contract Documents and Shop Drawings. Major components such as grouped raceway assemblies, cable tray systems, larger conduits, duct banks, racking, elevations, dimensions, etc. shall be shown on a clean architectural base plan(s) separate from the Contract Electrical Documents, as required to clearly delineate work. Obtain electronic base plan file from OAR.

1.16 "OBSERVATION OF WORK" REPORT

A. Reference the General Conditions.

B. Items noted by designer/OAR during construction and before final acceptance which do not comply with the Contract Documents will be listed in a "Observation of Work" report which will be sent to the Contractor for action. Correct all deficiencies in a prompt concise manner. After completion of the outstanding items, provide a written confirmation report for each item. The report shall indicate each item noted, and method of correction. Enter the date on which the item was corrected, and return the signed reports so items can be rechecked. Failure to correct the deficiencies in a prompt concise manner or failure to return the signed reports shall be cause for disallowing request for payments.

C. The electrical project superintendent shall be present at all required observation of work reviews as project progresses. Provide the OAR with equipment for access and review of all Work in place, as well as personnel fully familiar with all aspects of the work. Provide access to all electrical components such as junction boxes, panelboards, switchboards, devices and fixtures for their review by the designer/OAR.

D. Prior to start of Substantial Completion inspection, provide access to and prepare all electrical equipment and related components complete and ready for review by designer/OAR including but not limited to the following :

1. All panelboard covers removed
2. Switchboard and distributions panelboards readily for immediate removal of covers
3. Terminal cabinet covers open or removed.
4. Wireway covers open or removed
5. Underground pull boxes ready for immediate removal of cover(s)
6. Access to all grounding/bonding terminations
7. Access to rated wall and through floor fire stopping
8. Access to all control systems for the CCTV, Voice, Data, Fire Alarm, and Sound/Paging.
9. Access to mechanical equipment, electrical connection points, and control devices
10. Access to elevator and escalator machine rooms, hoistway, pits, etc.
11. Access to all raceways crossing structural expansion/deflection joints.
12. Access to all components of the fire alarm control system including control devices and fire dampers.
13. Access to power company equipment
14. Removal of access panels
15. Removal of a minimum of one (1) acoustical lay-in ceiling tile throughout each area of work. Larger areas shall have one (1)-ceiling tile removed for every 30 square foot of ceiling area.
16. Each and every item deemed necessary by A/E to perform a comprehensive review of the work as installed relative to the contract documents.

E. Items noted after acceptance during one-year guarantee period shall be checked by the Contractor in the same manner as above. The signed reports are to be returned by him when the items have been corrected.

1.17 SYSTEMS WARRANTY

A. Reference the General Conditions.

B. Warranty shall be by the Contractor to the Owner and shall cover for a period of one year from the date of the Substantial Completion. Warranty shall not include light bulbs lamps in service after one month from date of substantial completion of the System.

1. Explain the provisions of warranty to the Owner at the "Demonstration of Completed System" meeting to be scheduled with the OAR upon project completion.

C. Where items of equipment or materials carry a manufacturer's warranty for any period in excess of twelve (12) months, then the manufacturer's warranty shall apply for that particular piece of equipment or material.

D. Where extended Guarantees are called for herein, furnish three copies to be inserted in Operation and Maintenance Manuals.

E. All preventative maintenance and normal service will be performed by the Owner's maintenance personnel after final acceptance of the work which shall not alter the Contractor's warranty.

1.18 WASTE MATERIALS DISPOSAL

A. Include in base bid the transport and disposal or recycling of all waste materials generated by this project in accordance with all rules, regulations and guidelines applicable. Comply fully with Florida Statute 403.7186 regarding mercury containing devices and lamps. Lamps, ballasts and other materials shall be transported and disposed of in accordance with all DEP and EPA guidelines applicable at time of disposal. Provide OAR with written certification of approved disposal.

1.19 PROHIBITION OF ASBESTOS AND PCB

A. Prior to the Final Review field visit the Contractor shall certify in writing that the equipment and materials installed in this Project under this Division 26 contain no asbestos or PCB. Additionally, all manufacturers shall provide a statement with their submittal that indicates that their product contains no asbestos or PCB. This statement shall be signed by a duly authorized agent of the manufacturer.

PART 2- PRODUCTS (Not Applicable)

PART 3- EXECUTION (Not Applicable)

END OF SECTION 26 05 00

SECTION 26 05 10 - ELECTRICAL SYMBOLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Contractual Conditions and Division 01 Specification Sections, apply to this section.

1.2 SYMBOLS

A. In general the symbols used on the drawings conform to the Standard Symbols of the Institute of Electrical and Electronic Engineers with the exception of special systems or agencies as hereinafter noted.

1. Corps of Engineers.
2. Special Symbols as shown in schedules or legends.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 26 05 10

SECTION 26 05 12 OUC UNDERGROUND ELECTRIC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and General Conditions/Provisions of Contract, including Contractual Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 PROJECT DESCRIPTION

A. These specifications are for the construction of certain Orlando Utilities Commission (OUC) underground facilities and street lighting systems as shown in the contract documents. These facilities shall be more particularly described in later paragraphs of these specifications and by attached drawings. The nature and location of these facilities shall be further described on drawings, which are part of the contract documents. In general, these specifications shall cover the construction of, but not necessarily be limited to, the following general types:

1. Hand holes, pull boxes, and junction boxes
2. Direct buried duct line and conduit runs
3. Street lighting poles, fixtures, bracket arms, controllers, services etc.

B. All pull boxes, junction boxes, conduit, street lighting components, electrical service components, etc. shall be fabricated and installed in accordance with current OUC requirements and specifications. All materials, equipment and installations shall comply and be fabricated in accordance with current OUC requirements and specifications. All materials shall be submitted to the OAR for review by OUC and the Engineer.

C. The requirements of specification L-100-1.4 and L-100-1.5 are applicable to the work performed on the 26 05 12 installations.

D. Establishing Grade and Right of Way: In undeveloped, developing or road right-of-way areas where street grades and other final grades have not been established, it shall be the Contractor’s responsibility to obtain this information from the appropriate group or individual so that completed installations shall be at required depths and final grades. It shall also be the Contractor’s responsibility to establish the boundaries of right-of-way areas such that completed installations shall be within the proper right-of-way areas.

E. The Contractor shall perform and include in the price bid for the work all work shown on the plans not specifically identified as work to be performed by OUC. Work identified to be performed by OUC shall be included in the contractors lump sum bid.

F. All equipment and materials furnished and installed under this section shall be guaranteed against defects in materials and workmanship for a period of twelve

(12) months from final acceptance by the Owner. The defective materials and/or equipment shall be repaired or replaced, at the Owner's discretion, with no additional cost to the Owner.

PART 2 – PRODUCTS (Not Used)

PART 3 – EXECUTION

3.1 METHOD OF PERFORMANCE

A. The Contractor shall perform all work in accordance with the contract documents and shall comply with the latest directives of the State of Florida Department of Transportation, Orange County, the City of Orlando, OUC, Greater Orlando Aviation Authority (GOAA) Standards, NEC and other governmental authorities having jurisdiction.

3.2 CONCRETE ENCASED CONDUIT RUNS

A. All conduit/duct shall be concrete encased except as noted in Paragraph 3.3A. The conduit run shall consist of electrical grade Schedule 40 or Schedule 80 polyvinyl chloride conduit or rigid galvanized steel conduit, as noted. Rigid galvanized steel conduit shall be used for the first ten feet of all pole risers. The conduit shall be encased in concrete with 2 inch spacing between ducts and 3 inches of concrete cover on top, bottom and sides. Concrete or plastic spacers shall be used. The concrete envelope shall be P-610 or FDOT Class II concrete with 1 inch maximum size coarse aggregate (FDOT #57 stone) with a minimum 28 day compressive strength of 3,400 PSI or equivalent. The concrete encasing the ducts shall be free of voids and air pockets; a vibrator or other mechanical means of consolidation shall be used. The concrete encasement for the duct line shall have a minimum cover of 36 inches measured from final grade, unless specifically noted otherwise. Bell end fittings shall be used on each conduit where it terminates in a manhole or pull box and as required by the Authority Having Jurisdiction. The PVC conduit used in the duct line shall be solvent welded to prevent water from entering around the couplings. The Contractor shall install a 4/0 bare copper ground wire and terminations as part of the duct, pull box and manhole installation with no separate measurement or payment. The Contractor shall use an exothermic type welding process for 4/0 conductor terminations/splicing. The OAR shall inspect all welds with random inspections performed by OUC. A close fitting duct plug shall be installed in each duct end. A polyolefin jet line pulling string, 200 pound test, shall be installed in each conduit in a duct run. Schedule 80 PVC duct and rigid galvanized steel conduit shall not be paid for separately and shall be incidental to the respective size Schedule 40 PVC duct.

B. **Encasement of primary power voltage duct banks shall have a red dye added to the PCC to achieve a distinguishable red color of the encasement for identification in the field if encountered in a future excavation.**

C. **With the concurrence of the Engineer, the Contractor may use a combination of flowable fill with a 4" red dyed PCC cap in lieu of full encasement in more remote areas of the project site not subject to future excavation concerns. The limits of this approved modification shall be as shown on the drawings or as otherwise approved by the Engineer. The PCC cap shall extend the full width of the trench above the flowable fill to otherwise fully cover the duct bank limits.**

3.3 DIRECT BURIED STREET LIGHT CONDUIT RUNS

A. Street lighting conduit shall have a minimum cover of 30" and a maximum cover of 36", unless specifically approved on a case by case basis by OUC. Street lighting conduit shall not be concrete encased except where installed under roadways or where the 30" minimum cover cannot be obtained. When concrete encasement is required for street lighting conduits, as noted above, the additional cost of the concrete encasement shall be considered incidental to the respective size direct buried street lighting conduit installation. The conduit run shall consist of electrical grade Schedule 40 or Schedule 80 polyvinyl chloride conduit or rigid galvanized steel conduit, as noted. Rigid galvanized steel conduit shall be used for the first ten feet of all pole risers and under roadways. The direct buried street light conduit shall be encased in sand or natural earth, no part of which is retained by a 0.25" sieve, with 2 inch spacing between ducts and 4 inches of sand cover on top, bottom and sides. Concrete or plastic spacers shall be used. The fill encasing the ducts shall be free of voids and air pockets and vegetation. The direct buried duct line shall have a minimum cover of 36 inches measured from final grade. Bell end fittings shall be used on each conduit where it terminates in a manhole or pull box and as required by the Authority Having Jurisdiction. The conduit used in the duct line shall be solvent welded to prevent water from entering around the couplings. A close fitting duct plug shall be installed in each duct end. A polyolefin jet line pulling string, 200 pound test, shall be installed in each conduit in a duct run. Schedule 80 PVC duct and rigid galvanized steel conduit shall not be paid for separately but shall be paid for under the respective size Schedule 40 PVC duct pay item.

3.4 CONDUIT RUNS

A. The route, nature and size of the conduits and the location of the conduit runs shall be as indicated in the contract documents. All conduits used shall be designated as electrical grade, have 5° chamfered ends and shall comply with OUC requirements. OUC data sheets are included at the end of this Item.

B. All ducts shall be securely fastened in place during construction and progress of the work and shall be plugged to prevent seepage of grout, water, or dirt. Any duct section having a defective joint shall not be installed.

C. All conduits shall be installed with joints properly mated and glued. All conduit ends shall be chamfered 5° with an OUC approved chamfering tool. Any burrs or sharp projections at conduit ends or within the conduit shall be removed.

D. All exposed ends of conduit shall be plugged during construction to prevent the entrance of foreign matter and moisture into the conduit.

E. All rigid galvanized steel conduits installed below grade shall be coated with 6 mil of asphaltum paint.

F. All directional bore ducts shall be schedule 80 electrical utility grade PVC with 5 degree chamfered ends.

G. OUC approved restrained-joint schedule 40 conduit manufacturers:

1) Carlon; Bore-gard

2) Certainteed; Certa-Com

H. Bore-guard duct is stiffer than conventional HDPE duct. The contractor shall comply with the Bore-gard manufacturer's requirements.

I. Maintain 10 foot horizontal clearance and 5 foot vertical clearance between directional bore duct banks and all other underground utilities and structures, unless noted otherwise.

J. Maintain 20 feet minimum clearance between the bottom of a pond/canal and the top of any directional bore duct. Any blow-out of the drill mud shall be immediately corrected and cleaned up by the contractor at no additional cost to the owner.

K. Conduit to meet all applicable ASTM testing and be UL listed. Conduit to be chamfered on inside diameter male ends to minimize cable damage. The bending radius for 4" PVC pipe should be no greater than 100' as recommended by the PVC Pipe Industry. Installation bend radius should be kept at a minimum to reduce the tensile pull forces displaced onto the pipe. Pipe installation and joint assembly shall be per manufacturer recommendations.

L. Conduits terminating at a pole or a building shall be rigid galvanized steel, Schedule 40 walls, with one (1) full length (10 foot) up the structure preceded by a galvanized ell. Bell ends shall be "LONG BELL ENDS" manufactured by Carlon and shall be used on each conduit where it terminates in a manhole, pull box, or hand hole. Conduits terminating in the ground to be used for future extensions shall be closed up with a PVC cap and glued to the conduit stub out. Conduits at the base of a riser pole shall be terminated using a galvanized rigid coupling and a threaded PVC plug. A subgrade location marker provided by OUC shall be buried in line with the stubbed conduit. Contractor shall contact OUC to obtain markers and install markers in accordance with OUC requirements. Acquisition and installation of subgrade location markers is incidental to the respective duct installation.

M. Where conduits pass under driveways or other paved areas, a permanent marker (an ‘E’ cut in the concrete curb) shall be installed in the curb or in the edge of pavement when curbing is not used above the conduit installation. Street lighting conduits installed under roadways shall be rigid galvanized steel conduit.

N. A 200-pound test polyolefin pulling string furnished by the Contractor shall be installed in each and every conduit.

O. Where necessary, pipe bending should be utilized for offsets, “dog-legs”, back-sided risers, or other such runs in galvanized conduits. The cost of bending these pipes and the installation of these pipes is the responsibility of the Contractor. Bending of PVC pipe shall not be allowed without prior approval of the usage and bending technique by OUC. Bends, fittings, offsets/rolling of ducts around/over/under obstructions, etc. are an incidental component of the raceway pay items.

P. The use of “split” couplings or other such fittings shall be used only in those locations where it is extremely difficult to negotiate and where additional excavation or relocation of existing facilities is impractical and/or unreasonable. OUC shall approve the use of “split” couplings or other such fittings on a case-by-case basis. Approval for one instance does not constitute a blanket approval. Where these type fittings are used, it is the responsibility of the Contractor to insure a watertight fit and take required steps in water-proofing by sealing and grouting or by adapting the galvanized conduit and using a PVC fitting for this connection.

Q. A 4/0 bare copper ground wire shall be installed by the Contractor where specified. Maintain 3” minimum between the 4/0 copper cable above and the concrete encasement of the duct bank. ~~The ground wire shall be installed between the bottom two conduits unless otherwise specified.~~ The Contractor shall use an exothermic type welding process for conductor splicing. The OAR shall inspect all welds with random inspections performed by OUC’s Inspector. Bare copper wire for counterpoise installations shall be #4/0 AWG stranded wire conforming to ASTM Specifications B-1 and B-8 or B-3 and B-8, as required by the plans and details. The Contractor shall install a 4/0 bare copper ground wire as part of the duct, pull box and manhole installation with no separate measurement or payment.

R. The OUC duct bank between manholes is designed as a 12-way 6” or 6-way 6” duct bank. Due to existing conditions, elevation changes, directional changes, clearance from objects and route. Each of the multiple duct installations shall be the same physical length. Contractor is responsible for “means and methods” and shall account for this installation condition for the OUC duct bank. Each additional duct bank requires an additional 4/0 copper ground wire installed alongside each duct bank.

S. All conduits and fittings shall be of electrical grade only, Schedule 40 or 80, or rigid galvanized steel conduit as specified, and furnished by the Contractor.

T. All conduits runs shall have 4 mil thick, polyethylene, 6” wide, red color, black printing warning tape OUC stock # 048-03819 installed directly over the conduits, 18 inches below final grade. Multiple duct bank trenches shall have tape provided over each duct. OUC data sheets are included at the end of this Item.

Marked	
Buried Electric Line Below	1-1/4” High
Caution Caution Caution	1-1/4” High
Call Orlando Utilities Commission	3/4” High
407-434-4247	
Buried Electric Line Below	1-1/4” High

U. An iron-shod mandrel, not more than 1/4-inch (6 mm) smaller than the bore of the duct shall be pushed through each duct by means of jointed conduit rods. The mandrel shall have a leather or rubber gasket slightly larger than the duct hole.

V. All conduit shall be inspected, mandrel tested, pulling string installed, and accepted by OUC prior to any cable being installed or any meters being installed.

3.5 TRENCHING AND BACKFILLING

A. The Contractor shall do all trenching and backfilling. Backfill shall comply with civil specifications. Consideration shall be given to the property at all times. Restoration shall be to the original condition. ~~No trees shall be removed.~~ All restoration is incidental to the respective 26 05 12 (Civil) pay item of which it is a component part.

B. The Contractor shall install underground ducts at the locations indicated in the plans. If necessary, the OAR shall indicate specific locations as the work progresses. Ducts shall be of the size, material, and type indicated in the plans or specifications. All duct lines shall be laid so as to grade toward hand holes, manholes and duct ends for drainage. Grades shall be at least 3 inches (75 mm) per 100 feet (30 m). On runs where it is not practicable to maintain the grade all one way, the duct lines shall be graded from the center in both directions toward manholes, hand holes, or duct ends. Pockets or traps where moisture may accumulate shall be avoided.

C. Where turf is well established and the sod can be removed, it shall be carefully stripped and properly stored.

D. Trenches for ducts may be excavated manually or with mechanical trenching equipment. Walls of trenches adjacent to the duct bank and encasement shall be essentially vertical and may act as a side form if approved by inspector. Collapsed sidewalls shall be repaired to maintain minimum encasement coverage shown on the plans. Otherwise, additional back slopes or forms may be required. so that a minimum of shoulder surface is disturbed. Blades of road patrols or graders shall not be used to excavate the trench. The Contractor shall ascertain the type of soil or rock to be excavated before bidding. All excavation shall be unclassified.

E. Dewatering necessary for pull box, conduit, duct bank and street light installation, erosion and turbidity control, in accordance with Federal, State, and Local requirements is incidental to Item 26 05 12. The cost of all excavation regardless of type of material encountered, shall be included in the 26 05 12 Item. The cost of all area restoration, grading, sodding, paving, etc., shall be included in and is incidental to the 26 05 12 Item. All rigid galvanized steel conduit, fittings, etc. furnished and installed, as required, for 26 05 12 items shall be incidental to and included within the respective 26 05 12 PVC duct.

3.6 RESURFACING AND RESTORATION

A. All trenching and street openings shall be made by the Contractor. Back filling, compacting and resurfacing shall be done by the Contractor in strict accordance with the latest directives of the Greater Orlando Aviation Authority, City of Orlando, Orange County, and the latest edition of the Florida Department of Transportation standard specification for Road and Bridge Construction and the contract documents.

B. It shall be the responsibility of the Contractor to be thoroughly familiar with these directives and to notify the respective departments at least two weeks prior to starting any construction or any related segment of construction. It is a requirement of these agencies that newly sodded areas be watered until they are established.

C. All work shall be done in reasonable harmony with the respective property owners and all disturbed areas shall be restored to their satisfaction. All materials and equipment shall be subject to inspection by the Authority, City, County and/or State Inspector.

3.7 MISCELLANEOUS

A. The Contractor shall have all manholes, pull boxes, hand holes, and junction boxes clean and free of trash, dirt and other debris.

B. The Contractor shall adhere to the following OUC Safety Procedures:

C. When entering OUC manholes, the following equipment shall be utilized -

1. Air blower per OSHA Guidelines.

2. Ladder, non-metallic, with a minimum of 3 feet extending out of the top of the manhole.

3. Gas detection meter (Continuous monitoring).

D. Water removal from the manholes is the responsibility of the Contractor.

E. Where manholes, pull boxes, etc. have OUC facilities already installed, where line covers are required, or where existing lines need protection the Contractor shall notify the OUC construction office for scheduling an OUC stand-by crew, (407) 434-4011. A minimum of 72-hour notice shall be given.

3.8 ACCESS TO FACILITIES

A. For emergency power restoration, maintenance and any other necessary construction activities, OUC vehicles shall be able to access electric facilities at all times. A stabilized road bed is required for access to all OUC manholes, transformers and switch gear. Landscaping or other permanent structures placed in close proximity to OUC facilities shall be approved by OUC engineering prior to installation.

B. Manhole covers and junction box covers shall remain visible at all times.

C. Clearances:

1. Manholes - A 20’ horizontal radius of unobstructed area and a 18’ vertical clearance is required.

2. Transformers and Switch Gear – Contact OUC for minimum unobstructed horizontal clearance required. Vertical clearance shall vary depending on the size of the equipment. This clearance shall be determined by OUC engineering.

3. Meters - A minimum 3’ clearance shall be maintained in front of meters. Mounting height shall be a minimum of 4’ to a maximum of 6’.

3.9 DIRECTIONAL BORE DUCTS

A. Directional Bored Ducts shall be installed in accordance with OUC requirements and Item L-110D-02310, however no separate payment shall be made for directional bore duct. Directional bore duct shall be considered a component part of the respective 26 05 12 duct items.

B. Provide boring to place new duct banks under existing roadways and structures. Boring shall not weaken the roadbed or structures, or interfere with their operation. Boring tolerances shall be 2 percent in the lateral alignment and one percent in vertical grade. Jetting of ducts is not permitted.

C. The diameter of the excavation shall conform to the outside diameter of the pipe as close as practical. Any voids developed outside of the diameter of the bore shall be pressure grouted with an approved mix.

D. Submit for approval a plan showing proposed method of boring, boring equipment, dewatering method, material removal, pit excavation and shoring.

3.10 STREET LIGHTING

A. OUC street lighting luminaire, horizontal cutoff type (flat lens), LED light source, with photocell receptacle, photocell shorting device, painted with a semi-gloss enamel paint, standard gray. LED roadway lighting Luminaires shall be 4000K as noted on plans, with multi-volt (120/208/240/277v/480v) ballast. Part numbers and approved manufacturers are listed on the plans.

B. The furnishing and installation of the fixture and appurtenances is incidental to the 26 05 12 (Civil) street light.

C. OUC street lighting brackets shall be truss style, tapered with 2" slip-fitter at luminaire end, capable of supporting a 60-pound luminaire, for mounting on a flat surface concrete pole. Part numbers and approved manufacturers are listed on the plans.

D. The furnishing and installation of the truss bracket is incidental to the 26 05 12 street light installation.

E. OUC Street lighting poles shall be as shown on the plans. Poles shall be 606S-T4 ALUMINUM ALLOY TUBE, manufactured in accordance with OUC specifications. Approved manufacturer is VALMONT INDUSTRIES INC.

F. The furnishing and installation of the pole is incidental to the 26 05 12 street light installation.

G. OUC cable shall be provided and installed by OUC.

H. 13" X 24" flush to ground secondary service junction box and cover shall be light traffic rated (minimum 5000-pound wheel bearing weight). Junction box shall be tapered, have open flanged bottom, and the cover shall fasten down with at least one (1) pentahead stainless steel bolt. A polymer concrete ring and cover (or preapproved overhang device of another type) around the top shall act a concrete (side walk) lock in device. Covers shall have a non-skid surface and the "OUC ELECTRIC" logo permanently embedded into the top. Each junction box shall have the cover bolted into place when shipped. The covers and pentahead bolts shall not be shipped separately. Boxes shall be OUC stock # 046-08000. Order per OUC specifications. OUC data sheets are included at the end of this Item. The 13" X 24" secondary service pull box and cover shall be considered incidental to its respective 26 05 12 conduit installations.

I. 10" X 15" flush to ground street light junction box and cover shall be light traffic rated (minimum 5000-pound wheel bearing weight). Junction box shall be tapered, have open flanged bottom, and the cover shall fasten down with at least one (1) pentahead stainless steel bolt. A polymer concrete ring and cover (or preapproved overhang device of another type) around the top shall act a concrete (side walk) lock in device. Covers shall have a non-skid surface and the "OUC ELECTRIC" logo permanently embedded into the top. Each junction box shall have the cover bolted into place when shipped. The covers and pentahead bolts shall not be shipped separately. Boxes shall be OUC stock #

036-26039. Order per OUC specifications. OUC data sheets are included at the end of this Item. The 10” X 15” street light junction box and cover shall be considered incidental to the OUC Street Light 26 05 12 street light installation.

J. Street light controller shall be provided and installed by OUC.

K. Install all fixtures in accordance with manufacturers' written instructions, and the requirements of GOAA, OUC, NEC, IES and National Electrical Safety Code.

L. Install lighting poles at locations indicated. Install poles plumb. On aluminum poles, provide double nuts to adjust plumb and grout around each base using non-shrink grout specified elsewhere. Install lamps in each luminaire. Bond luminaires, metal accessories and metal poles to branch circuit equipment grounding conductor as required by OUC standards. All grounding required by FDOT, GOAA, NEC and OUC is incidental to the OUC Street Light 26 05 12 (Civil) pay item. Provide supplementary grounding electrodes at each pole as required by FDOT and OUC standards. Grounding conductors and electrodes shall be considered incidental to the OUC Street Light 26 05 12 installation. Pole installation shall comply with wind loading criteria stated on the plans. Duct sealing compound shall be installed to seal all conduits entering exterior light fixtures from underground.

M. Street light pole ground rods shall be copper clad steel sectional type, 3/4" in diameter. 20’ of ground rod shall be installed at each street light pole and 40’ of ground rod at each street light service. Additional length of the rod shall be determined by earth resistance testing. Each rod shall be individually tested for a not to exceed earth resistance of 25 ohms prior to connection of the grounding conductors. Additional sections shall be added until the not to exceed value of 25 ohms is obtained. The Contractor shall perform the necessary inspection and test for these items concurrently with the installation because of subsequent inaccessibility of some components. Earth resistance test method shall be by the “Three Point Method” and the proposed method shall be submitted to the OAR for approval. Earth resistance testing results shall be recorded on an approved form and testing shall be performed in the presence of the OAR. All grounding materials and installation is incidental to the 26 05 12 installation of which it is a component part.

3.11 ELECTRIC UTILITY SERVICES

A. Electric Utility Service: Provide service post, primary disconnect, meter base, and secondary service fused disconnect per OUC requirements. Contractor shall confirm these requirements with OUC prior to start of work. OUC to provide high voltage transformers, primary cabling, and transformer grounding. Contractor shall furnish and install transformer pads and switch pads, all trenches and conduit from primary power manhole/pull box to transformer/switch and metering post. Utility to install transformers, primary feeders and transformer grounding. Contractor shall provide and install all transformer secondary cable, meter base, meter post equipment and electrical distribution equipment.

B. The Contractor's installation shall comply with the requirements of GOAA, OUC, NEC, IES, National Electrical Safety Code and the Authority Having Jurisdiction. Contractor is responsible for obtaining all electrical permits and required inspections. The costs for permits and inspections shall be considered incidental to the respective pay item of which it is a component part. Contractor is responsible to furnish and install all materials and equipment to provide a fully operational electrical service in accordance with the contract documents and acceptable to the OAR.

C. Ground rods shall be copper clad steel sectional type, 3/4" in diameter. The length of the rod shall be determined by earth resistance testing. Each rod shall be individually tested for a not to exceed earth resistance of 5 ohms prior to connection of the counterpoise or grounding conductors. Additional sections shall be added until the not to exceed value of 5 ohms is obtained. The Contractor shall perform the necessary inspection and test for these items concurrently with the installation because of subsequent inaccessibility of some components. Each ground rod shall be located and dimensioned on the As-built Drawings. Earth resistance test method shall be by the "Three Point Method" and the proposed method shall be submitted to the OAR for approval. Earth resistance testing results shall be recorded on an approved form and testing shall be performed in the presence of the OAR. All grounding materials and installation is incidental to the 26 05 12 (Civil) pay item of which it is a component part.

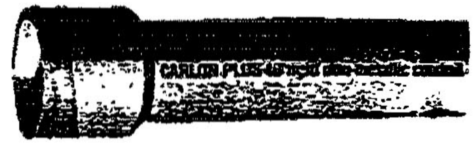
3.12 PAY ITEMS

A. General

1. All work identified on the plans and described herein shall be the responsibility of the Contractor. The Contractor shall coordinate all work for underground OUC electric, street lighting and electrical service facilities and refer to the plans and OUC for any division of work between OUC and the Contractor's work effort. This work shall include all concrete, rebar, markers, tags, sealants, adhesives, gravel, sodding, excavation, backfill, dewatering, incidentals and appurtenances, etc., necessary for the complete installation of the item to the satisfaction of the OAR and OUC. This lump sum price shall be full compensation for furnishing all materials and for all preparation, assembly and installation of these materials, and for all appurtenances necessary to complete these items and to be installed by the specific FDOT Standard Indexes called out on the plans. Any incidental work items not specifically identified and not provided by OUC shall be part of the Contractor's work effort, and included as part of the pay items below with no separate identification and payment.

Description / Requirements

SCHEDULE 40 AND 80 PVC CONDUIT



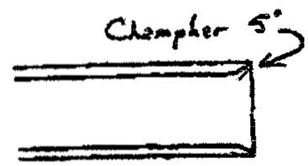
Conduit, PVC (Polyvinyl Chloride)
Gray Electrical Grade

- Schedule 40 is ordered in ten and twenty feet lengths - Schedule 80 in only 10 feet lengths. A coupling at one end is required and may be either a glued-on or expanded type (if expanded type is supplied, min. socket depth dimensions must comply with ASTM F512-95 Table 2). The end without coupling must have the inside lip edge **chamfered 5 degrees** to remove any sharpness from the edges (this requirement applies to <u>both</u> Schedule 40 and Schedule 80 conduit and <u>all</u> of the various diameter sizes). - Conduit must be shipped in bundles in a manner which allows unloading by a forklift (preferably on an open flatbed truck or trailer). - Order by type and size per above specifications.

Belled End Dimensions (Inches):

Size	Avg. Entrance Diameter	Avg. Bottom Diameter	Tolerance On Diameters	Out of Round Tolerance	Socket Depth Min.	Socket Depth Max.
1	1.331	1.320	+- 0.005	0.060	1.000	1.750
1 ½	1.921	1.906	+- 0.006	0.060	1.375	2.125
2	2.400	2.381	+- 0.006	0.060	1.750	2.500
3	3.538	3.508	+- 0.008	0.060	2.875	3.625
4	4.544	4.509	+- 0.009	0.100	3.375	4.125
5	5.614	5.573	+- 0.010	0.100	4.000	4.750
6	6.687	6.636	+- 0.011	0.100	5.000	5.750

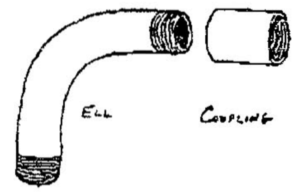
Details & OUC Stock No.		Manufacturer & Catalog No.
<u>Schedule 40</u>		**Approved Manufacturers for PVC conduit are Cantex, Carlon and <u>Georgia Pipe</u>**
1 inch x 10 feet	046-22010	See above -
1 1/2 inch x 10 feet	046-22015	See above -
2 inch x 20 feet	046-22020	See above -
2 inch x 10 feet	046-22021	See above -
3 inch x 20 feet	046-02030	See above -
3 inch x 10 feet	046-22031	See above -
4 inch x 20 feet	046-02040	See above -
4 inch x 10 feet	046-22041	See above -
5 inch x 20 feet	046-02050	See above -
5 inch x 10 feet	046-22051	See above -
6 inch x 20 feet	046-02060	See above -
6 inch x 10 feet	046-22061	See above -
<u>Schedule 80</u>		
1 inch x 10 feet	046-22810	See above -
2 inch x 10 feet	046-22820	See above -
3 inch x 10 feet	046-02830	See above -
4 inch x 10 feet	046-02840	See above -
6 inch x 10 feet	046-02860	See above -



OUC The Reliable One

Electric System
Approved
Material Manual

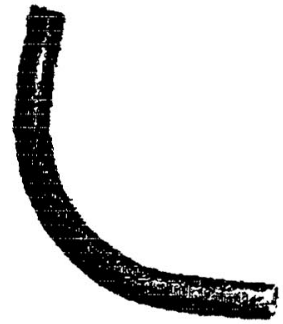
Revision Date: **08 / 25 / 99**
Category **CONDUIT**
Page Identification No. **CO-40**

Description / Requirements	GALVANIZED CONDUIT ACCESSORIES
- Couplings, galvanized conduit, 1 inch diameter to 6 inch diameter sizes. - Ells, 90 degree, galvanized conduit, 1 inch diameter to 6 inch diameter sizes. - Ells, 45 degree, galvanized conduit, 2 - 4 inch diameters only. - Ells, 11 and 22.5 degree, galv., in 4 inch and 6 inch diameters. - Sweep ells, galv., 3 ft. radius. Specify diameter and length. * All galvanized ells must have threads which will accept common PVC to galvanized female adapters.	

Approved Manufacturers for galvanized conduit and conduit accessories are: Conduit Pipe Products, Picoma, Pittsburgh Nipple, Robroy, Shamrock and Wheatland.

Details & OUC Stock No.		Manufacturer & Catalog No.
1 inch coupling	046-25110	See above -
2 inch coupling	046-25120	See above -
3 inch coupling	046-05130	See above -
4 inch coupling	046-05140	See above -
5 inch coupling	046-05150	See above -
6 inch coupling	046-05160	See above -
1 inch 90 degree ell	046-25210	See above - (min. radius 5 3/4")
2 inch 90 degree ell	046-05220	See above - (min. radius 9 1/2")
2 inch 45 degree ell	046-05320	See above - (min. radius 9 1/2")
2 ½ inch 90 degree ell (St. Cloud)	**046-55225**	*See above (radius 48")*
3 inch 90 degree ell	046-05230	See above - (min. radius 13")
3 inch 45 degree ell	046-05330	See above - (min. radius 13")
4 inch 90 degree ell	046-05240	See above - (min. radius 16")
4 inch 45 degree ell	046-05340	See above - (min. radius 16")
4 inch 22.5 degree ell	046-05540	See above -
4 inch 11 degree ell	046-05440	See above -
5 inch 90 degree ell	046-05250	See above - (min. radius 24")
6 inch 90 degree ell	046-05260	See above - (min. radius 30")
6 inch 45 degree ell	046-05360	See above - (min. radius 30")
6 inch 22.5 degree ell	046-05560	See above -
6 inch 11 degree ell	046-05460	See above -
Conduit, 6 inch sweep ells	046-07031 **DISCONTINUED**	See above - (36" radius) 60” Radius ~~48" Radius~~ See CO-705

ORLANDO UTILITIES COMMISSION Electric Engineering Standards Approved Material List	Date **June 8, 1998** Category **CONDUIT** Page Identification No. **CO-30**

DESCRIPTION / REQUIREMENTS	Sweep - SCH 40 PVC
	90° Elbow 

DETAILS & OUC STOCK NO.			MANUFACTURER & CATALOG NO.
Non-metallic SCH 40 PVC sweep with 90 degree bend.			
Size: 1"	Radius: 5-3/4" (std)	046-26210	See page CO-80
Size: 2"	Radius: 9-1/2' (std)	046-26220	See page CO-80
Size: 2"	Radius: 24"	046-56221	Cantex 5121019 Carlon UA9DJ
Size: 2"	Radius: 48"	046-56222	Cantex 5121075 Carlon UA9HJ
Size: 2-1/2"	Radius: 24"	046-56225	Cantex 5121028 Carlon UC9DKB
Size: 2-1/2"	Radius: 36"	046-56226	Cantex 5121016 Carlon UC9FKB
Size: 2-1/2"	Radius: 48"	046-56227	Cantex 5121030 Carlon UA9HK
Size: 3	Radius: 13" (Std)	046-06230	See page CO-80
Size: 5"	Radius: 48"	046-56251	Cantex 5121025 Carlon UA9HP
Size: 6"	Radius: ~~48"~~ 60"	046-56261	Cantex 5121026 60" Radius Carlon UA9HR

OUC / ST. CLOUD ELECTRIC ENGINEERING STANDARDS APPROVED MATERIAL LIST	DATE MAY 1, 1997 CATEGORY CONDUIT PAGE IDENTIFICATION NO. CO-705 ✓

AURSI - Online Approved Materials Manual
Orlando Utilities Commission

Stock #:	048-03819
Revision Date:	
Description:	

TAPE WARNING "RED"

Specs/Remarks:

Warning Tape for buried "Electric" cables - placed in ground as a warning device a short distance above underground cables and ducts,4 mils thick, polyethylene, 6" wide x 1000' long. ARED@ in color with Black printing. Marked: BURIED ELECTRIC LINE BELOW -CAUTION CAUTION CAUTION = (1 1/4" high) Call Orlando Utilities Commission 407-823-9150 = (3/4" high) BURIED ELECTRIC LINE BELOW (1 1/4" high)

Available Spec Sheets Online:

Manufacturer	**Catalog #**	**Revised By**	**Revision Date**
MICHAEL ARNOLD	PER SPEC	AURSI	
REEF INDUSTRIES	PER SPEC TERRA TAPE	AURSI	
THOR ENTERPRISES	PER SPEC SHIELDTEC	AURSI	

Engineering Contact(s)

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Purchasing Contact(s)

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Mark Ausley	mausley@ouc.com	407-384-4080

Provided by www.aursi.com

AURSI - Online Approved Materials Manual
Orlando Utilities Commission

Stock #:	036-22015
Revision Date:	
Description:	
SHORTING CAP TWIST-LOCK	
Specs/Remarks:	

Available Spec Sheets Online:

Manufacturer	Catalog #	Revised By	Revision Date
FISHER PIERCE	S1039	AURSI	
GE	C403G003	AURSI	
LAMPAS	6120-SC	AURSI	
RIPLEY	6005	AURSI	

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Provided by www.aursi.com

AURSI - Online Approved Materials Manual
Orlando Utilities Commission

Stock #:	036-26039
Revision Date:	11/20/2002

Description:
BOX, FLUSH TO GROUND STREET LIGHT 10 X 15 INCH

Specs/Remarks:
Box and Cover, for streetlight cable connections, 10K "parkway" load rated. Approximate dimensions: 10 inches wide x 15 inches long (top measurements) x 12 inches deep. Box will be tapered and have an open flanged bottom and the cover will fasten down with at least one pentahead stainless steel bolt. A poly-mer concrete ring and cover around the top will act as a concrete (sidewalk) lock-in device. Covers will have a non-skid surface and the "OUC ELECTRIC" logo and "10K" (load rating) permanently embedded into the top. Each box will have the cover bolted (pentahead bolts) into place when shipped.

Available Spec Sheets Online:

Manufacturer	**Catalog #**	**Revised By**	**Revision Date**
ARMORCAST	A6001923AX12	Mark Hoover	11/7/2002
CARSON INDUSTRIES	1419-12-HP-PR-BL	AURSI	
CDR SYSTEMS	PA40-1015-12	AURSI	

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Purchasing Contact(s)

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Mark Ausley	mausley@ouc.com	407-384-4080

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AURSI - Online Approved Materials Manual
Orlando Utilities Commission

Stock #:	046-08000
Revision Date:	11/18/2002

Description:

BOX, FLUSH TO GROUND SECONDARY JUNCTION 13 X 24 INCH

Specs/Remarks:

Box and cover - for secondary services, 10K "Parkway" load rated. Approximate dimensions: 13 inches wide x 24 inches long (top measurements) x 18 inches deep. Box will be tapered, have an open flanged bottom and the cover will fasten down with at least one pentahead stainless steel bolt. A polymer concrete ring and cover around the top will act as a concrete (sidewalk) lock-in device. Covers will have a non-skid surface and the "OUC ELECTRIC" logo and "10K" (load rating) permanently embedded into the top. Each box will have the cover bolted (with pentahead bolts) into place when shipped.

Available Spec Sheets Online:

Manufacturer	Catalog #	Revised By	Revision Date
ARMORCAST	A6001946AX18	Mark Hoover	11/7/2002
CARSON INDUSTRIES	1324-15-HP-BL	AURSI	
CDR SYSTEMS	PA10-1324-18	AURSI	
QUAZITE	PG1324BA18	AURSI	

Engineering Contact(s)

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Purchasing Contact(s)

Harvey Lippa	hlippa@ouc.com	407-737-4290
Mark Ausley	mausley@ouc.com	407-384-4080

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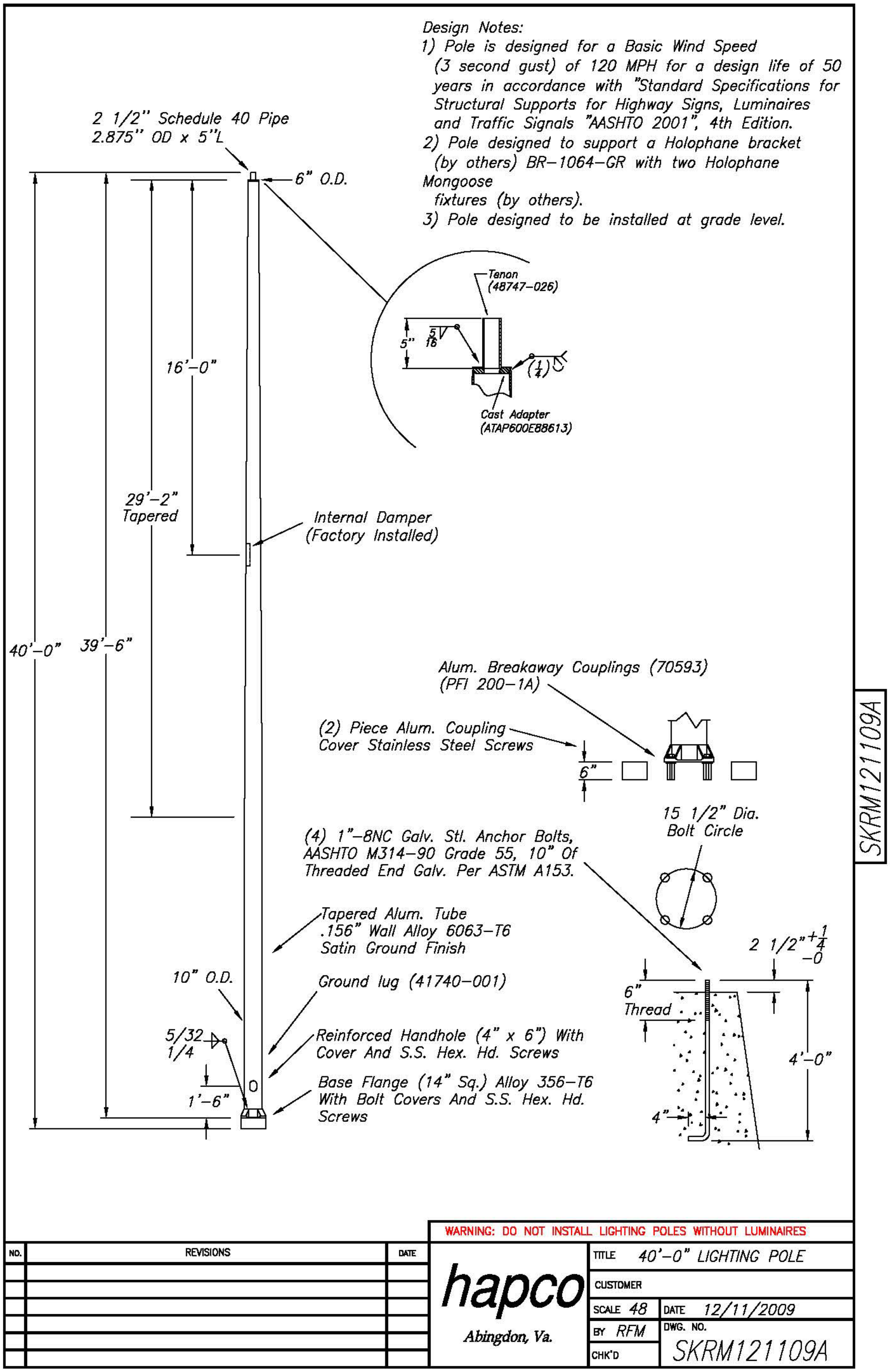
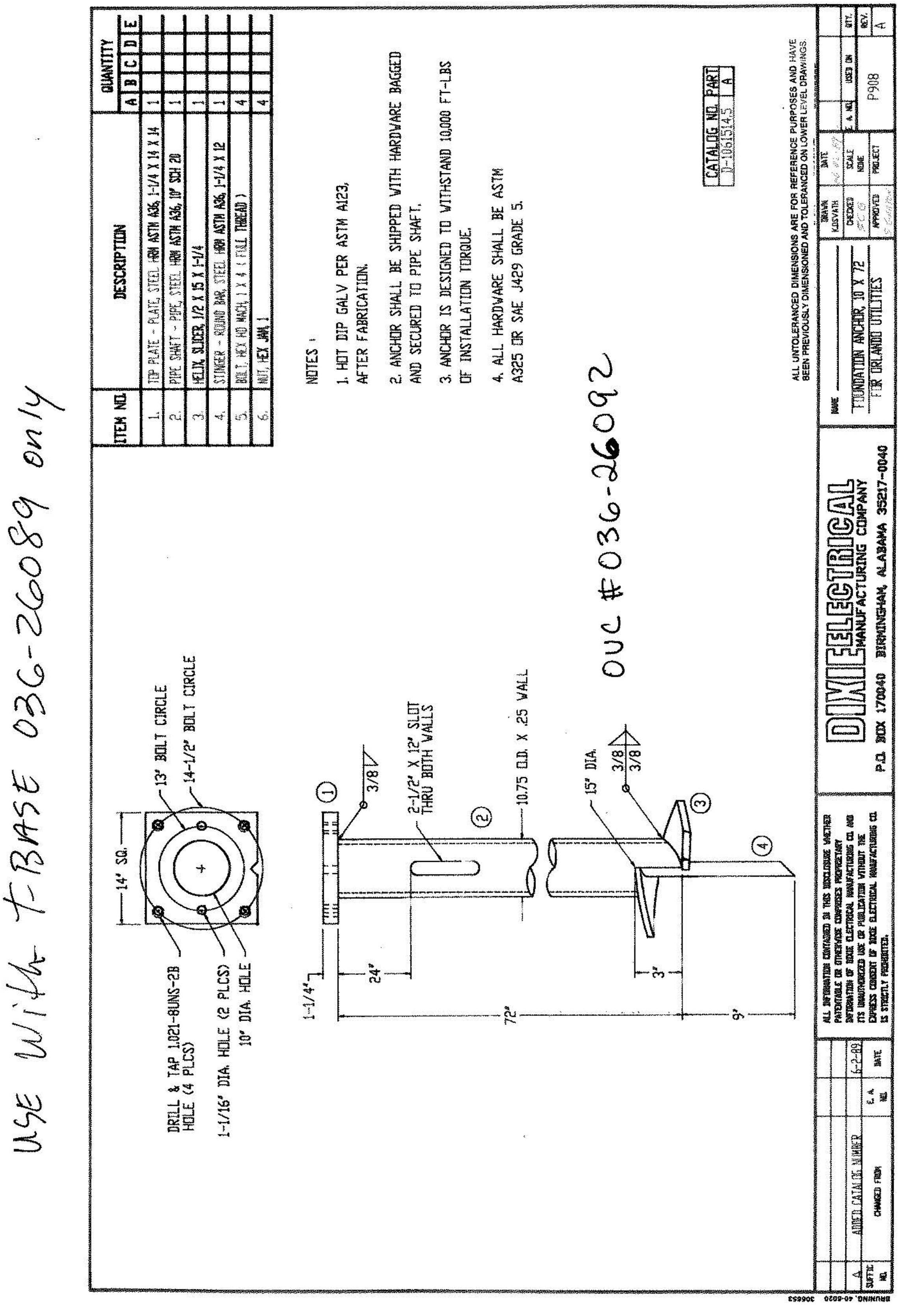

Design Notes:
1) Pole is designed for a Basic Wind Speed (3 second gust) of 120 MPH for a design life of 50 years in accordance with "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals "AASHTO 2001", 4th Edition.
2) Pole designed to support a Holophane bracket (by others) BR-1064-GR with two Holophane Mongoose fixtures (by others).
3) Pole designed to be installed at grade level.
2 1/2" Schedule 40 Pipe
2.875" OD x 5"L
6" O.D.
Tenon
(48747-026)
5"
5/16
(1/4)
Cast Adapter
(ATAP600E88613)
16'-0"
29'-2"
Tapered
Internal Damper
(Factory Installed)
40'-0"
39'-6"
Alum. Breakaway Couplings (70593)
(PFI 200-1A)
(2) Piece Alum. Coupling
Cover Stainless Steel Screws
6"
15 1/2" Dia.
Bolt Circle
(4) 1"-8NC Galv. Stl. Anchor Bolts, AASHTO M314-90 Grade 55, 10" Of Threaded End Galv. Per ASTM A153.
Tapered Alum. Tube
.156" Wall Alloy 6063-T6
Satin Ground Finish
2 1/2" +1/4 -0
10" O.D.
Ground lug (41740-001)
6"
Thread
5/32
1/4
Reinforced Handhole (4" x 6") With Cover And S.S. Hex. Hd. Screws
4'-0"
1'-6"
Base Flange (14" Sq.) Alloy 356-T6 With Bolt Covers And S.S. Hex. Hd. Screws
4"
SKRM121109A
WARNING: DO NOT INSTALL LIGHTING POLES WITHOUT LUMINAIRES
NO.
REVISIONS
DATE
hapco
Abingdon, Va.
TITLE 40'-0" LIGHTING POLE
CUSTOMER
SCALE 48
DATE 12/11/2009
BY RFM
DWG. NO.
CHK'D
SKRM121109A

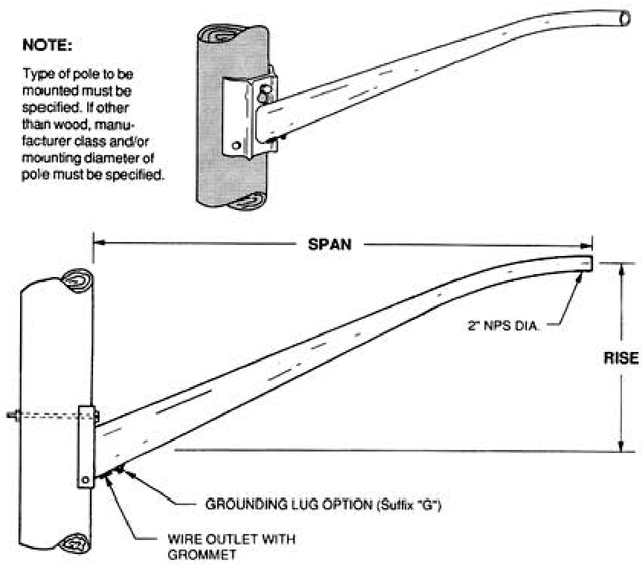

USE With T-BASE 036-26089 only
OUC #036-26092
ITEM NO. | DESCRIPTION | QUANTITY A B C D E
1. TOP PLATE - PLATE, STEEL HRM ASTM A36, 1-1/4 X 14 X 14 | 1
2. PIPE SHAFT - PIPE, STEEL HRM ASTM A36, 10" SCH 20 | 1
3. HELIX, SLICER, 1/2 X 15 X 1-1/4 | 1
4. STINGER - ROUND BAR, STEEL HRM ASTM A36, 1-1/4 X 12 | 1
5. BOLT, HEX HD MACH, 1 X 4 (FULL THREAD) | 4
6. NUT, HEX JAM, 1 | 4
NOTES :
1. HOT DIP GALV PER ASTM A123, AFTER FABRICATION.
2. ANCHOR SHALL BE SHIPPED WITH HARDWARE BAGGED AND SECURED TO PIPE SHAFT.
3. ANCHOR IS DESIGNED TO WITHSTAND 10,000 FT-LBS OF INSTALLATION TORQUE.
4. ALL HARDWARE SHALL BE ASTM A325 OR SAE J429 GRADE 5.
CATALOG NO. D-1061514.5 PART A
DRILL & TAP 1.021-8UNS-2B HOLE (4 PLCS)
1-1/16" DIA. HOLE (2 PLCS)
10" DIA. HOLE
14" SQ.
13" BOLT CIRCLE
14-1/2" BOLT CIRCLE
1-1/4"
24"
72"
3"
9"
3/8
2-1/2" X 12" SLOT THRU BOTH WALLS
10.75 O.D. X .25 WALL
15" DIA.
ALL UNTOLERANCED DIMENSIONS ARE FOR REFERENCE PURPOSES AND HAVE BEEN PREVIOUSLY DIMENSIONED AND TOLERANCED ON LOWER LEVEL DRAWINGS.
DIXIE ELECTRICAL MANUFACTURING COMPANY
P.O. BOX 170040 BIRMINGHAM, ALABAMA 35217-0040
FOUNDATION ANCHOR, 10 X 72
FOR ORLANDO UTILITIES
DRAWN K.JOSVATH
CHECKED
APPROVED
SCALE NONE
PROJECT P908
REV. A
A ADDED CATALOG NUMBER 6-2-89
SUFFIX NO. CHANGED FROM E.A. NO. DATE

Curlee Machinery Company, Inc.

Home
What's New
Company Information
Mounting Specifications
Tapered Brackets
Pipe Brackets
Floodlighting
"A" Frames & Truss Designs

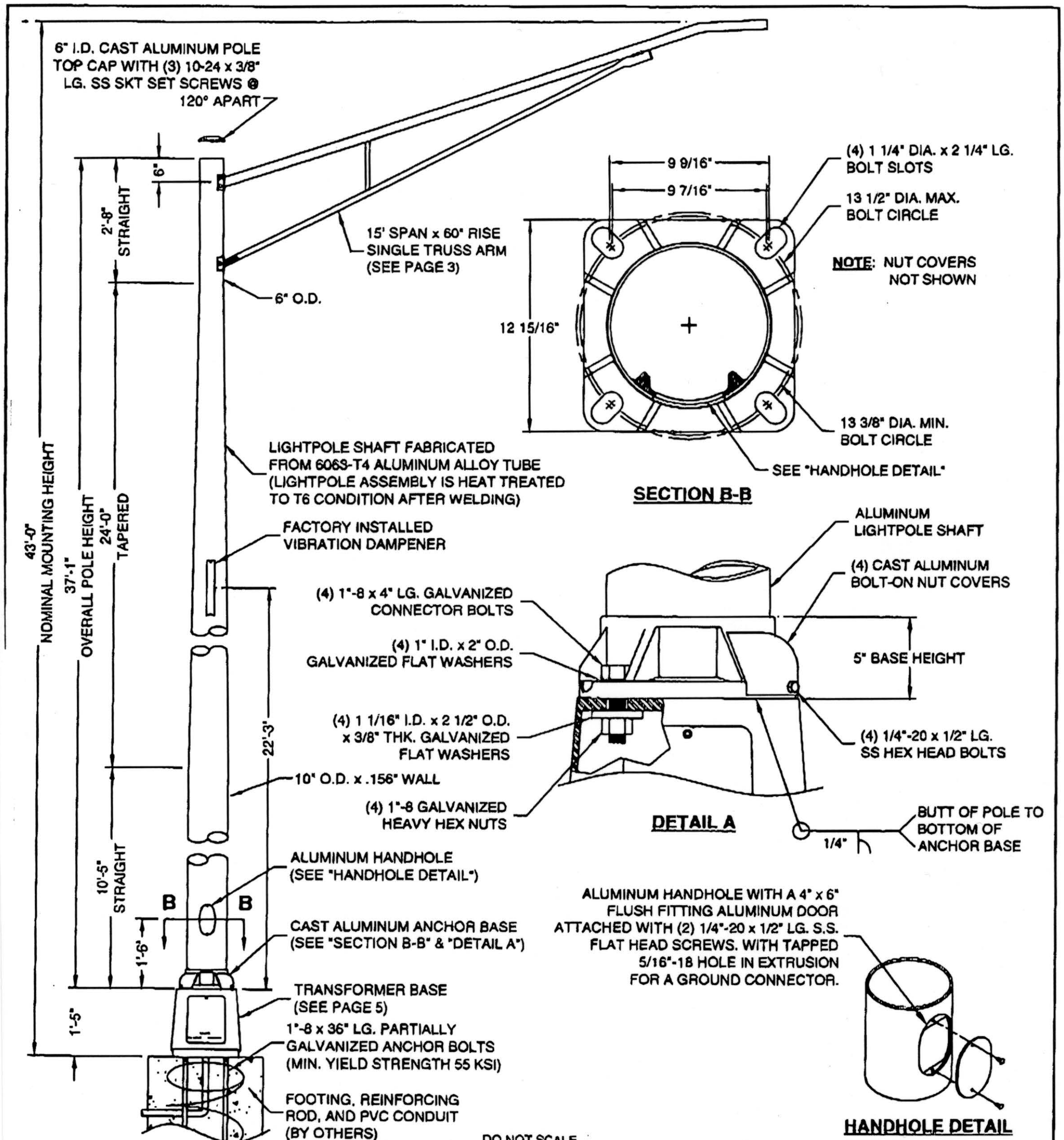
Tapered Brackets

"Tapertruss" - Fabricated Aluminum Brackets for Wood, Concrete or Fiberglass Poles



CATALOG NO.	TYPE	SPAN	RISE
2004515T(G)	4 FT.	45"	15"
2006824T(G)	6 FT.	68"	24"
2009032T(G)	8 FT.	90"	32"
20011439T(G)	10 FT.	114"	39"
20013846T(G)	12 FT.	138"	46"

"Tapertruss" - Fabricated Aluminum Brackets



valmont

Structures Division, Valmont Industries, Inc.
20805 Eaton Ave Farmington,
Minnesota 55024-0228
Phone: (651) 463-8990 (800) 899-7577
Fax: (651) 463-3349

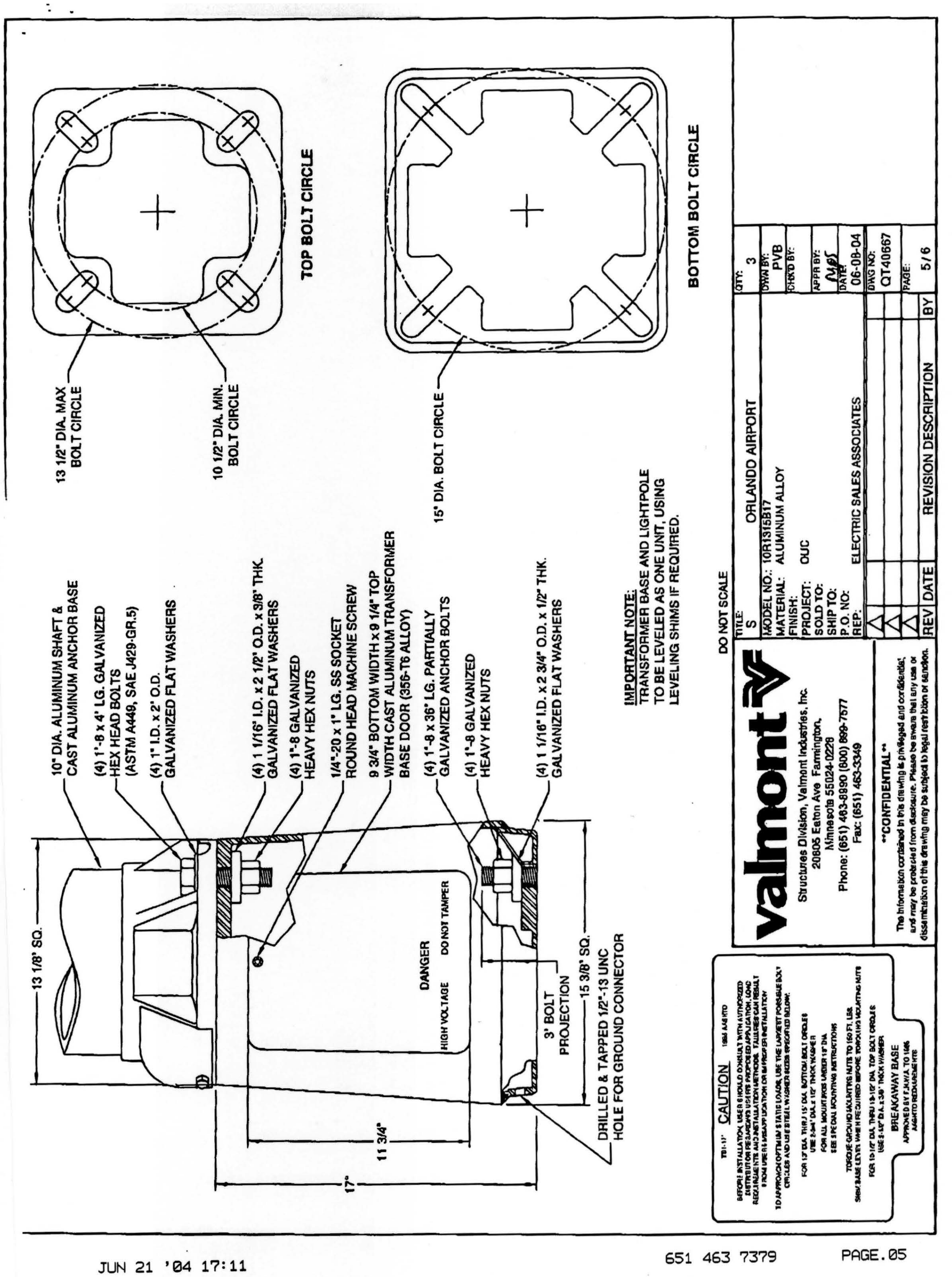
"CONFIDENTIAL"

The information contained in this drawing is privileged and confidential, and may be protected from disclosure. Please be aware that any use or dissemination of this drawing may be subject to legal restriction or sanction.

TITLE: S	ORLANDO AIRPORT	QTY: 3
MODEL NO.:		DWN BY: PVB
MATERIAL:	ALUMINUM ALLOY	CHK'D BY:
FINISH:	100 GRIT SATIN POLISH	
PROJECT:	OUC	APPR BY: MP
SOLD TO:		
SHIP TO:		
P.O. NO:		DATE: 06-08-04
REP:	ELECTRIC SALES ASSOCIATES	DWG NO: QT40667
		PAGE: 1 / 6

REV	DATE	REVISION DESCRIPTION	BY
△			
△			
△			

JUN 21 '04 17:09 651 463 7379 PAGE.01



END OF SECTION L-109S-26 05 12

SECTION 26 05 13 - MEDIUM VOLTAGE CABLE

PART 1 - GENERAL

1.1 DESCRIPTION OF SYSTEM

A. Provide and install all electrical for medium voltage service and distribution system including but not limited to:

1. Medium voltage cable.
2. Cable terminations.

1.2 REFERENCES

A. AEIC CS8-13 - Specification for Extruded Dielectric, Shielded Power Cables Rated 5 Through 46 kV - 4th Edition

B. ANSI/ICEA S-94-649-2013 - Standard For Concentric Neutral Cables Rated 5 Through 46 kv

C. ANSI/IEEE C2 - National Electrical Safety Code.

D. ANSI C119.4-2011 - American National Standard for Electric Connectors - Connectors for Use Between Aluminum-to-Aluminum and Aluminum-to-Copper Conductors Designed for Normal Operation at or Below 93°C and Copper-toCopper Conductors Designed for Normal Operation at or Below 100°C

E. ANSI/NFPA 70 - National Electrical Code.

F. IEEE 48 - Test Procedures and Requirements for High- Voltage Alternating-Current Cable Terminations.

G. NEMA WC 8 - Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

1.3 SUBMITTALS

A. Submit Product Data: Provide for cable, terminations, and accessories.

B. Submit Test Reports: Indicate results of cable test in tabular form and in plots of current versus voltage for incremental voltage steps, and current versus time at 30 second intervals at maximum voltage.

C. Submit water block testing reports.

D. Submit connection testing reports.

E. Submit Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements.

F. Submit Manufacturer's Instructions: Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.

1.4 PROJECT RECORD DOCUMENTS

A. Submit accurately record of actual sizes and locations of cables.

1.5 OPERATION AND MAINTENANCE DATA

A. Submit Maintenance Data: Include instructions for testing and cleaning cable and accessories.

1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing Products specified in this Section with minimum three years experience.

B. Installer: Company specializing in installing Products specified in this Section with minimum five (5) years experience.

1.7 REGULATORY REQUIREMENTS

A. Conform to requirements of ANSI/NFPA 70 and ANSI/IEEE C2 whichever is most stringent.

B. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for purpose specified and shown.

C. Except as noted, this cable shall be manufactured and tested in accordance with the latest AEIC CS8 and ICEA S-94-649 standards.

1.8 QUALITY ASSURANCE TESTS

A. Testing of Water Blocking: Production testing and qualification testing shall be done in accordance with ICEA T-34-664, “Test Method for Conducting Longitudinal Water Penetration Resistance Tests on Longitudinal Water Blocked Cables”, with water pressure at 5 psi. All cable supplied must be accompanied by certified test reports showing passing results.

B. Connection Test: A test report shall be supplied with submittals demonstrating the connection integrity of normal compression type sleeves and terminals when applied to a regular production cable made with conductor filled with the same type compound as will be used for this order if awarded. The test should be in accordance with ANSI C119.4, formerly IEEE TDJ 162 (500 cycle). The test results should show that the temperature of an insulated splice connector is equal to or less than the insulated conductor to which it is connected and that the resistance is stable in comparison to initial resistance measurements.

C. Testing: All testing shall be in accordance with AEIC CS8 and ICEA S-94-649 and the applicable standards referenced therein.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Accept cable and accessories on site in manufacturer's packaging. Inspect for damage.

B. Store and protect in accordance with manufacturer's instructions.

C. Protect from weather. Provide adequate ventilation to prevent condensation.

1.10 PROJECT CONDITIONS

A. Verify that field measurements are as shown on Drawings.

B. Verify routing and termination locations of cable bank prior to rough-in.

C. Cable routing is shown on Drawings in approximate locations unless dimensioned. Route as required to complete wiring system.

PART 2 - PRODUCTS

2.1 MEDIUM VOLTAGE CABLE

A. Manufacturers:

1. Okinite

2. General Cable

B. Voltage: 15 kV, grounded.

C. Grounding Conductors: Insulated copper with a rating of 600 volts and conforming to the Section for 600V wiring in this specification. Provide a THWN AWG #4/0 copper grounding conductor in every conduit used for medium voltage cable. Bond grounding conductor to every termination to form multiple-point grounded system (also called short-circuit shield system).

2.2 CABLE, SINGLE, CROSSLINKED POLYETHYLENE, 15 kV, 2/0 AWG COPPER

A. This specification is for polyethylene-jacketed 2/0 AWG, filled-strand stranded copper, 15 kV tree retardant crosslinked polyethylene insulated, single conductor cable further described as follows:

1. Conductor: The conductor shall consist of class B (19 strand) concentric-lay-stranded (compressed optional) annealed copper wires according to ASTM specifications B-3 and B-8. Compact conductor is not acceptable. The center strand wire shall be indented with an abbreviation of manufacturer name and year made. The inner interstices shall be filled with a powder or suitable tacky semi conducting water-blocking compound.
2. Conductor Shield: The conductor shield shall consist of extruded semiconducting thermosetting compound, compatible with and having the same (or better) thermal characteristics as the major insulation. The application of this layer shall be so as to produce a smooth, uniform cylindrical outer surface bonded to the insulation. The thickness of the conductor shield shall be in accordance with ICEA S-94-649.
3. Insulation: The insulation shall be a tree retardant crosslinked polyethylene compound with a minimum point thickness of 165 mils and a maximum point thickness of 205 mils per ICEA S-94-649. The minimum and maximum diameters over the insulation shall be in accordance with ICEA S-94-649.
4. Insulation Shield: The insulation shield shall consist of extruded semiconducting thermosetting compound, compatible with and having the same (or better) thermal characteristics as the major insulation. The thickness shall be in accordance with ICEA S-94-649The insulation shield shall be strippable with pulling tensions within the limits provided in the most recent ICEA S-94-649 standard for extruded insulation. The minimum and maximum diameters over the insulation shield shall be in accordance with ICEA S-94-649.
5. Extrusion: The application of the above referenced three layers of extruded compound shall be by means of a single pass with a true triple extrusion process.
6. Concentric Neutral: The neutral shall consist of twelve (12) strands of #14 AWG coated or uncoated (preferred) copper wire. (The ampacity of these 12 wires amounts to slightly more than one third the conductor ampacity). The concentric neutral wires shall be applied in accordance with ICEA S-94-649.
7. Jacket: The cable is to be protected with an extruded black insulating linear low density polyethylene jacket covering and filling the spaces between the neutral wires. This shall fit tightly against the semiconducting insulation shield but strip freely away from the insulation shield. Three red stripes, equally spaced, shall be extruded into the jacket. The minimum and maximum thicknesses of the jacket shall be in accordance with ICEA S-94- 649.
8. Identification: The jacket shall have repeatedly printed along its length "2/0 CU" and "175 MIL TR-XLPE" along with the manufacturer name and year made. The jacket shall also be labeled with a sequential footage every 2 feet.

2.3 CABLE, SINGLE, ETHYLENE PROPYLENE, 15 kV, 500 kcmil COPPER

A. This specification is for polyethylene jacketed 500 kcmil, filled-strand stranded copper 15 kV ethylene propylene rubber (EPR) insulated, single conductor cable further described as follows:

1. Conductor: The conductor shall consist of class B (37 strand) concentric-lay-stranded compressed optional) annealed copper wires according to ASTM specification B-3 and B-8. Compact conductor is not acceptable. The center strand wire shall be indented with an abbreviation of manufacturer name and year made.
2. Conductor Shield: The conductor shield shall consist of extruded semiconducting thermosetting compound, compatible with and having the same (or better) thermal characteristics as the major insulation. The application of this layer shall be so as to produce a smooth, uniform cylindrical outer surface bonded to the insulation. The thickness of the conductor shield shall be in accordance with ICEA S-94-649.
3. Insulation: The insulation shall consist of Type II thermosetting ethylene propylene rubber compound with a minimum point thickness of 165 mils and a maximum point thickness of

205 mils per ICEA S-94-649. The minimum and maximum diameters over the insulation shall be in accordance with ICEA S-94-649. A 120 mesh screen or finer shall be used in the final mixing operation of the compound.

4. Insulation Shield: The insulation shield shall consist of extruded semiconducting thermosetting compound, compatible with and having the same (or better) thermal characteristics as the major insulation. The thickness shall be in accordance with ICEA S-94-649. The insulation shield shall be strippable with pulling tensions within the limits provided in the most recent ICEA S-94-649 standard for extruded insulation shields. The minimum and maximum diameters over the insulation shield shall be in accordance with ICEA S-94-649.

5. Extrusion: The application of the above referenced three layers of extruded compound shall be by means of a single pass with a triple extrusion process.

6. Concentric Neutral: The neutral copper wire shield shall consist of twenty (20) strands of #14 AWG coated or uncoated (preferred) copper wire. (The ampacity of these 20 wires amounts to slightly more than one third the conductor ampacity). The concentric neutral wires shall be applied in accordance with ICEA S-94-649.

7. Jacket: The cable is to be protected with an extruded black insulating linear low-density polyethylene jacket covering and filling the spaces between the neutral wires. The minimum and maximum thicknesses of the jacket shall be in accordance with ICEA S-94-649.

8. Identification: The jacket shall have repeatedly printed along its length "500 CU" and "175 MIL EPR" along with the manufacturer name and year made. The jacket shall also be labeled with a sequential footage every 2 feet.

2.4 CABLE, SINGLE, CROSSLINKED POLYETHYLENE, 15 kV, 2/0 AWG ALUMINUM

A. This specification is for polyethylene-jacketed 2/0 AWG, filled-strand stranded aluminum, 15 kV tree retardant crosslinked polyethylene insulated, single conductor cable further described as follows:

1. Conductor: The conductor shall consist of class B (19 strand) concentric-lay-stranded (compressed optional) aluminum. Compact conductor is not acceptable. Conductor temper shall be AL 1350-H19 (full hard) in accordance with ASTM specification B609. The center strand wire shall be indented with an abbreviation of manufacturer name and year made. The inner interstices shall be filled with a powder or suitable tacky semi conducting water-blocking compound.

2. Conductor Shield: The conductor shield shall consist of extruded semiconducting thermosetting compound, compatible with and having the same (or better) thermal characteristics as the major insulation. The application of this layer shall be so as to produce a smooth, uniform cylindrical outer surface bonded to the insulation. The thickness of the conductor shield shall be in accordance with ICEA S-94-649.

3. Insulation: The insulation shall be a tree retardant crosslinked polyethylene compound with a minimum point thickness of 165 mils and a maximum point thickness of 205 mils per ICEA S-94-649. The minimum and maximum diameters over the insulation shall be in accordance with ICEA S-94-649.

4. Insulation Shield: The insulation shield shall consist of extruded semiconducting thermosetting compound, compatible with and having the same (or better) thermal characteristics as the major insulation. The thickness shall be in accordance with ICEA S-94-649. The insulation shield shall be strippable with pulling tensions within the limits provided in the most recent ICEA S-94-649 standard for extruded insulation shields. The minimum and maximum diameters over the insulation shield shall be in accordance with ICEA S-94-649.

5. Extrusion: The application of the above referenced three layers of extruded compound shall be by means of a single pass with a true triple extrusion process.

6. Concentric Neutral: The neutral shall consist of eight (8) strands of #14 AWG coated or uncoated (preferred) copper wire. (The ampacity of these 8 wires amounts to slightly more than one third the conductor ampacity). The concentric neutral wires shall be applied in accordance with ICEA S-94-649.

7. Jacket: The cable is to be protected with an extruded black insulating linear low-density polyethylene jacket covering and filling the spaces between the neutral wires. This shall fit tightly against the semiconducting insulation shield but strip freely away from the insulation shield. Three red stripes, equally spaced, shall be extruded into the jacket.

8. The minimum and maximum thicknesses of the jacket shall be in accordance with ICEA S-94-649.

9. Identification: The jacket shall have repeatedly printed along its length "2/0 AL" and "175 MIL TR-XLPE" along with the manufacturer name and year made. The jacket shall also be labeled with a sequential footage every 2 feet.

2.5 CABLE, SINGLE, CROSSLINKED POLYETHYLENE, 15kV, 750 kcmil ALUMINUM

A. This specification is for polyethylene jacketed 750 kcmil, filled-strand stranded aluminum, 15 kV tree retardant crosslinked polyethylene insulated, single conductor cable further described as follows:

1. Conductor: The conductor shall consist of class B (61 strand) compressed concentric-lay-stranded aluminum. Compact conductor is not acceptable. Conductor temper shall be AL 1350-H14 (half hard) or AL 1350-H16 (three-quarter hard) in accordance with ASTM specification B609. The center strand wire shall be indented with an abbreviation of manufacturer name and year made. The inner interstices shall be filled with a suitable tacky semiconducting water blocking compound.

2. Conductor Shield: The conductor shield shall consist of extruded semiconducting thermosetting compound, compatible with and having the same (or better) thermal characteristics as the major insulation. The application of this layer shall be so as to produce a smooth, uniform cylindrical outer surface bonded to the insulation. The thickness of the conductor shield shall be in accordance with ICEA S-94-649.

3. Insulation: The insulation shall be a tree retardant crosslinked polyethylene compound with a minimum point thickness of 165 mils and a maximum point thickness of 205 mils per ICEA S-94-649. The minimum and maximum diameters over the insulation shall be in accordance with ICEA S-94-649.

4. Insulation Shield: The insulation shield shall consist of extruded semiconducting thermosetting compound, compatible with and having the same (or better) thermal characteristics as the major insulation. The thickness shall be in accordance with ICEA S-94-649. The insulation shield shall be strippable with pulling tensions within the limits provided in the most recent ICEA S-94-649 standard for extruded insulation shields. The minimum and maximum diameters over the insulation shield shall be in accordance with ICEA S-94-649.

5. Extrusion: The application of the above referenced three layers of extruded compound shall be by means of a single pass with a true triple extrusion process.

6. Concentric Neutral: The neutral copper wire shield shall consist of twelve (12) strands of #14 AWG coated or uncoated (preferred) copper wire. The concentric neutral wires shall be applied in accordance with ICEA S-94-649.

7. Jacket: The cable is to be protected with an extruded black insulating linear low density polyethylene jacket covering and filling the spaces between the neutral wires. This shall fit

tightly against the semiconducting insulation shield but strip freely away from the insulation shield. Three red stripes, equally spaced, shall be extruded into the jacket. The min/max thickness of the jacket shall be in accordance with ICEA S-94-649.

8. Identification: The jacket shall have repeatedly printed along its length "750 AL" and "175 MIL TR-XLPE" along with the manufacturer name and year made. The jacket shall also be labeled with a sequential footage at least every 2 feet.

2.6 CABLE, SINGLE, ETHYLENE PROPYLENE, 15 kV, 1000 kcmil ALUMINUM 175 MIL INSULATION, CONCENTRIC NEUTRAL

A. This specification is for polyethylene jacketed 1000 kcmil filled-strand stranded aluminum, 15 kV ethylene propylene rubber insulated, single conductor cable further described as follows:

1. Conductor: The conductor shall consist of 61 strands of class B compressed concentric-lay- stranded aluminum according. Compact conductor is not acceptable. Conductor temper shall be AL 1350-H19 (full hard) in accordance with ASTM specification B609. The center strand wire shall be indented with an abbreviation of manufacturer name and year made. The inner interstices shall be filled with a powder or suitable tacky semi conducting water- blocking compound.

2. Conductor Shield: The conductor shield shall consist of extruded semiconducting thermosetting compound, compatible with and having the same (or better) thermal characteristics as the major insulation. The application of this layer shall be so as to produce a smooth, uniform cylindrical outer surface bonded to the insulation. The thickness of the conductor shield shall be in accordance with ICEA S-94-649.

3. Insulation: The insulation shall consist of a Type II thermosetting ethylene propylene rubber compound with a minimum point thickness of 165 mils and a maximum point thickness of 205 mils per ICEA S-94-649. The minimum and maximum diameters over the insulation shall be in accordance with ICEA S-94-649. A 120 mesh screen or finer shall be used in the final mixing operation of the compound.

4. Insulation Shield: The insulation shield shall consist of extruded semiconducting thermosetting compound, compatible with and having the same (or better) thermal characteristics as the major insulation. The thickness shall be in accordance with ICEA S-94-649. The insulation shield shall be strippable with pulling tensions within the limits provided in the most recent ICEA S-94-649 standard for extruded insulation shields. The minimum and maximum diameters over the insulation shield shall be in accordance with ICEA S-94-649.

5. Extrusion: The application of the above referenced three layers of extruded compound shall be by means of a single pass with a triple extrusion process.

6. Concentric Neutral: The neutral copper wire shield shall consist of fifteen (15) strands of

7. #12 AWG coated or uncoated (preferred) copper wire. The concentric neutral wires shall be applied in accordance with ICEA S-94-649.

8. Jacket: The cable is to be protected with an extruded black insulating linear low-density polyethylene jacket. The minimum and maximum thicknesses of the jacket shall be in accordance with ICEA S-94-649.

9. Identification: The jacket shall have repeatedly printed along its length "1000 AL" and "175 MIL EPR" along with the manufacturer name and year made. The jacket shall also be labeled with a sequential footage at least every 2 feet.

2.7 CABLE TERMINATIONS

A. Lugs and Connectors:

1. All splices and terminations shall be made with compression connectors and lugs.

2. Connectors.

B. Splices:

1. All splices shall meet the requirements of IEEE Standard 404-977.
2. Splices shall be designed in accordance with wire manufacturer's specific instructions and shall be designed for splicing 15 KV cable of size as shown.
3. There shall be no splices between switchgear and transformer, switchgear and equipment. Cable shall be precut and shipped to job site. Field cutting shall be limited to trimming cable ends prior to termination.
4. Splice 2/0 AL/CU 15 KV Straight Slide On Splice
   a) Acceptable Products:
      1. 3M Catalog #: 5411-20006
      2. Cooper Power Catalog #: 2637858B07M
      3. Elastimold Catalog #: 15PCJ1G1250
5. Splice Straight Slide On 1000 AL 15 KV
   a) Acceptable Products:
      1. Elastimold Catalog #: 15PCJ1N1410-CS820

C. Load Break Elbows

1. 200 A 2/0 AL/CU Fused Load Break Elbow
   a) Acceptable Products:
      1. Elastimold Catalog #: 166FLR-GA-2/0

D. Dead Break 600 AMP Separable Connections

1. Acceptable Products:
   a) Elastimold

E. Terminators:

1. All terminations shall meet the requirements of IEEE Standard 48-1975 for Class Terminations at 5KV-15KV.
2. Indoor Switchgear: All terminations in the indoor switchgear shall utilize silicone rubber pre-stressed tubing kits.
3. Grounding: All terminator kits shall be furnished with mechanical grounding strap assemblies. Bond all terminations to external circuit grounding conductor.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that conduit is ready to receive cable.

3.2 PREPARATION

A. Use swab to clean conduits and ducts before pulling cables.

3.3 INSTALLATION

A. Install cable and accessories in accordance with manufacturer's instructions.

B. Avoid abrasion and other damage to cables during installation.

C. Use suitable lubricants and pulling equipment.

D. Do not exceed cable pulling tensions and bending radius.

E. Ground cable shield at each termination and splice.

F. Cable ends shall be sealed and remain sealed during all cable handling and installation procedures until splicing or terminating begins.

G. Cable ends subjected to pulling stresses shall be cut off one meter from the end, or more if required.

H. Any damaged cable shall be replaced in its entirety. This includes damage due to manufacture or installation.

I. Once a cable termination or splice commences it shall be completed without undue delay.

J. For ductbank installations all three phase conductors of a given circuit shall be pulled into common duct. Phase conductor shall be pulled into exterior ducts, leaving interior duct(s) for spare(s).

K. For interior installations, the neutral or grounding conductor must be pulled into the same conduit as the phase conductors.

L. Splices and Terminations:

1. Cable shall be trained in a straight line approach to splices and terminations, without sharp bends to insure that undue stresses are not applied to the splice and terminator sleeves, or to the cable.

2. Special care shall be taken to perform splicing and terminating under clean and dry conditions and to prevent moisture, dirt and other foreign material from coming in contact with the splicing materials.

3. All splices, taps, and terminations shall be made by methods and with material identified for the purpose and as specified herein, shall have voltage and current ratings equal to or greater than cable ratings, and shall be made in strict accordance with the cable manufacturer's recommendations and instructions.

M. Labeling:

1. All cables in pull boxes and switchgear, shall be labeled using wrap around plastic identification tags similar to Thomas and Betts "Ty-Taps". Tags shall identify the circuit voltage and circuit number. Every cable of every circuit shall also be marked to identify the connected phase. Label cables at every splice and termination, and at every point of cable access pull boxes.

N. Signs: Provide signs in all pull boxes and on outside of all switchgear. Signs shall be OSHA-standard "DANGER-HIGH VOLTAGE< KEEP AWAY". Place signs adjacent to cable labels, which identify circuit voltage, phase and number. Covers of pull and junction boxes shall be permanently marked per NEC 370-52 (e).

O. Qualifications: Contractor shall submit to the Engineer its qualifications for performing high voltage cable work, including prior job listing and names and qualifications of installers who will be working on this job.

P. Conduit Sealing: Provide watertight conduit sealing at every conduit stub up.

Q. Cable Reels (Spools): Cable shall be precut and shipped to jobsite on spools. Contractor shall be responsible for proper receipt, storage and handling of all cable and reels. Contractor shall obtain and comply with manufacturer's storage recommendations and shall include any cost of handling and storage in base bid. In addition, if reusable reels are provided, contractor shall coordinate with manufacturer and return reels within predefined time period that refunds reel security deposit. Reel security deposit shall be refunded to Owner. Cable spools shall be handled carefully and in accordance with recommendations of the cable manufacturer. A spool showing signs of abuse on the jobsite shall be considered to be damaged cable and may be rejected by Owner and replaced at Contractor's expense prior to cable installation.

3.4 FIELD QUALITY CONTROL

A. Inspect exposed cable sections for physical damage.

B. Inspect cable for proper connections as shown on Drawings.

C. Inspect shield grounding, cable supports, and terminations for proper installation.

D. High Voltage Cable Testing:

1. General: High potential proof tests shall be made on all high voltage cables before system energization, final observation and acceptance of work by the Architect. Engage the services of an Independent Testing Firm (ITF) to perform the high voltage d-c test on each cable under the direction of the Engineer. The Contractor is responsible for all costs to be charged by the ITF. Said testing service shall have equipment capable of accurately making all tests as described herein and by IEEE 400, IEEE 510, NEMA WC-8, and ICEA S-68-516. All reports shall be submitted by the ITF directly to the Contractor and not to the cable installation contractor. Submit the original and one copy of all cable test reports at completion of each test to the Architect, certified true and correct. A preliminary report, consisting of a carbon copy or other duplication of the field test, shall be received by the Architect within five working days after each test.

2. Type of Test: a non-destructive D.C. testing device, such as Biddle Megger and DC Dielectric Test Sets, "Kenotron", Westinghouse "High Type Tester", or accepted equal, capable of generating twice rated voltage of cable plus 1000 volts DC under normal leakage conditions of installed cable, shall be used for the tests.

3. Optional Cable Delivery Test: At the option of the Contractor, the ITF shall test all cable upon delivery to the job site and prior to installation. This optional test is intended to verify cable integrity as delivered and to identify cable that does not meet specifications before that cable is pulled into site circuit configurations. Cable that does not pass delivery testing shall be replaced by the Contractor. Include cable manufacturer, distributor and cable shipper job order records in both cable test reports (optional delivery test, if performed and installation test).

4. General Set Up: All cables shall be tested in place, with all splices and terminations made up but not connected to switchgear or any other load device, and dead end seals shall be temporarily opened and then resealed. Prior to each high potential test, each high voltage cable conductor shall be separately "megged" with a 2,500 volt megohm meter, or equal, from conductor to sheath or ground. Low megger readings of less than 25 megohms shall be cause for rejection of the cable. The test voltage shall be in accordance with ICEA recommended values except where the cable terminates in a switch or switchgear with a lower recommended test value, in which case the lower value shall be used. Cables with one or more switching points in a cable run shall be sectionalized with the switches and tested in sections in order to test the cable at the highest possible voltage which the ICEA recommends.

5. Results: In case of failure during the test, every effort shall be made to locate the faulty splice, termination or cable section, as the case may be. The Architect shall be notified before repairs are made. Should the test reports indicate that the condition of the circuit is unsatisfactory in the opinion of the Architect, the Contractor shall make all repairs and/or replacements as necessary, including new cable. Additional proof tests shall be made on all repaired sections at the Contractor's expense for duration of warranty period. Cable installations will not be accepted until satisfactory certified proof test reports are obtained.

6. Safety: Adequate means shall be taken to insure safety during the tests and all safety

instructions of the test operator and test set manufacturer, and recommendation of the cable manufacturer, shall be carried out. Maintain solid grounding connection to all cable segments tested for at least four times the duration of the test to prevent dc charge buildup.

7. Test Report Form: Each cable shall be tested for a minimum of fifteen (15) consecutive minutes or until the current reading levels off and remains steady for at least three minutes. The potential shall be raised at a slow uniform rate with current readings taken every fifteen seconds until full voltage is reached; thereafter, current readings shall be recorded separately. The removal of the voltage shall be done in an accepted manner to prevent damaging the cable. Test data shall be recorded on a form similar to the one included herein.

END OF SECTION 26 05 13

SECTION 26 05 19 – BUILDING WIRE AND CABLE

PART 1- GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Contractual Conditions and Division 01 Specification sections apply to this section.

1.2 SUMMARY

A. This section includes the requirements for provision and installation of Building Wire and Cable.

1.3 DESCRIPTION

A. Provide all equipment, labor, material, accessories, and mounting hardware to properly install all conductors and cables rated 600 volts and less for a complete and operating system for the following:

1. Building wire and cable.
2. Wiring connectors and connections.

B. No aluminum conductors shall be permitted.

C. All sizes shall be given in American Wire Gauge (AWG) or in thousand circular mils (MCM/KCMIL).

1.4 SUBMITTALS

A. Product Data: Submit catalog cut sheet showing, type and UL listing of each type of conductor, connector and termination.

1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum five years experience.

1.6 REFERENCES AND REGULATORY REQUIREMENTS

A. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for purpose specified and shown.

B. Conform to the requirements of ANSI/NFPA 70.

1.7 PROJECT CONDITIONS

A. Verify that field measurements are as shown on Drawings.

B. Conductor sizes are based on copper.

C. Wire and cable routing shown on Drawings is approximate unless dimensioned. Route wire and cable as required to meet Project Conditions.

D. Where wire and cable routing is not shown, and destination only is indicated, determine exact routing and lengths required. Record actual routing on red lined as-builts.

E. Conductors with different voltages (i.e. 120 volt and 277 volt) shall not be combined in the same conduit without prior written approval from OAR and Engineer.

F. Conductors for each branch of power (Normal, Life safety, Critical, Security, and Equipment) shall be installed in its own dedicated raceway system.

1.8 COORDINATION

A. Determine required separation between cable and other work.

B. Coordinate cable routing to avoid interference with other work disciplines.

PART 2 - PRODUCTS

2.1 BUILDING WIRE AND CABLE

A. Description: Single conductor insulated wire.

B. Conductor: Copper.

C. Insulation Voltage Rating: 600 volts.

D. Insulation: ANSI/NFPA 70, Type THHN/THWN and XHHW.

E. Cable supports shall be O Z/Gedney Type “S” or approved substitution.

PART 3 - EXECUTION

3.1 GENERAL

A. Install products in accordance with manufacturer’s instructions.

B. Neatly train and lace wiring inside boxes, equipment, and panelboards.

C. Before installing raceways and pulling wire to any mechanical equipment, verify electrical characteristics with final submittal on equipment to assure proper number and AWG of conductors. (As for multiple speed motors, different motor starter arrangements, etc.).

D. Conductors #12 AWG shall be 600 volt type THHN/THWN, solid unless specifically noted otherwise, rated 90 degrees C. dry.

E. Use conductor not smaller than 12 AWG for power and lighting circuits.

F. Provide dedicated neutral conductor for each branch phase conductor for 120V and 277V circuits (power and lighting). Multi-pole breakers to comply with NEC 210.4 are not permitted.

G. Use 10 AWG conductors minimum for 20 ampere, 120 volt branch circuits longer than 75 feet (23 m). See General Notes on drawings for additional requirements.

H. Use 10 AWG conductors minimum for 20 ampere, 277 volt branch circuits longer than 200 feet (61 m). See General Notes on drawings for additional requirements.

I. All conductors shall be installed in raceway.

J. Conductor sizes indicated on circuit homeruns or in schedules shall be installed over the entire length of the circuit unless noted otherwise on the drawings or in these specifications.

K. Coordinate all wire sizes with lug sizes on equipment, devices, etc. Provide/install lugs as required to match wire size.

L. Where oversized conductors are called for due to voltage drop, etc., provide/install lugs as required to match conductors, or provide/install splice box, and splice to reduce conductor size to match lug size.

3.2 EXAMINATION

A. Verify that interior of building has been protected from weather.

B. Verify that mechanical work likely to damage wire has been completed.

3.3 PREPARATION

A. Completely and thoroughly swab raceway before installing wire.

3.4 WIRING METHODS

A. Use only building wire, Type THHN/THWN insulation, in raceway unless noted otherwise.

B. Wiring in vicinity of heat producing equipment: Use only XHHW insulation, in raceway.

C. Conductors installed within fluorescent fixture channels shall be Type THHN or XHHW, rated 90 degrees C dry. Conductors for all other light fixtures shall have temperature ratings as required to meet the UL listing of the fixture; however, in no case shall the temperature rating be less than 90 degrees Centigrade. Remove incorrect insulation types in new work.

3.5 INTERFACE WITH OTHER PRODUCTS

A. Identify wire and cable under provisions of Section 26 05 53 Identification for Electrical Systems.

B. Identify each conductor with its circuit number or other designation indicated on Drawings.

C. Identify neutrals with its associated circuit number(s) per NEC Article 210.4(D).

3.6 FIELD QUALITY CONTROL

A. Perform field inspection and testing under provisions of the General Requirements of the Contract Documents and Section 26 08 13 Tests and Performance Verification.

B. Inspect wire for physical damage and proper connection.

C. Measure tightness of bolted connections and compare torque measurements with manufacturer's recommended values.

D. Verify continuity of each branch circuit conductor.

E. Submit “Conductor Insulation Resistance Test” form as required in Section 26 08 13.

3.7 VERTICAL RISERS

A. Provide vertical cable riser supports per Article 300-19 in NFPA 70. These shall be located in accessible pullboxes of adequate size. Provide for adequate structural connection of cable supports to pullbox, which will transfer cable weight to building.

3.8 PULLING

A. No wire shall be pulled until the conduit system is complete from pull point to pull point and major equipment terminating conduits have been fixed in position.

B. Mechanical pulling devices shall not be used on conductors sized #8 and smaller. Pulling means which might damage the raceway shall not be used.

C. Use only powdered soapstone or other pulling lubricant acceptable to the Designer/OAR. Compound or lubricant shall not cause the conductor or insulation to deteriorate.

D. All conductors to be installed in a common raceway shall be pulled together. The manufacturer's recommended pulling tensions shall not be exceeded.

E. Bending radius of insulated wire or cable shall not be less than the minimum recommended by the manufacturer.

F. Where coaxial type conductors are installed, special requirements shall apply as outlined under that specific system detail specifications.

G. Where control or signal circuits with a lower insulation rating enter an enclosure with conductors having a 600 volt or higher insulation rating, a separate wire way will be installed or proper clearance distance will be maintained per NEC.

H. All conductors shall be pulled in conduits by industry approved cable pulling “tuggers” equipment. The use of construction equipment such as fork lifts, tractors and other vehicles will not be allowed. All conductors will be routed and protected by using the proper pulleys and sheaves.

3.9 CONTROL AND SIGNAL CIRCUITS

A. For control and signal circuits above 50 VAC, conductors shall be #14 AWG minimum size, Type XHHW or THHN/THWN as permitted by NFPA 70, within voltage drop limits, increased to #12 AWG as necessary for proper operation.

B. For control and signal circuits 50 VAC and below, conductors, at the Contractor's option, may be #16 AWG, 300 volt rated, PVC insulated, except where specifically noted otherwise in the contract documents.

C. Conductor insulation for fire alarm systems shall be as approved by Code Inspection Authority only. Wire approvals by the Designer/OAR shall not supersede this final approval for conditions of this specific project.

D. Install circuit conductors in conduit.

E. Circuit conductors #10AWG and larger to be stranded.

3.10 COLOR CODING

A. All power feeders and branch circuits No. 6 and smaller shall be wired with color-coded wire with the same color used for a system throughout the building. Power feeders above No. 6 shall either be fully color-coded or shall have black insulation and be similarly color-coded with tape in all junction boxes and panels. Tape shall completely cover the full length of conductor insulation within the box or panel.

B. Unless otherwise approved or required by DESIGNER to match existing, color-code shall be as follows: Neutrals to be white for 120/208V system, natural grey for 277/480V system; ground wire green, bare or green, insulated ground conductor green with yellow tracer. 120/208V, Phase A - black; Phase B - red; Phase C - blue. 480/277V, Phase A brown; Phase B - orange; Phase C - yellow. All switch legs, other voltage system wiring, control and interlock wiring shall be color-coded other than those above.

3.11 TAPS/SPLICES/CONNECTORS/TERMINATIONS

A. Taps and splices are not acceptable unless specifically noted otherwise on drawings or special written approval is granted by Designer/OAR. (See 3.1K) Submit locations, sizes, etc., where taps will be necessary to coordinate with lug sizes/quantities for review and approval prior to installation.

B. Clean conductor surfaces before installing lugs and connectors.

C. Make splices, taps, and terminations to carry full ampacity of conductors with no perceptible temperature rise.

D. Power and lighting conductors shall be continuous and unspliced where located within conduit. Splices shall occur within troughs, wireways, outlet boxes, or equipment enclosures where sufficient additional room is provided for all splices. No splices shall be made in in-ground pull boxes (without special written approval of OAR).

E. Splices in lighting and power outlet boxes, wireway, and troughs shall be kept to a minimum, pull conductors through to equipment, terminal cabinets, and devices.

F. No splices shall be made in junction box, and outlet boxes (wire No. 8 and larger) without written approval of OAR.

G. No splices shall be made in communications outlet boxes, pull boxes or wireways (i.e., fire alarm, computer, telephone, intercom, sound system, etc.) without written approval of OAR. Pull cables through to equipment cabinets, terminal cabinets and devices.

H. No splices shall be made in circuits of #8 AWG conductors or larger of 1000 feet or less without written approval of the OAR.

I. Allow adequate conductor lengths in all junction boxes, pull boxes and terminal cabinets. All termination of conductors in which conductor is in tension will be rejected and shall be replaced with conductors of adequate length. This requirement shall include the providing by the Contractor of sleeve type vertical cable supports in vertical raceway installations provided in pullboxes at proper vertical spacings.

J. A calibrated torque wrench shall be used for all bolt tightening. A torque mark should be used after torqueing is performed. Torque mark should consist of a permanent mark over the mechanical lug, bolt, nut, etc.

K. Interior Locations:

1. All (non-electronic systems) copper taps and splices in No. 8 or smaller shall be fastened together by means of "Screw-on spring type (wire nut)" connectors. All “Push-in” or “Stab-in” type connectors are prohibited. All taps and splices in wire larger than No. 8 shall be made with compression type connectors approved by OAR and taped to provide insulation equal to wire.

END OF SECTION 26 05 19

SECTION 26 05 26 - GROUNDING AND BONDING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Contractual Conditions and Division 01 Specification sections apply to this section.

1.2 SUMMARY

A. This section includes the requirements for provision and installation of grounding and bonding.

1.3 DESCRIPTION

A. Provide all labor, materials, and equipment necessary to properly install a grounding system conductor in all new branch wiring and feeder installations that shall be in full compliance with all applicable Codes as approved by the authorities having jurisdiction. The secondary distribution system shall include a grounding conductor in all raceways in addition to the return path of the metallic conduit.

B. In general, all electrical equipment (metallic conduit, motor frames, panelboards, etc.) shall be bonded together with a green insulated or bare copper system grounding conductor in accordance with specific rules of Article 250 of the N.E.C. and State codes. Bonding conductor through the raceway system shall be continuous from main switch ground bus to panel ground bar of each panelboard, and from panel grounding bar of each panelboard to branch circuit equipment and devices.

C. All raceways shall have an insulated copper system ground conductor throughout the entire length of circuit installed with-in conduit in strict accordance with NEC. Grounding conductor shall be included in total conduit fill determining conduit sizes, even though not included or shown on drawings. Grounding conductors run with feeders in PVC conduit outside of building(s) shall be bare only.

D. Section Includes

1. Grounding electrodes and conductors.
2. Equipment grounding conductors.
3. Bonding.
4. Counterpoise System
5. Ground Ring.

1.4 SUBMITTALS

A. Submit catalog cut sheet showing brand and selection for all conductors, test wells, components, etc., as specified herein showing that all materials are UL listed and labeled as applicable and manufactured in the United States.

B. Product data shall prove compliance with Contract Documents, National Electric Code, Underwriters Laboratories, manufacturer’s specifications, manufacturer’s written installation data and compliance with all performance criteria.

C. Include instructions for storage, handling, protection, examination, preparation, operation and installation of product.

D. Indicate application conditions and limitations of use stipulated by product testing agency specified under regulatory requirements.

E. Show all dimensions, colors, configurations, covers and applicable labeling/stamping.

F. Record actual locations of grounding electrodes on red lined as-built documents.

G. Submit test results of each ground rod. See Section 26 08 13.

1.5 REFERENCES AND REGULATORY REQUIREMENTS

A. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for purpose specified and shown.

B. Conform to requirements of ANSI/NFPA 70 - National Electrical Code.

PART 2 - PRODUCTS

2.1 ROD ELECTRODE

A. Material: Copper-clad steel.

B. Diameter: 5/8 inch.

C. Length: 30 feet minimum. Increase lengths as required to achieve specified resistance.

2.2 MECHANICAL CONNECTORS

A. All grounding connectors shall be in accordance with UL 467 and UL listed for use with rods, conductors, reinforcing bars, etc., as appropriate.

B. Connectors and devices used in the grounding systems shall be fabricated of copper or bronze materials, and properly applied for their intended use. Specified items of designated manufacturers indicate required criteria and equal products may be provided if approved. All connectors and devices shall be compatible with the surfaces being bonded and shall not cause galvanic corrosion by dissimilar metals. Materials in items not listed herein shall be of equal quality to the following specified items:

1. Lugs: substantial construction, of cast copper or cast bronze, with "ground" (micro-flat) surfaces equal to Burndy QQA-B Series, two hole, T&B, or approved substitution. Light weight and "competitive" devices shall be rejected.
2. Grounding and Bonding Bushings: Malleable iron, Thomas and Betts (T&B), or approved substitution.

3. Piping Clamps: Burndy "GAR-TC series" with two hole compression lug under U-Bolt nut, or T&B, or approved substitution.
4. Grounding Screw and Pigtail: Raco No. 983 or approved substitution.
5. Fastening hardware: Grade 5 silicone bronze with beveled washers. Copperplate is not acceptable

C. Mechanical lugs or wire terminals shall be used to bond ground wires together or to junction boxes and panel cabinets and shall be manufactured by Anderson, Buchanan, Thomas and Betts Co., or Burndy.

2.3 WIRE

A. Material: Stranded copper.

B. Size: Size to meet NFPA 70 requirements as a minimum, increase size if called for on drawings, in these specifications, or as required for voltage drop.

C. Insulated THWN (or bare as noted elsewhere).

2.4 GROUNDING WELL COMPONENTS

A. Grass Non-Traffic Areas:

1. Well: Minimum 12 inch long by 12 inch wide by 18 inches deep with open.
2. Well Cover: High density plastic, composolite, or cast iron with legend "GROUND" embossed on cover.
3. Material: Structural Plastic, composolite, or concrete.
4. Manufacturer: Brooks Products 70 Series or equal by Quazite or approved substitution.
5. Increase depth, diameter or size as required to provide proper access at installed location.

B. Paving and Low Traffic Areas:

1. Well: Minimum 12 inch long by 12 inch wide by 18 inches deep with open bottom.
2. Well Cover: Traffic rated for use with "GROUND" embossed on cover.
3. Material: Composolite.
4. Manufacturer: Quazite or approved substitution.
5. Increase depth, diameter or size as required to provide proper access at installed location.

2.5 GROUNDING BARS/GROUND BUS (INCLUDING 'SYSTEMS' GROUND BUS/BARS AND GROUND BUS BARS)

A. Ground bars shall be copper of the size and description as shown on the drawings. If not sized on drawings, bus bar shall be minimum 1/4" x 2" bus grade copper, spaced from wall on insulating 2" polyester molded insulator standoff/supports, and be 12" or greater minimum overall length, allowing 2" length per lug connected thereto. Increase overall length as required to facilitate all lugs required while maintaining 2" spacing. Size of bus bar used in main electrical room shall be similar except minimum of 4" high and 24" long.

B. Provide bolt tapping lug with two hex head mounting bolts for each terminating ground conductor, sized to match conductors. Mount on bus bar at 2 inches on center spacing. Lugs to be manufactured by Burndy, T&B or approved substitution.

C. Bus bar shall have rows of holes in accordance with NEMA Standards for specified lugs.

D. Standoff supports to be 2" polyester as manufactured by Glastic #2015-4C or approved substitution.

PART 3 - EXECUTION

3.1 GENERAL

A. Install products in accordance with manufacturer's instructions.

B. Install grounding electrodes conductor, bonding conductors, ground rods, etc. with all required accessories.

C. Grounding shall meet (or exceed as required to meet these specifications) all the requirements of the N.E.C., the NFPA, and applicable standards of IEEE.

D. Where there is a conflict between these specifications and the above applicable codes or standards, or between this section and other specifications sections then the most stringent or excessive requirement shall govern. Where there is an omission of a code/standard requirement in these specifications then the code/standard requirements shall be complied with.

E. Requirement in these specifications to comply with a specific code/standard article, etc. is not to be construed as deleting of requirements of other applicable codes/standards and their articles, etc.

F. Verify that final backfill and compaction has been completed before driving rod electrodes.

3.2 GROUNDING ELECTRODES

A. All connections shall be exothermic welded unless otherwise noted herein. All connections above grade and in accessible locations may be by exothermic welding or by brasing or clamping with devices UL listed as suitable for use except in locations where exothermic welding is specifically specified in these specifications or called for on drawings.

B. Each rod shall be die stamped with identification of manufacturer and rod length.

C. Install rod electrodes at locations indicated and/or as called for in these specifications.

D. Ground Resistance:

1. Main Electrical Service (to each building and Site) and Generator Locations:

    a) Grounding resistance measured at each main service electrode system and at each generator electrode system shall not exceed 5 ohms.

2. Lightning Protection Ground Locations:

    a) Lightning Protection system ground locations shall not exceed 5 ohms measured at ground electrode.

3. Site Distribution Counterpoise Ground Locations:

   a) Counterpoise system ground locations shall not exceed 25 ohms measured at ground electrode.

4. Other Locations:

   a) Resistance to ground of all non-current carrying metal parts shall not exceed 25 ohms measured at motors, panels, busses, cabinets, equipment racks, light poles, transformers, and other equipment.

5. Resistance called for above shall be maximum resistance of each ground electrode prior to connection to grounding electrode conductor. Where ground electrode system being measured consists of two (2) or more ground rod electrodes at each location, then the resistance specified above shall be the maximum resistance with two (2) or more rods connected together but not connected to the grounding electrode conductor.

E. Install additional rod electrodes as required to achieve specified resistance to ground (specified ground resistance is for each ground rod location prior to connection to ground electrode conductor).

F. Provide grounding well with cover at each rod location, with the only exception being a site distribution counterpoise ground rod. Install grounding well top flush with finished grade.

G. Install ground rods not less than 1 foot below grade level and not less than 2 feet from structure foundation.

3.3 GROUND RESISTANCE AT LOCATION OTHER THAN LOCATION OF GROUNDING ELECTRODES.

A. Resistance to ground of all non-current carrying metal parts shall not exceed 25 ohms measured at motors, panels, busses, cabinets, equipment racks, light poles, transformers, and other equipment.

3.4 GROUNDING ELECTRODE CONDUCTOR

A. Conductor shall be sized to meet (or exceed requirements of Contract Documents) the requirements of NEC 250.66.

3.5 EQUIPMENT GROUNDING CONDUCTOR

A. Grounding conductors shall be provided with every circuit to meet (or exceed requirements of Contract Documents) the requirements of NEC 250.122.

B. At every voltage level, new portions of the electrical power distribution system shall be grounded with a dedicated copper conductor which extends from termination back to power source in supply panelboard.

C. Provide separate, insulated (bare if with feeder in PVC conduit) conductor within each feeder and branch circuit raceway. Terminate each end on suitable lug, bus, or bushing.

D. Except as otherwise indicated, each feeder raceway on the load side of the service entrance shall contain a ground conductor sized as indicated and where not shown shall be sized to meet (or exceed requirements of Contract Documents) the requirements of NEC 250.122. Conductor shall be connected to the equipment grounding bus in switchboards and panelboards, to the Grounding Bus in all motor control centers, and as specified, to lighting fixtures, motors and other types of equipment and outlets. The ground shall be in addition to the metallic raceway and shall be connected, using a lug device located within each item enclosure at the point of electric power connections to permit convenient inspection.

E. Provide green insulated ground wire for all grounding type receptacles and for equipment of all voltages. In addition to grounding strap connection to metallic outlet boxes, a supplemental grounding wire and screw equal to Raco No. 983 shall be provided to connect receptacle ground terminal to the box.

F. All plugstrips and metallic surface raceway shall contain a green insulation ground conductor from supply panel ground bus connected to grounding screw on each receptacle in strip and to strip channel. Conductor shall be continuous.

G. Where integral grounding conductor is specified elsewhere in bus duct construction, provide equivalent capacity conductor from supply switchboard or panelboard grounding bus to the bus duct grounding conductor. Bond integral conductor to bus duct enclosure at each tap and each termination.

H. All motors, all heating coil assemblies, and all building equipment requiring flexible connections shall have a green grounding conductor properly connected to the frames and extending continuously inside conduit with circuit conductors to the supply source bus with approved connectors regardless of conduit size or type. This shall include "Equipment By Owner" to which an electric conduit is provided under this Division.

3.6 MAIN ELECTRICAL SERVICE

A. Complete installation shall meet or exceed the requirements of the NEC 250.

B. Artificial electrodes shall be provided for the main service in sufficient number and configuration to secure resistance specified.

C. Provide and bond to all of the following:

1. Ground rods.
2. Metal water pipe.
3. Building metal frame, structural steel or reinforced structural concrete.
4. Encased Electrodes.
5. Ground ring.
6. Site distribution counterpoise ground system.
7. Lightning protection system.

D. A main ground, bare copper conductor, sized per NEC Table 250.66, but in no case less than #2/0, shall be run in conduit from the main switchgear of each building to the building steel in respective building. This ground conductor shall also be run individually from the main switchgear and be bonded to the main water service ahead of any union in pipe and must be metal pipe of length and location as acceptable by authorities having jurisdiction. Provide properly sized bonding shunt around water meter and/or dielectric unions in the water pipe. Also required is the same size ground wire to ground rod electrode as called for below:

1. Three 30 ft. ground rods in a delta configuration at no less than 30 ft. spacing driven to a minimum depth of 30 feet, one foot below grade.
2. Bond ground rod electrodes together with a bare copper ground conductor that matches size required by NEC Table 250.66, but in no case less than #2/0.
3. Provide additional rod electrodes as required to achieve specified ground resistance.

E. Ground/bond neutral per NEC 250.

F. A main ground, bare copper conductor, sized per applicable Table in NEC 250, but in no case less than #2/0, shall be run in conduit from the main switchgear of each building to a concrete encased electrode per NEC 250.52(3).
    1. For New Buildings: Provide and install and bond to concrete encased electrode in compliance with the NEC.
    2. For Existing Buildings: Bond to existing concrete encased electrode when available.

G. Bond grounding electrodes to site counterpoise grounding system and lightning protection system where provided.

H. Provide and install ground bus bar on wall near main service disconnect/switchboard. Connect to ground bar in disconnect/switchboard bonded to switchboard/disconnect enclosure/neutral with copper grounding conductor sized per NEC Table 250.66.

3.7 TRANSFORMER GROUNDING

A. Ground all transformers and enclosures of 120/208V and 277/480V "separately derived systems" as specified herein.

1. Ground per NEC 250 and these specifications.
2. Bond neutral to transformer frame/enclosure and the equipment grounding conductors of the derived system with copper ground conductor sized per NEC Table 250.66.
3. Connect transformer neutral/ground to grounding electrode per NEC 250.30 with grounding electrode conductor sized per NEC Table 250.66.
4. In addition to connection to grounding electrode conductor called for above, provide supplemental grounding electrode as follows:
    a) Where grounding required per NEC 250.30 is to building steel/structure, supplement this grounding with connection to nearest available effectively grounded metal water pipe.
    b) Where grounding connection required per NEC 250.30 is to grounded metal water pipe, supplement with connection to building steel/structure in addition to any other available electrodes specified in NEC 250.50 and 250.52.
    c) Where supplemental grounding electrodes required above is a ground rod electrode, provide two or more 30 ft. ground rod electrodes at no less than 30 ft. spacing, driven full length into the earth one foot below grade.
5. Where neither building steel nor water pipe grounding electrodes are available (i.e. exterior locations with no available water pipe electrode) provide two (2) ground connections: each 30 ft. ground rod electrodes at not less than 30 ft. spacing, driven full length into the earth one foot below grade.
6. Where transformer is mounted to exterior of building, one (1) of the two (2) ground electrodes required shall be ground rod electrode as called for in 5. above. This ground rod electrode shall also be connected to counterpoise system.

B. Provide additional ground electrodes as required to achieve specified ground resistance.

C. Where two or more ground electrodes are used at any required ground location, they shall be bonded together with a copper ground conductor, sized to meet NEC Table 250.66, but in no case less than #2/0.

D. Complete installation shall meet or exceed the minimum requirements of NEC 250.

E. Equipment ground conductors shall be provided in addition to above grounding. See 'EQUIPMENT GROUNDING CONDUCTOR', NEC 250.122.

F. Provide ground bus bar on wall near transformer (or in associated electrical room for exterior mounted transformers). Connect to ground lug in transformer bonded to transformer enclosure/neutral with copper ground conductor sized per NEC Table 250.66.

G. Multiple separately derived systems may be grounded as allowed in NEC 250.~~-~~30(A)(4).

3.8 GENERATOR GROUNDING

A. Separately derived systems (i.e. systems where generator neutral is not solidly interconnected to service supplied system neutral such as 4 pole switched neutral transfer switch systems).

1. Ground per NEC 250.20, 250.30, 250.66 and these specifications.
2. Bond neutral to transformer frame/enclosure and the equipment grounding conductors of the derived system with copper ground conductor sized per NEC Table 250.66.
3. Connect generator neutral/ground to grounding electrodes per NEC 250.30 with grounding electrode conductor sized per NEC Table 250.66.
4. In addition, provide supplemental grounding electrode as follows:

    a) Where grounding required per NEC 250.30 is to building steel/structure, supplement with connection to nearest available effectively grounded metal water pipe.
    b) Where grounding connection required per NEC 250.30 is to grounded metal water pipe, grounding with connection to other electrodes specified in NEC 250.50 and 250.52.
    c) Where supplemental grounding electrode required above is a ground rod electrode, provide two or more 30 ft. ground rod electrodes at no less than 30 ft. spacing, driven vertical to a minimum depth of 30 ft. plus 1 foot below grade.

5. Where neither building steel nor water pipe grounding electrodes are available provide two (2) ground connections: each to two (2) or more 30 ft. ground rod electrodes at no less than 30 ft. spacing, driven vertical to a minimum depth of 30 ft. plus 1 foot below grade.
6. Where generator is mounted to exterior of building, one (1) of the two (2) ground electrodes required shall be ground rod electrode as called for in Paragraph 3.8 A.5. This ground rod electrode shall also be connected to counterpoise system.

B. Provide additional ground electrodes as required to achieve specified ground resistance.

C. Where two or more ground electrodes are used at any one required ground location, they shall be bonded together with a copper ground conductor, sized to meet NEC Table 250.66, but in no case less than #2/0.

D. Complete installation shall meet or exceed the minimum requirements of NEC 250.

E. Equipment ground conductors shall be provided in addition to above grounding. See 'EQUIPMENT GROUNDING CONDUCTOR'.

3.9 LIGHTNING PROTECTION SYSTEMS

A. Ground per Section 26 41 13 – Lightning Protection for Structures, NFPA 780, and as specified herein. The most stringent requirements shall govern.

B. Bond lightning protection system grounds to electrical service system ground, and counterpoise system ground where provided.

3.10 EXTERIOR GRADE (OR FREE STANDING ABOVE GROUND) MOUNTED EQUIPMENT

A. General:

1. All equipment mounted exterior to building shall have their enclosures grounded directly to a grounding electrode at the equipment location in addition to the building equipment ground connection.
2. Bond each equipment enclosure, metal rack support, mounting channels, etc. to ground electrode system at each rack with an insulated copper ground conductor sized to match the grounding electrode conductor required by NEC Table 250.66 based on equipment feeder size, but in no case shall conductor be smaller than #6 copper or larger than #2 copper. This connection is in addition to grounding electrode connections required for services.

B. Main electrical service rack mounted equipment.

1. Ground per "MAIN ELECTRICAL SERVICE".
2. Bond all metal parts as noted in this section.

C. Electrical sub service rack mounted equipment.

1. Ground per "MAIN ELECTRICAL SERVICE", except do not bond neutral to ground.
2. Bond all metal parts as noted in this section.

D. Electrical equipment connection rack mounted equipment.

1. Bond all metal parts as noted in this section.

E. Grounding electrodes (ground electrodes system) shall be:

1. Located at each rack location.
2. For service equipment: Ground electrode required per "MAIN ELECTRICAL SERVICE".
3. For equipment connection: Two or more 30 ft. ground rods at no less than 30 ft. spacing, driven vertical to a minimum depth of 30 ft. plus 1 ft. below grade. Bond ground rods together with a size to meet NEC Table 250.66, but no less than a #2 copper ground conductor. Provide additional rod electrodes as required to achieve specified ground resistance.

F. Complete installation shall meet or exceed the minimum requirements of NEC 250 and, when applicable, NFPA 78.

3.11 ROOF MOUNTED EQUIPMENT

A. Bond all roof mounted electrical equipment to lightning protection system (when provided) per NFPA 780.

3.12 LIGHTING FIXTURES

A. All new and reinstalled fixtures shall be provided with green grounding conductor, solidly connected to unit. Individual fixtures grounds shall be with lug to fixture body, locate at point of electrical connection to the fixture unit.

B. All suspended fixtures and those supplied through flexible metallic conduit shall have green ground conductor from outlet box to fixture. Cord connected fixtures shall contain a separate green ground conductor.

C. Pole Light Fixtures:

1. Metal Pole Light Fixtures:

   a) Freestanding pole mounted lighting fixtures shall each have a - Class I or Class II Materials - lightning protection main copper down conductor connected to grounding electrodes at base of pole.
   b) Conductor shall be bonded to metal pole via UL Listed ground clamp suitable for use. Locate ground lug opposite to handhole (or adjacent if visible through handhole).

2. Concrete or Non-Metallic Pole:

   a) Freestanding pole mounted lighting fixtures shall each have a Class I or Class II lightning protection main copper down conductor connected to grounding electrodes at base of pole.
   b) Conductor shall be extended from grounding electrode to top of pole and terminate at the top of pole in a Class I or Class II copper lightning protection air terminal.
   c) Each metal part of light fixture assembly, bracket, ballast cabinet, disconnect, transformer, etc. that is mounted to pole shall be bonded to down conductor.

3. Fixtures located on elevated roadway ramps: provide with a connection to lightning counterpoise grounding system.
4. Grounding electrode(s) at each pole shall be bonded to site distribution counterpoise system.
5. Grounding Electrodes:

   a) Two or more 30 ft. ground rods at no less than 30 ft. spacing shall be driven full length into the earth one foot below grade.
   b) Bond ground rod electrodes together with a Class I or Class II lightning protection main copper conductor.
   c) Provide additional rod electrodes as required to achieve specified ground resistance.
   d) Two (2) or more grounding rod electrodes shall be installed at each light pole.

6. Installation shall exceed minimum requirements of NFPA 780.

3.13 PULLBOX, MANHOLE, HANDHOLE GROUNDING.

A. One 30 ft. ground rod electrode shall be driven vertically to a minimum depth of 30 ft. plus 1 ft. below grade in each manhole, handhole or pullbox (in ground).

B. The complete installation shall exceed the minimum requirements of the NEC.

C. Provide additional ground rod electrodes as required to provide resistance called for herein.

D. Where more than one ground rod electrode is required bond the two or more ground rod electrodes together with a copper ground conductor as called for under 'Counterpoise System.'

E. Bond to counterpoise system.

F. Bond grounding electrode to all exposed metal parts of manhole, handhole, pullbox (including metal cover) with #6 copper ground conductor. Connect to ground rod electrode with exothermic weld. Connect to metal cover with exothermic weld. Connect to other metal parts with exothermic weld or UL approved grounding clamp. Provide minimum 3 ft. slack ground cable on cover connection to facilitate removal of cover.

3.14 HAZARDOUS LOCATIONS

A. Grounding in hazardous locations shall be done in accordance with applicable portions of Articles 500, 501, 502, 503, 511 and 514 of the National Electrical Code.

3.15 GROUND RING

A. Provide complete underground building perimeter ground ring system, completely encircling building.

B. Install minimum 2-1/2 feet depth into earth.

C. Install ground rods (minimum 30 ft. long) every 150 feet section of ground ring conductor.

D. Bond ground ring to building steel every 150 feet of building perimeter, bond to any and all electrical and piping systems that cross the ground ring system, bond to lightning protection down conductors and to any lightning or other earth grounding electrodes that may be present on the premises.

E. Bond to building service and counterpoise ground systems.

3.16 MISCELLANEOUS GROUNDING CONNECTIONS

A. Provide bonding to meet regulatory requirements.

B. Required connections to building steel shall be with UL approved non-reversible crimp type ground lugs exothermically welded to bus bar that is either exothermically welded to steel or bolted to steel in locations where weld will affect the structural properties of the steel.

C. Install grounding conductors to permit shortest and most direct path from equipment to ground; install in conduit; bond to conduit at both ends when conduit is metal; have connections accessible for inspection; and made with approved solderless connectors brazed (or bolted) to the equipment ground; in NO case be a current carrying conductor; have a green jacket unless it is bare copper; be run in conduit with power and branch circuit conductors. The main grounding electrodes conductor shall be exothermically welded to ground rods, water pipe, and building steel.

D. All surfaces to which grounding connections are made shall be thoroughly cleaned to maximum conductive condition immediately before connections are made thereto. Metal rustproofing shall be removed at grounding contact surfaces, for 0 ohms by digital Vm. Exposed bare metal at the termination point shall be painted.

E. All ground connections that are buried or in otherwise inaccessible locations, shall be welded exothermically. The weld shall provide a connection which shall not corrode or loosen and which shall be equal or larger in size than the conductors joined together. The connection shall have the same current carrying capacity as the largest conductor.

F. Install ground bushings on all metal conduits entering enclosures where the continuity of grounding is broken between the conduit and enclosure (i.e. metal conduit stub-up into a motor control center enclosure or at ground bus bar). Provide an appropriately sized bond jumper from the ground bushing to the respective equipment ground bus or ground bus bar.

G. Each feeder metallic conduit shall be bonded at all discontinuities, including at switchboards and all subdistribution and branch circuit panels with conductors in accordance with Table 250.122 of NEC for parallel return with respective interior grounding conductor.

H. Grounding provisions shall include double locknuts on all heavywall conduits.

I. Install grounding bus in all existing panelboards of remodeled areas, for connection of new grounding conductors, connected to an approved ground point.

J. Bond together reinforcing steel and metal accessories in pool and fountain structures and bond to electrical system per NEC.

K. Where reinforced concrete is utilized for building grounding system, proper reinforced bonding shall be provided to secure low resistance to earth with "thermite" type devices, and #10AWG wire ties shall be provided to not less than ten (10) full length rebars which contact the connected rebar. Provide size and length of rod to meet NEC requirements.

3.17 GROUNDING BAR/GROUND BUS (INCLUDING 'SYSTEMS' GROUND BUS/BAR ON GROUND BUS/BAR) INSTALLATION

A. Where indicated on the drawings, provide grounding bar/ground bus (bus bar). Metal sheaths of underground cables are also to be grounded thereto at points of building entrance.

B. Mount bolt tapping lugs with hex head bolts to bus bar at 2" o.c. spacing, one for each ground conductor.

C. Mount bus bar to wall using 2" polyester molded insulator stand-off.

D. Extend a #2/0 (minimum size) or larger THWN insulated copper ground conductor (if larger size is called for on drawings or required by N.E.C. for service ground, etc.) in PVC conduit to approved service ground installation or ground bus/bar in main service equipment enclosure.

E. Extend #6 insulated copper ground wire from respective bus/bar to each 'local' ground bus/bar in each cabinet for system.

F. 'SYSTEMS' grounding bus/bar must be connected with #2/0 insulated copper conductor to grounding electrodes system as defined in NEC "Article 800.~~-~~40~~(b)~~.

3.18 COUNTERPOISE SYSTEM

A. Install counterpoise and ground over all sections of underground ductbanks, conduits, or cables outside (exterior) to building.

B. No. 2 bare stranded copper counterpoise shall be run 6 inches above all underground duct banks, conduits and cables outside (exterior) to building.

C. Provide one counterpoise conductor for ductbanks (or conduit groupings) 12 inches wide or less. Provide two counterpoise conductors above outside edge of ductbank (or conduit groupings) over 12 inches wide.

D. Counterpoise shall run to building and be grounded at each building to the main building electrical service ground rod electrode (exterior to building). Counterpoise shall be bonded to ground rod at all light poles, pullboxes, manholes, handholes and at each building. Provide and install appropriate ground rod every 150 foot length of counterpoise conductor (see "Grounding Electrodes"). Counterpoise conductor shall not be run into interior of building. Route counterpoise underground around exterior perimeter of building to main service ground rod installation.

3.19 TESTING AND REPORTS

A. Raceway Continuity: Metallic raceway system as a component of the facilities ground system shall be tested for electrical continuity. Resistance to ground throughout the system shall not exceed specified limits.

B. Ground resistance measurements shall be made on each system utilized including:

1. Building structural steel.
2. Driven grounding system.
3. Water pipe grounding system.
4. Other approved systems.

C. Ground resistance measurements shall be made in normally dry weather, not less than 24 hours after rainfall, and with the ground under test isolated from other grounds and equipment. Resistances measured shall not exceed specified limits.

D. Upon completion of testing, the testing conditions and results shall be certified by the Contractor and submitted to the Designer as called for in Section 26 08 13 - Test and Performance Verification.

3.20 INTERFACE WITH OTHER PRODUCTS

A. Interface with site grounding system.

B. Interface with lightning protection system installed under Section 26 41 13.

3.21 FIELD QUALITY CONTROL

A. Inspect grounding and bonding system conductors and connections for tightness and proper installation.

B. Use suitable test instruments to measure resistance to ground of system. Perform testing in accordance with test instrument manufacturer's recommendations using the fall- of-potential method.

END OF SECTION 26 05 26

SECTION 26 05 29 – HANGERS AND SUPPORTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Contractual Conditions and Division 01 Specification sections apply to this section.

1.2 SUMMARY

A. This section includes the requirements for provision and installation of supporting devices.

1.3 DESCRIPTION

A. Furnish and install all supports, anchors, fasteners, hangers and inserts required to mount fixtures, conduit, cables, pullboxes and other equipment furnished under this Division.

1.4 REFERENCES AND REGULATORY REQUIREMENTS

A. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for purpose specified and shown.

B. Conform to the requirements of the following:

1. NECA - National Electrical Contractors Association.
2. ANSI/NFPA 70 - National Electrical Code.

1.5 SUBMITTALS

A. Submit catalog cut sheet showing brand of conduit supporting hardware to be used and (where applicable) showing that conduit supporting hardware is UL listed and labeled, and manufactured in the United States.

B. Submit catalog cut sheet on all types of conduit support fittings, hardware, straps, and hangers.

C. Product data shall be submitted for approval on:

1. Mounting hardware and inserts.
2. Conduit straps, hangers and fittings.
3. Supporting channel.

D. Product data shall prove compliance with Contract Documents, National Electric Code, National Board of Fire Underwriters, manufacturer's specifications and written installation data.

E. Submit shop drawing showing routing and location of all conduit racking systems. Provide coordination drawings.

PART 2 - PRODUCTS

2.1 PRODUCT REQUIREMENTS

A. Materials and Finishes: Provide corrosion resistance.

B. Provide materials, sizes, and types of anchors, fasteners and supports to carry the loads of equipment and conduit. Consider weight of wire in conduit when selecting products.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Provide anchors, fasteners, and supports in accordance with NECA "Standard of Installation."

C. Do not fasten supports to pipes, ducts, mechanical equipment, and conduit.

D. Do not use spring steel clips and clamps and metal banding straps.

E. Do not fasten supports to sides or bottom of pre-cast structural beams.

F. Obtain permission from Owner before using powder-actuated anchors.

G. Obtain permission from OAR before drilling, or cutting structural members.

H. Fabricate supports from structural steel or steel channel. Rigidly weld members or use hexagon head bolts to present neat appearance with adequate strength and rigidity. Use spring lock washers under all nuts.

I. Install surface-mounted cabinets and panelboards with minimum of four anchors.

J. In wet and damp locations use stainless steel channel supports to stand cabinets and panelboards one inch (25) mm) off wall.

K. Use sheet metal channel to bridge studs above and below cabinets and panelboards recessed in hollow partitions.

L. All items shall be supported from the structural portion of the building, except standard ceiling-mounted lighting fixtures. Small devices may be supported from ceiling system where permitted by ceiling system manufacturer, however, no sagging of the ceiling will be permitted. Wire shall not be used as a support. Boxes and conduit shall not be supported or fastened to ceiling suspension wires or to ceiling channels.

M. Lay out and install work in advance of the laying of floors or walls, and provide all sleeves that may be required for openings through floors, walls, or other assemblies. Where plans call for conduit to be run exposed, provide all inserts and clamps for the supporting of conduit.

N. All conduits shall be securely fastened in place on maximum of 8 foot intervals. Hangers, supports or fastenings shall be provided at each elbow and at the end of each straight run terminating at a box or cabinet. The use of perforated iron for supporting conduits will not be permitted. The required strength of the supporting equipment and size and type of anchors shall be based on the combined weight of conduit, hanger and cables. Horizontal and vertical conduit runs may be supported by one-hole malleable straps, clamp-backs, or other approved devices with suitable bolts, expansion shields (where needed) or beam-clamps for mounting to building structure or special brackets.

O. Where two or more conduits are ran parallel or in a similar direction, they shall be grouped together and supported by means of 1½" x 1½", 12 gauge, pre-galvanized zinc (B-Line or approved substitution), conduit channel trapeze hanger system (racking) consisting of concrete inserts, threaded rods, washers, double nuts for each rod, locknut washers and galvanized "L" angle iron, or Unistrut cross members. Where galvanized "L" angle iron is used, conduits shall be individually fastened to the cross members with malleable iron hangers listed and approved for use on "L" angle iron, bolted with proper size cadmium machine bolts, washers and nuts. Conduits supported to unistrut channel shall be individually fastened with two piece unistrut straps with bolts and nuts listed and approved for such use. Mineralak hangers or one hole type straps fastened to Kindorf racking is not acceptable. Beam clamps shall be malleable iron. All single panelboard, switchboard and motor control center feeder raceway runs shall be supported by means of a trapeze channel hanger support system with provisions for future as specified.

P. All hangers and mounting hardware clamps shall be made of durable material suitable for the application involved. Where excessive corrosive conditions or exterior and damp conditions are encountered, hanger assemblies shall be malleable iron or protected after fabrication by hot dipped galvanizing and where written approval is authorized by the OAR, special paint or other suitable preservative methods may be used.

Q. On concrete or brick construction, an electric or hand drill shall be used for drilling holes for all inserts in brick, concrete or similar construction. In brick, inserts shall be near center of brick, not near edge or in joint. Where steel members occur, same shall be drilled and tapped, and round head machine screws shall be used. All screws, bolts and washers used for supporting conduit or outlets shall be fabricated from rust-resisting metal. Self-tapping power driven fasteners are acceptable on block or brick construction only. Plastic anchors are not acceptable.

R. Spring type conduit clip devices are not acceptable for conduit support.

S. Threaded rod hangers shall be galvanized continuous thread type, minimum 3/8" diameter. Increase size as required to support assembly. Bending of rod hangers is not permitted.

T. Concrete anchors, thread rods, or similar fasteners installed on side or bottom of pre-stressed beams are not acceptable.

U. Group related conduits; support using conduit rack. Construct rack using steel channel in dry locations and galvanized channel or aluminum channel in damp or wet locations (minimum of 24", increase, distance as required for quantity of conduits and spare capacity) provide space on each rack for Building Automation Systems (BAS) raceways and 25 percent additional conduits. Group conduits on channel racking adjacent to each other at one side, allowing all remaining unused space as spare capacity. Spacing between conduits shall not exceed 1" unless written permission is granted by OAR.

V. Each rack shall be provided with minimum of two (2) threaded rod hangers located at the ends of the channel. Increase number of hangers as required to support the assembly.

W. Rack Mounted Equipment: Use channel support system for all rack mounted equipment including all free standing rack mounted equipment. Exterior rack support system to be stainless steel channel. See details on drawings where available. Exterior units shall be thoroughly inspected after installation.

END OF SECTION 26 05 29

SECTION 26 05 33~~-13~~ - CONDUIT

PART 1- GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Contractual Conditions and Division 01 Specification sections apply to this section.

1.2 SUMMARY

A. This section includes the requirements for provision and installation of conduit.

1.3 DESCRIPTION

A. Provide and install all equipment, labor, material, accessories, and mounting hardware for a complete and operating system for the following:
1. Rigid Metal Conduit (RMC) NEC 344
2. Aluminum Rigid Metallic conduit (RMC) NEC 344
3. Intermediate Metal Conduit (IMC) NEC 342
4. PVC coated Metal Conduit.
5. Flexible metal conduit (FMC) NEC 348
6. ~~Liquidtight~~Liquid tight flexible metal conduit (LFMC) NEC 350
7. Electrical metallic tubing (EMT) NEC 358
8. Rigid Polyvinyl Chloride Conduit (PVC) (RNC) NEC 352
9. Flexible Metal Clad Cable (MC/HCF)
10. Fittings and conduit bodies.

B. Raceways and conduits shall begin at an acceptable enclosure and terminate only in another such enclosure except conduit/raceway stub-outs.

C. A raceway shall be provided for all electrical power, lighting and electrical systems.

D. Where the Contract Documents refer to the terms "raceway" or "conduit" the materials shall be as listed above in conjunction with NEC 100 definition of "raceway" MC and HCF flexible metal cables shall not be considered a substitute for raceway or conduit.

1.4 SUBMITTALS

A. Submit catalog cut sheet showing brand of conduit to be used and showing that conduit is UL listed and labeled, and manufactured in the United States.

B. Submit catalog cut sheet on all types of conduit bodies, and fittings.

C. Submit product data on:

1. Conduits.
~~2. Conduit straps, hangers and fittings.PVC solvent(s) and bending box.~~

~~3.~~2. Fitting entering and leaving the ground or pavement.
~~4. Cables~~
~~5.~~3. Expansion/deflection fittings.

D. Submit UL listed fire and smoke stopping assemblies for each applicable application. Provide details from UL Fire Directory and manufacturer's corresponding product data and details.

E. Product data shall prove compliance with Specifications, National Electrical Code, National Board of Fire Underwriters, manufacturer's specifications and written installation data.

1.5 PROJECT AS-BUILT DOCUMENTS

A. As-built documents shall accurately record actual routing of conduits.

1.6 REFERENCE AND REGULATORY REQUIREMENTS

A. Furnish products listed and classified by Underwriters Laboratories as suitable for purpose specified and shown.

B. Conform to the following:

1. ANSI/NFPA 70 - National Electrical Code
2. ANSI C80.1 - Electrical Rigid Steel Conduit
3. ANSI C80.3 – Steel Electrical Metallic Tubing
4. ANSI C80.5 – Electrical Rigid Aluminum Conduit
5. ANSI C80.6 – Electrical Intermediate Metal conduit
6. ANSI/UL 651 – Schedule 40, 80, Type EB and A Rigid (PVC Conduit and Fittings)
7. ANSI/NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable Assemblies
8. NECA National Electrical "Installation Standards"
9. ANSI C80.1/NEMA RN 1 - Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
10. NEMA TC 2 Electrical Polyvinyl Chloride (PVC) conduit
11. NEMA TC 3 – Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing
12. ANSI/Federal Specification A-A-59544 Cable and Wire, Electrical (Power Fixed Installation)
13. ANSI/Federal Specification J-C-30B – Flexible Metal Cables, Galvanized steel jacket

1.7 DELIVERY, STORAGE, AND HANDLING

A. Protect conduit from corrosion and entrance of debris by storing above grade. Provide appropriate covering.

B. Protect PVC conduit from sunlight.

1.8 PROJECT CONDITIONS

A. Verify that field measurements are as shown on Drawings.

B. Verify routing and termination locations of conduit prior to rough-in.

C. Conduit routing is shown on Drawings in approximate locations unless dimensioned. Route as required to complete wiring system.

PART 2 - PRODUCTS

2.1 GENERAL

A. All conduits shall bear UL label (or other nationally recognized testing agency and shall be manufactured in the United States).

B. Conduit systems and all related fittings, boxes, supports, and hangers must meet all the requirements of national, state, requirements and all related FAA codes and other Federal codes where applicable.

2.2 MINIMUM TRADE SIZE

A. Power/Lighting Homeruns 3/4 inch.

B. Power/Lighting Branch Circuits Between Devices and Fixtures 1/2 inch.

~~C. Systems Conduit 1inch.~~

~~D.~~C. Flexible and Seal-tite metallic conduit 1/2 inch C (maximum 6 feet long).

2.3 RIGID METAL CONDUIT(RMC)

A. Comply with:

1. ANSI C80.1
2. UL 6
3. NEC 344
4. Fed. Specification WW-C-581e

B. Conduit material:

1. Hot galvanized steel.

C. Fittings:

1. Threaded.
2. Insulated bushings shall be used on all rigid metal conduits terminating in panels, boxes, wire gutters, or cabinets, and shall be impact resistant plastic molded in an irregular shape at the top to provide smooth insulating surface at top and inner edge. Material in these bushings must not melt or support flame.
3. Hot galvanized malleable iron or steel.

D. Conduit Bodies:

1. Comply with ANSI/NEMA FB 1
2. Threaded hubs.
3. Hot galvanized malleable iron.

2.4 ALUMINUM RIGID METAL CONDUIT (RMC)

A. Comply with:

1. ANSI C80.5
2. UL 6
3. NEC 344
4. Federal Specification WW-C-540A

B. Conduit material: Aluminum.

C. Fittings:

1. Threaded.
2. Aluminum.
3. Insulated bushings on terminations.

D. Conduit bodies:

1. Comply with ANSI/NEMA FB 1
2. Threaded hubs.
3. Aluminum.

2.5 INTERMEDIATE METAL CONDUIT (IMC)

A. Comply with:

1. UL Standard 1242
2. ANSI C80.3
3. NEC 342
4. Fed. Specification WW-C-581e

B. Conduit material: Zinc coated steel.

C. Fittings:

1. Threaded.
2. Zinc plated malleable iron.
3. Insulated bushings on terminations.

D. Conduit bodies:

1. Comply with ANSI/NEMA FB 1
2. Threaded hubs.
3. Hot galvanized malleable iron

2.6 PVC COATED METAL CONDUIT

A. Comply with:

1. UL 6
2. NSI C80.1
3. NEC 344
4. NEMA RN 1
5. Fed. Specification WW-C-581E

B. Conduit material: Hot galvanized rigid steel with external PVC coating, 20 mil. thick.

C. Fittings:

1. Threaded.
2. Insulated bushings on terminations.
3. Hot galvanized malleable iron or steel with external PVC coating, 20 mil. thick.

D. Conduit bodies:

1. Comply with:

a) ANSI/NEMA FB 1
b) Threaded hubs
c) Hot galvanized malleable iron.

2.7 FLEXIBLE METAL CONDUIT(FMC)

A. Comply with:

1. NEC 348
2. ANSI/UL 1
3. Fed. Specification WW-C-566

B. Conduit material: Hot galvanized Steel, interlocked.

C. Fittings:

1. ANSI/NEMA FB 1
2. ANSI/UL 514B
3. Malleable iron, zinc plated.
4. Direct flexible conduit bearing set screw type not acceptable.
5. Insulated throat on terminations.
6. Compression EMT to flexible conduit coupling is not acceptable unless special written permission is gratned by OAR.
7. Comply also with Fed. Specification W-F-406

2.8 LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC)

A. Comply with:

1. NEC 350
2. ANSI/UL 360

B. Conduit material:

1. Flexible hot galvanized steel core, interlocked.
2. Continuous copper ground, built into core up to 1-1/4 inch size.
3. Extruded polyvinyl gray jacket.

C. Fittings:

1. Threaded for IMC/rigid conduit connections.
2. Approved for hazardous locations where so installed.
3. Provide sealing washer in wet/damp locations.

4. Compression type.
5. ANSI/NEMA FB 1
6. ANSI/UL 514B
7. Hot galvanized malleable iron or steel.
8. Insulated throat on terminations.
9. Comply with Fed. Specification W-F-406.
10. Connections to vibrating equipment and transformers.
    a) Connectors to have wire mesh conduit grip.

2.9 ELECTRICAL METALLIC TUBING (EMT)

A. Comply with:

1. UL 797
2. ANSI C80.3
3. NEC 358
4. ANSI/UL 797
5. Fed. Specification WWC-563

B. Conduit material: Hot Galvanized steel tubing (Electrogalvanized zinc is not acceptable).

C. Fittings:

1. ANSI/NEMA FB 1
2. Compression type.
3. Insulated throat on terminations.
4. Hot galvanized malleable iron or steel.
5. Fed. Specification WF 408

2.10 RIGID POLYVINYL CHLORIDE CONDUIT (PVC) (RNC)

A. Comply with:

1. NEMA TC-2
2. UL 651
3. NEC 352
4. Fed. Specification WC 1094A

B. Conduit material:

1. Shall be high impact PVC - tensile strength 55 PSI, flexural strength 11000 PSI.

C. Fittings:

1. Comply with: NEMA TC-3 and UL 514B

D. General:

1. Shall be UL listed.
2. Fittings and elbows shall be by the same manufacture as conduit.

2.11 FLEXIBLE METAL CLAD CABLE (MC/HCF-90)

A. Comply with:

1. NEC 330
2. NEC 517
3. NEC 250.96
4. ANSI/UL 4
5. ANSI/UL 83
6. UL 1479
7. Federal Specification J-C-30B

B. Cable material:

1. Jacket material:
    a) Galvanized Steel, interlocked.
2. Conductor covering: Paper wrap.
3. Conductor Material:
    a) Copper, Solid, THHN.
    b) Minimum #12 gauge.
    c) Maximum #8 gauge.
    d) 90 degree C, 600 volt.
    e) Full size insulted grounding conductor, green.
    f) 16 AWG integral bond wire in combination with armor jacket.
    g) Conductor color coding to match system voltage. Comply with Section 26 05 19 Building Wire and Cable, “Color Coding”.

C. Fittings:

1. ANSI/NEMA FB 1
2. ANSI/UL 514B
3. Zinc plated Malleable iron, or steel.
4. Direct flexible conduit bearing set screw type not acceptable.
5. Install insulated bushings or equivalent protection (i.e., anti-short) between core conductors and outer jacket.

2.12 EXPANSION FITTINGS

A. For all exterior locations as defined by the National Electrical Code and these specifications, Expansion/deflection fittings shall be:

1. Listed, hot ~~dipped~~ galvanized inside and outside providing a 4 inch expansion chamber and deflection (where applicable) when used with rigid conduit, intermediate metal conduit and electrical metallic conduit.
2. Expansion fittings shall be UL listed, polyvinyl chloride providing a minimum 6 inch expansion chamber when used with non-metallic conduit (PVC), and shall meet the requirements of and as specified elsewhere for non-metallic conduit.
3. Fittings shall be provided with an external braided grounding and bonding jumper with approved clamps UL Listed for the application.
4. Expansion fittings with an internal bonding jumper that are UL Listed for the application and in compliance with the National Electrical Code may be considered for exterior locations only. Submit fitting with manufacturer’s data and UL Listing for approval prior to installation.
5. Expansion/deflection fittings installed in interior/dry locations as defined by the National Electrical Code and these specifications shall comply with all of the above and outside when used with electrical metallic conduit.
6. Where expansion fittings are installed under an expansion joint which is exposed to the weather from floor above, expansion fittings shall be exterior type.
~~6.~~7. Sleeves intended for use for expansion fittings shall be flagged and inspected by O.A.R. prior to pour to verify size/alignment.

PART 3- EXECUTION

3.1 LOCATION REQUIREMENTS

A. Underground Installations:

1. Use Schedule 40 thickwall nonmetallic conduit only unless local authority having jurisdiction or applicable codes/utility requirements, etc. require rigid steel conduit.
2. Encase conduit in a concrete envelope of not less than 3 inch thickness on all sides and not less than 1-1/2 inches between conduits (where more than one conduit is installed together) for:

   a) All conduits installed under roads, taxiways, and runways.
   b) All conduits installed for primary electric circuits, main feeders, and data/communications systems (i.e. Telephone, data, parking revenue, radio, flight information, air traffic control systems, security, fiber optic).

3. All conduits or elbows entering or leaving any slab or the ground shall be rigid steel conduit coated with asphalt paint.
4. Where rigid metallic conduit is installed underground as noted above it shall be coated with waterproofing black mastic before installation, and all joints shall be re-coated after installation.
5. All PVC runs over 100 feet in length shall utilize rigid steel 90 degree elbows at each horizontal change in direction. All PVC risers shall utilize rigid steel 90 degree elbows. Elbows shall be coated with black mastic or PVC coating. Bond all metal elbows per NEC 250.80 and NEC 300.5
6. Underground raceway systems shall conform to all national, state, local and FAA regulations, in general and NEC 300.5

   a) Depth of conduits shall be not less than 18 inches with the following exceptions:

      1) Conduits installed in concrete floors of buildings to have a minimum concrete cover not less than 2 inches.
      2) Conduits passing under taxiways, runways, ramps, holding areas, and docking areas, must be installed below the concrete pour, in the sub base, and shall be encased in not less than 3 inches of concrete, the specifications of which shall meet the same standards required for runways and taxiways except that slump shall be 3 inches to 4 inches.

7. Verify finished lines in areas where raceways will be installed underground before the grading is complete.

B. In Slab, Above or On Grade:

1. Use coated rigid steel conduit, coated intermediate metal conduit (if approved) or thickwall nonmetallic conduit.
2. In slab conduit is permitted only where written consent is granted by Architect and Structural Engineer, regardless of that shown or noted by drawings. Install as directed by Architect/Structural Engineer.

C. Penetration of Slab:

1. Exposed Location:

a) Where penetrating a floor in an exposed location from underground or in slab, a black coated galvanized rigid steel conduit shall be used.

2. Concealed Location:

a) Where penetrating a floor in a location concealed in block wall and acceptable by applicable codes, non-metallic conduit may be used up to first outlet box, provided outlet box is at a maximum height of 40 inches above finished floor.
b) Where penetrating a floor from underground or in slab, a coated galvanized rigid steel conduit shall be used.

D. Outdoor Location:

1. Above Grade:

a) Where penetrating the finished grade, a coated galvanized rigid steel conduit shall be used.
b) All exterior conduit runs shall be rigid conduit and threaded connectors as specified elsewhere.
c) All areas subject to exterior conditions such as overhangs, galvanized rigid steel conduit shall be used.

2. Roofs:

a) Conduit is not to be installed on roofs, without written authorization by OAR for specific conditions.
b) When approved by written authorization conduit shall comply with the following:

1) Be PVC coated rigid galvanized metal conduit.
2) All fittings, etc. are to be PVC coated.
3) Conduit shall be supported above roof at least 6 inches using approved conduit supporting devices. Refer to applicable roofing specifications.
4) Fasten supports to roof per roofing manufacturer’s recommendations.

3. Cooling Towers:

a) Conduit installed at cooling towers shall be PVC coated rigid galvanized conduit.

E. Interior Dry Locations:

1. Concealed:
a. Use rigid galvanized steel and electrical metallic tubing. Thickwall non-metallic conduit (PVC) may be used inside block walls up to first outlet to a maximum of 40 inches AFF except where prohibited by the NEC.
b. The use of metal clad cables and HCF-90 armored cables are permitted in very limited applications as specified herein, provided acceptable by the local inspecting authority having jurisdiction and applicable codes and standards. Refer to “Additional Requirements for Metal Clad/Armor HCF-90 Cables” below

2. Exposed:

a) Use rigid galvanized steel and electrical metallic tubing. EMT may only be used where not subject to damage which is interpreted by this specification to be above 96 inch AFF and exiting the top of panelboards, terminal cabinets, and control panels.

3. Concealed or exposed flexible conduit:

    a) Concealed: Flexible steel conduit or seal tight flexible steel conduit shall be in lengths not longer than 6 feet in length with a ground conductor firmly attached to the terminating fitting at the extreme end of the flex. Direct change over from conduit to flexible conduit is not acceptable unless written permission is granted by OAR or specifically noted on drawings.
    b) Exposed: Liquid tight flexible steel conduit shall be used for connections to motors, movable equipment, or vibration equipment (transformers, pumps, AHU's, loading bridges, etc.) as specified herein. Lengths shall not exceed 6 feet in length unless written authorization by OAR for specific conduits is granted. Connections to vibration equipment, motors, etc shall be made with wire mesh grip fittings as specified herein. Flexible steel conduit is not acceptable in exposed locations. All exposed flexible metal conduit shall be liquid tight.

F. Interior Wet and Damp Locations:

1. Use rigid galvanized steel in interior wet and damp locations. Areas which are subject to direct exterior conditions such as parking garages, open ramp overhangs and the Baggage Claim Areas within 100 feet of the east/west tug openings, etc., shall be classified "WET/EXTERIOR LOCATION."

G. Concrete Columns or Poured in-place Concrete Wall Locations:

1. Use thickwall non-metallic conduit. Penetration shall be by approved metal raceway (i.e. metal conduit as required elsewhere in these specifications).
2. Locations Near 400 Hz Distribution Systems
3. Metal ferrous conduit or support equipment is not to be installed within 6 inches of any 400 Hz distribution system conduit or wire. Increase distance if so required by 400 Hz system manufacturer.

H. Corrosive Locations:

1. Comply with all codes and standards.
2. Retail Concession Spaces
3. The use of metal clad cable for the wiring of power, lighting, control and signal circuits in these spaces is permitted except where otherwise specified.

3.1 ADDITIONAL REQUIREMENTS FOR RIGID METAL STEEL CONDUIT

A. Rigid metal conduit shall be cut and threaded with tools approved for the purpose and by qualified personnel.

1. Approved pipe vise.
2. Roller/bade type cutter or band saw.
3. Reamer capable of completely removing al ridges or burrs left by the cutter. Reaming with pliers is not acceptable.

B. Hangers shall be installed 8 feet apart.

C. Conduits stubbed through floor slabs, above grade and not contained inside walls, shall be rigid galvanized metallic conduit.

D. One hole pipe straps shall be malleable iron. Wet location applications shall include malleable iron back clamp spacers.

E. Use of two piece threaded union fittings and rigid set screw fittings are not permitted. Threaded unions may be acceptable where required for special field conditions only when special written permission is granted by OAR.

3.2 ADDITIONAL REQUIREMENTS FOR INTERMEDIATE METAL CONDUIT (IMC)

A. May be installed only by special written permission.

B. If written approval is received then IMC may be used in locations acceptable by NEC and elsewhere in these specifications, whichever is most stringent.

3.3 ADDITIONAL REQUIREMENTS FOR ELECTRICAL METALLIC TUBING (EMT)

A. Electric metallic tubing (thin wall) may be installed inside buildings above ground floor where not subject to mechanical injury.

B. All cuts shall be reamed smooth and free of sharp and abrasive areas by use of an approved reamer.

C. Cut conduit square using approved hacksaw with 32 tooth per inch blade; de-burr cut ends. Roller/blade type pipe cutter is not acceptable.

D. One hole pipe straps, where specified herein, shall be heavy duty type.

3.4 ADDITIONAL REQUIREMENTS FOR ALUMINUM CONDUIT

A. May be used only for 400 Hz electrical distribution system.

3.5 ADDITIONAL REQUIREMENTS FOR FLEXIBLE STEEL CONDUIT AND LIQUID-TITE FLEXIBLE METAL CONDUIT

A. Shall be properly grounded.

B. Shall be installed with approved fittings.

C. Shall be used for final connections to vibrating equipment such as motors, pumps, transformers, etc.

D. Liquid-tight conduit termination connectors at vibration equipment (i.e. pumps, AHU’s, motors, moveable equipment, etc) shall be provided with wire mesh grips.

3.6 ADDITIONAL REQUIREMENTS FOR NON METALLIC CONDUIT (PVC)

A. PVC conduit is not allowed anywhere inside building(s) except underground, in slab, in poured in place concrete, and in block wall up to first outlet box (if not over 40 inches AFF) if allowed by codes. In elevated slabs, conduit is permitted only where written consent is granted by Structural Engineer, regardless of that shown or noted by drawings. Install as directed by Architect/Structural Engineer.

B. Join nonmetallic conduit using cement as recommended by manufacturer. Wipe nonmetallic conduit dry and clean before joining. Apply full even coat of cement to entire area inserted in fitting. Allow joint to cure for 20 minutes, minimum.

C. Threads will not be permitted on PVC conduit and fittings, except for rigid steel to PVC couplings.

D. Installation of PVC conduit shall be in accordance with manufacturer's recommendations.

E. PVC conduit shall not be used to support fixture or equipment.

F. Field bends or direction changes shall be by manufactured bends only. Heating with flame and hand held dryers are prohibited.

G. PVC fittings and elbows shall be by same manufacturer as conduit.

3.7 ADDITIONAL REQUIREMENTS FOR METAL CLAD/ARMOR HCF-90 CABLES

A. Metal Clad Cables may be used only as specified, where permitted by NEC, and if approved by the local inspecting Authority Having Jurisdiction.

B. Type HCF-90 cable, where permitted, may be used in retail concession leases or part thereof (i.e. multifunction buildings, etc.) and where permitted by NEC 517, and where redundant grounding path are not required by NEC 250~~-91(b)~~.118 Armor HFC-90 cables shall not be used in Places of Assembly.

C. Cables, where permitted, shall be used only in interior dry locations of stud wall partition framing (vertical wall construction only) and for final connections to lighting luminaries from conduit system/junction box above each fixture, (looping cables from fixture to fixture is not permitted).

D. MC cable shall not be used for any other building wiring or for branch circuit homeruns to panelboards or similar equipment. Branch circuit homeruns and branch electrical distribution wiring system shall utilize conduit system (i.e. GRC, IMC, EMT, etc.) as specified elsewhere in this document.

E. MC cable shall not extend more than 10 feet from the point the cable exits the wall partition framing. Extend conduit system (i.e. EMT, GRC, etc as specified herein) to a junction box at the wall for transition to MC cable.

F. Cables shall not be installed where subject to mechanical injury or exposure to heat.

G. Multi-conductor home run cable is prohibited.

H. Cables for use other than power and lighting branch circuits are not permitted.

I. Cables shall not be used for Life Safety Emergency Branch Circuits~~ (i.e., NEC 700/701)~~ (NEC 700) or legally required branch circuits (NEC 701).

J. For branch circuit lighting and power circuits only, maximum #8 gauge permitted. Cables shall not be used for feeder circuits or for systems, Each Section of Divisions 27 and 28, (i.e.. fire alarm, voice, data, television, etc.).

K. Connectors and supporting components shall be UL listed for such use.

L. Cut cables with UL listed tools intended for such use. Ream smooth and free of sharp and abrasive areas. Install bushing between conductors and outer jacket. The use of slide cutters or dikes to cut cables is not acceptable.

M. Maintain minimum 1/2 inch separation between each cable and support per NEC 334. The practice of bundling cables is not acceptable.

N. Support maximum of 1 foot-0 inches from every box, cabinet, etc., secure at intervals not to exceed 5 feet-0 inches.

O. Install parallel and perpendicular to building lines. Required metal stud openings shall be made with an approved stud punch tool.

P. Install metal sleeves where cables pass through rated walls, one sleeve per cable with minimum 2 inches between each. Increase spacing as required per applicable UL fire stopping detail/assembly.

Q. Install cables minimum of 1 foot-0 inches from communications cables.

R. The use of standard type A/C cables in lieu of MC cables is not permitted unless cable is HCF-90 as specified herein.

S. Attachment of cables to ceiling system is prohibited. Secure cables in strict accordance with NEC 300.11.

T. Attachment of cables to, on, or from mechanical (HVAC) equipment, supports, etc., is not permitted.

U. Install cables parallel and perpendicular to building structure.

V. Install additional supports as necessary to omit cable sagging.

W. Complete installation shall be in a neat and workmanlike manner to the satisfaction of the OAR per NEC 110.12.

X. Zigzagging cables through building elements, as method of support is not acceptable.

Y. Cable with outer metal sheath damaged by construction elements and/or improper installation shall be replaced at no additional cost to owner.

Z. Cables shall be securely fastened with UL listed devices and methods intended for such use.

AA. Observe fire-rating requirements for quantity of cables in wall cavities.

3.2 ADDITIONAL REQUIREMENTS FOR PVC COATED CONDUIT

A. All cuts, pinholes and ends shall be sealed using liquid PVC patch. PVC coated conduit shall be thoroughly inspected after installation to assure all voids, cuts, pinholes or other violation of the integrity of the PVC coating are sealed.

3.8 SUPPORTS

C. Comply with the requirements of Section 26 05 29 Hangers and Supports.

D. Arrange supports to prevent misalignment during wiring installation.

3.9 EXPANSION/DEFLECTION FITTINGS

C. Provide suitable fittings to accommodate expansion and deflection where conduit crosses, control and expansion joints.

D. Expansion fittings shall be installed in the following cases:

1. In each conduit run wherever it crosses an expansion joint in the concrete structure.
2. On one side of joint with its sliding sleeve end flush with joint, and with a length of bonding jumper in expansion/deflection equal to at least three times the normal width of joints.
3. In each conduit run which mechanically attaches to separate structures to relieve strain caused by shift on one structure in relation to the other.
4. In straight conduit run above ground that is more than one hundred feet long and interval between expansion/deflection fittings in such runs shall not be greater than 100 feet.

3.10 GROUNDING

C. All raceways shall have a copper system grounding conductor throughout the entire length of circuit installed within conduit in strict accordance with NEC codes.

D. Grounding conductor shall be included in total conduit fill determining conduit sizes, even though not included or shown on drawings.

E. Grounding conductors run with exterior/ underground feeders shall be bare only.

F. Grounding conductors run with feeders shall be bonded to portions of conduit that are metal by approved ground bushings.

G. See other sections of these specifications for additional requirements.

H. Grounding conductors (including lightning protection down conductors) run in metal conduit shall be bonded to metal conduit at both ends.

3.11 CONDUITS PENETRATING TWO HOUR ASSEMBLIES OR GREATER

C. Conduits with conductors penetrating the wall shall have blow out patches on each side of the wall.

D. Multiple conduits run through rated walls side by side shall have blow out patches on each side of the wall.

E. Data or telephone conductors run exposed and penetrating a wall rated 2 hour for fire, smoke or smoke/fire shall be sleeved with steel conduits 30 inches each side of the wall and conduit ends packed with approved fire sealant.

3.12 FIRE AND SMOKE STOPPING

C. Contractor is to provide fire stopping and smoke sealing for all penetrations of existing (or new if applicable) fire or smoke assemblies as required to maintain rating of assembly.

D. All penetrations shall be fire stopped in strict accordance with UL Fire Directory. Submit applicable details for acceptance. Prepare and install as delineated by UL detail(s).

E. Each penetration shall be identified with the corresponding UL fire assembly number. Labels shall be typed or computer generated minimum 1/2 inch high black lettering, self-adhesive type.

F. Comply with UL Fire Directory "F" and "T" ratings respectfully.

3.13 FIRE PROTECTION

C. Emergency life safety feeder-circuit wiring shall be installed either in spaces fully protected by an approved automatic fire suppression system or shall be a listed electrical circuit protection system with a 1-hour fire rating. Fire circuit protection shall be in accordance with UL Fire Protection equipment Directory and UL Building Materials Directory (latest edition).

3.14 VERTICAL RACEWAYS

C. Cables in vertical raceways shall be supported per NEC 300.19. Provide supporting devices for cables, including any necessary accessible pull boxes as required regardless if shown on drawings or not. Provide and install access panels as required. Coordinate location of pull box and access panel with designer prior to installation. This includes empty raceways for future use.

3.15 GENERAL

C. Install conduit in accordance with NECA 1-2009 Standard Practice of Good Workmanship in Electrical Contracting” Contractor shall lay out all work prior to rough-in.

D. Install nonmetallic conduit in accordance with manufacturer's instructions.

E. Arrange conduit to maintain headroom and present neat appearance.

F. Route conduit installed above accessible ceilings or exposed to view parallel or perpendicular to walls. Do not run from point to point.

G. Route conduit in and under slab from point-to-point.

H. Do not cross conduits in slab.

I. Maintain adequate clearance between conduit and piping.

J. Maintain 12 inch clearance between conduit and surfaces with temperatures exceeding 104 degrees F (40 degrees C).

K. Maintain minimum of 3 inch separation between power and communications raceways. Increase separation if so required to comply with EIA/TIA referenced standards.

L. Systems raceways shall be installed in accordance with ANSI/EIA/TIA Communications Standards.

1. Maintain proper separation between PDS system cables and all power and unshielded cables, as required to prevent noise or crosstalk interference.
2. Raceway bends shall have minimum inside radius of 6 times the internal diameter. Increase bend radius to 10 times for raceway larger than 2 inch size. Provide proper bend for all changes of direction. Pull and splice boxes shall not be used in lieu of a bend.
3. Install raceways so no more than two 90 degree bends are in any raceway section without a pullbox. Install additional pull boxes as required to maintain maximum of two 90 degree bends between pull boxes and termination points.
4. Install boxes in straight sections of raceway.

M. Cut conduit square using saw or pipecutter; de-burr cut ends.

N. Bring conduit to shoulder of fittings; fasten securely.

O. Use conduit hubs or sealing locknuts to fasten conduit to sheet metal boxes in damp locations and to cast boxes. Use threaded conduit hubs to fasten conduit to sheet metal boxes, disconnects switches and equipment control panels in wet and exterior locations.

P. Install no more than equivalent of three 90-degree bends between boxes for power and lighting systems. Use conduit bodies to make sharp changes in direction, as around beams, Use appropriate boxes and conduit bodies for fire alarm, voice/data and sound/paging systems. Use factory elbows for bends in metal conduit larger than 2- inch size.

Q. Avoid moisture traps; provide junction box with drain fitting at low points in conduit system.

R. Provide pull boxes, junction boxes and fire barrier at fire rated walls as required by NEC 300, whether shown on drawings or not.

S. Provide continuous fiber polyline 1000 lb. minimum tensile strength pull string in each empty conduit except sleeves and nipples. This includes all raceways which do not have furnished conductors. Pull cords must be fastened to prevent accidental removal. A phenolic or brass nameplate shall be attached to each end indicating the location of both ends of conduit as follows: THIS END = "LOCATION," OTHER END = "LOCATION."

T. Use suitable seals to protect installed conduit against entrance of dirt and moisture and insects.

U. Ground and bond conduit under provisions of Section 26 05 26 Grounding and Bonding.

V. Identify conduit under provisions of Section 26 05 53 Identification for Electrical Systems.

W. Install all conduit concealed from view unless specifically shown otherwise on drawings

X. Rigid steel box connections shall be made with double locknuts and bushings.

Y. All wire raceways shall be kept clear of plumbing fixtures to facilitate future repair or replacement of said plumbing fixtures without disturbing wire raceways. Except where it is necessary for control purposes, all raceways shall be kept away from items producing heat.

Z. All raceway runs in masonry shall be installed at the same time as the masonry so that no face cutting is required, except to accommodate boxes.

AA. All raceways shall be run from outlet to outlet as shown on the drawings, unless permission is granted, to alter arrangement shown. If permission is granted arrangement shall be marked on red lined As-Built drawings as previously specified.

BB. Spare conduit stubs shall be capped and location and use marked with concrete marker set flush with finish grade. Marker shall be 6" round x 6" deep with appropriate symbol embedded into top to indicate use. Also, tag conduits in panels where originating.

CC. All conduit stubbed above floor shall be strapped to a metal channel supported by conduit driven into ground or tied to steel. Spare conduit stubs shall be capped with a UL listed and approved cap or plug for the specific intended use and identified with ink markers as to source and labeled "Spare".

DD. All connections to motors or other vibrating equipment including transformers or at other locations where required shall be made with not less than 12" nor more than ~~24~~36" of flexible liquid-tight steel conduit, with nylon insulated throat connectors and wire mesh grip fittings at both terminations of conduit. Use angle connectors wherever necessary to relieve angle strain on flex conduit.

EE. Provide a conduit sealing fitting or pliable compound wherever conduit system is exposed to widely temperature changes which may cause condensation within the raceway; as from the inside to the outside of coolers or freezers.

FF. Route conduit through roof openings for piping and ductwork or through suitable roof jack with pitch pocket. Coordinate location with roofing installation specified under other Sections of these specifications.

GG. All raceways shall be run in neat and workmanlike manner per NEC 110.12 and shall be properly installed in accordance with the latest edition of NEC with approved conduit clamps, hanger rods and structural fasteners.

HH. All raceway runs, whether terminated in boxes or not, shall be capped during the course of construction until wires are pulled in, and covers are in place. No conductors shall be pulled into raceways until construction work which might damage the raceways has been completed.

II. Electrical raceways shall be supported independently of all other systems and supports, and shall in every case avoid proximity to other systems which might cause confusion with such systems or might provide a chance of electrolytic actions, contact with live parts or excessive induced heat.

JJ. Raceways, boxes, etc shall not be attached to an acoustical grid ceiling system or support wire per NEC 300.11. Support all components directly from building structure.

END OF SECTION 26 05 33

SECTION 26 05 34 - OUTLET BOXES

PART 1- GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Contractual Conditions and Division 01 Specification sections apply to this section.

1.2 SUMMARY

A. This section includes the requirements for provision and installation of all boxes used as outlet, device, junction, or outlet.

1.3 DESCRIPTION

A. Provide and install all outlet boxes (flush or surface) complete with all accessories as required to facilitate installation of electrical system and as required by the NEC.

1.4 SUBMITTALS

A. Submit catalog cut sheet/product data on:

1. Outlet and device boxes
2. Junction and pull boxes
3. Surface, flush and in ground boxes
4. Surface cast boxes
5. All outlet boxes to be used on project.

1.5 PROJECT AS-BUILT DOCUMENTS

A. Record actual locations and junction boxes not covered in Section 26 05 35 pull and junction boxes (surface, flush or in ground mounted). submit product data showing dimensions, covers, and construction.

1.6 REFERENCES AND REGULATORY REQUIREMENTS

A. Furnish products listed and classified by Underwriters Laboratories as suitable for purpose specified and shown.

B. Conform to the requirements of the following:

1. ANSI/NEMA FB 1 – Fittings, Cast Metal Boxes and Conduit Bodies Supports for Conduit, Electrical Metallic Tubing and Cable Assemblies.
2. ANSI/NEMA OS 1 - Sheet-steel Outlet Boxes, Device Boxes, Covers, and Box Supports.
3. ANSI/NFPA 70 - National Electrical Code.

4. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

1.7 PROJECT CONDITIONS

A. Verify field measurements are as shown on Drawings.

B. Verify locations of outlets in offices and work areas prior to rough-in.

C. Electrical boxes are shown on Drawings in approximate locations unless dimensioned. Install at location required for box to serve intended purpose.

PART 2 - PRODUCTS

2.1 GENERAL

A. Provide box accessories as required for each installation, including mounting brackets, wallboard hangers, extension rings, outlet boxes, and corrosion-resistant knockout closures compatible with outlet boxes being used and meeting requirements of individual wiring situations.

B. All boxes shall be of the size and shape required by NFPA 70 for their respective locations.

C. Boxes shall be of such form and dimensions as to be adapted to the specific use and location, type of device or fixtures to be used, and number and size of conductors and arrangement, size and number of conduits connecting thereto.

D. Handy boxes shall not be used.

E. Outlet Boxes for outlets and devices shall be one-piece.

F. 4 inch x 4 inch boxes and 4 11/16 inch x 4 11/16 inch boxes used as junction boxes shall be one piece.

2.2 SHEET METAL OUTLET BOXES:

A. ANSI/NEMA OS 1, Galvanized Steel.

B. Luminaire and Equipment Supporting Boxes: Rated for weight of equipment supported; include 1/2 inch (13 mm) male fixture studs where required.

C. Concrete Ceiling Boxes: For concrete location installation, providing fire resistance rating as required.

D. Interior flush outlet boxes shall be galvanized steel constructed with stamped knockouts in back and sides, and threaded holes with screws for securing box coverplates or wiring devices. T & B, Steel City, Raco or approved substitution.

E. Ceiling outlet boxes shall be 4 inch octagonal or 4 inch square X 1 1/2 inch deep or larger as required for number and size of conductors and arrangement, size and number of conduits terminating at them one piece.

F. Switch, wall receptacle, telephone and other recessed wall outlet boxes in drywall shall be 4 inch square X 1 1/2 inch deep one piece. For recessing in exposed masonry, provide one piece 4 inch square x 1 1/2 inch deep wall boxes with appropriate 4 inch square cut tile wall covers Steel City series #52-C-49/52-C-52 or approved substitution. For recessing in furred-out block walls, provide one piece 4 inch square box with required extension for block depth and required extension for drywall depth.

G. For Communication/Systems Telephone, Data, TV, CCTV, Video, and Computer device outlet boxes shall be one piece 4 inch square x 2 1/8 inch deep, minimum. Increase outlet box to 4-11/16 inch with single gang plaster ring as required for special devices respectfully.

2.3 CAST BOXES:

A. NEMA FB 1

B. Interior surface outlet boxes and conduit bodies installed from 0 inch AFF to 90 inch AFF (including fire alarm device backbox) shall be heavy cast aluminum or iron with external threaded hubs for power devices and threaded parts for low voltage devices - Appleton, Crouse Hinds or approved substitution. Trim rings shall also be of one piece construction.

C. Weatherproof outlet boxes shall be constructed of corrosion-resistant cast iron suited to each application and having threaded conduit hubs, cast metal face plate with spring-hinged waterproof cap suitable configured, gasket, and corrosion-proof fasteners.

D. Boxes to be Type FD unless otherwise noted on drawings.

E. Free standing cast boxes are to be type FSY (with flange). Other cast zinc boxes are not acceptable.

PART 3- EXECUTION

3.1 GENERAL

A. Install electrical boxes as shown on Drawings, and as required for splices, taps, wire pulling, equipment connections and compliance with regulatory requirements.

B. Install electrical boxes to maintain headroom and to present neat mechanical appearance.

C. Inaccessible Ceiling Areas: Install outlet and junction boxes no more than 6 inches from ceiling access panel or from removable recessed luminaire.

D. Above ceiling outlet and junction boxes shall be install to permit readily accessible access from ladder or staging from corresponding floor without the need to extend ladder up through ceiling system to facilitate ease of maintenance.

E. Install boxes to preserve fire resistance rating of partitions and other elements.

F. Align adjacent wall-mounted outlet boxes for switches, thermostats, and similar devices with each other.

G. Outlets for 120V clocks shall be recessed so that the clock will hang flush with the finished surface of the wall.

H. Use flush mounting outlet boxes in finished areas.

I. Do not install flush mounting boxes back-to-back in walls; provide minimum 6 inch separation. Provide minimum 24 inches (one stud space) separation in acoustic and rated walls.

J. Secure flush mounting box to interior wall and partition studs. Accurately position to allow for surface finish thickness.

K. Use stamped steel bridges to fasten flush mounting outlet box between studs.

L. Install flush mounting box without damaging wall insulation or reducing its effectiveness.

M. Lighting control switches shall be located at the latch side of door. If the drawings indicate otherwise, issue a request for clarification prior to rough-in.

N. Support all outlet boxes from structure with minimum of one 3/8 inch all-thread rod hangers. Boxes larger than 25 square inches shall be supported with two all-thread rod hangers, minimum.

O. Do not fasten boxes to ceiling support wires.

P. Support boxes independently of conduit.

Q. Use gang box where more than one device is mounted together. Do not use sectional box.

R. Use gang box with plaster ring for single device outlets.

S. Comply with applicable portions of the National Electrical Contractors Association (NECA) Standard of Installation.

T. Install outlets in the locations shown on the drawings; however, the OAR shall have the right to make, prior to rough-in, slight changes in locations to reflect room furniture layouts.

U. Coordinate each electrical box so that the type is suitable for the wall or ceiling construction anticipated and suitable fireproofing is built into fire rated assemblies.

V. Relocate electrical boxes as required so that electrical devices, once installed, will be symmetrically located with respect to the room layout.

W. All boxes shall be installed in a flush rigid manner with box lines at perpendicular and parallel angles to finished surfaces. Boxes shall be supported by appropriate hardware selected for the type of surface from which the box shall be supported. For example, provide metal screws for metal, wood screws for wood, and expansion devices for masonry or concrete. No surface mounted boxes will be allowed without OAR approval.

X. For damp and wet locations provide weatherproof boxes and accessories.

Y. As a minimum, provide pull boxes in all raceways over 150 feet long. The pull box shall be located near the midpoint of the raceway length.

Z. Provide knockout closures to cap unused knockout holes where blanks have been removed, and plugs for unused threaded hubs.

AA. Provide conduit locknuts and bushings of the type and size to suit each respective use and installation.

BB. Boxes and conduit bodies shall be located so that all electrical wiring is accessible.

CC. Avoid using round boxes where conduit must enter box through side of box which would result in a difficult and insecure connection with a locknut or bushing on the rounded surface.

DD. All flush outlets shall be mounted so that covers and plates will finish flush with finished surfaces without the use of shims, mats or other devices not submitted or approved for the purpose. Add-a-Depth rings or switch box extension rings (Steel City #SBEX) are not acceptable. Plates shall not support wiring devices. Gang switches with common plate where two or more are indicated in the same location. Wall-mounted devices of different systems (switches, thermostats, etc.) shall be coordinated for symmetry when located near each other on the same wall. Outlets on each side of walls shall have separate boxes. Through-wall type boxes shall not be permitted. Back-to-back mounting shall not be permitted. Trim rings shall be extended to within 1/8 inch of finish wall surface.

EE. Outlet Boxes mounted in metal stud walls, are to be supported to studs with minimum of two self-tapping screws inside, at the back of outlet box, to a horizontal stud brace between vertical studs or pre-manufactured heavy duty box bracket equal to Caddy Corporation # SGB/TSGB series, to prevent movement of outlet box after wall is finished.

FF. All outlet boxes that do not receive devices in this contract are to have blank plates installed matching wiring device plates.

GG. Mount Height.

1. Height of wall outlets to bottom above finished floors shall be as follows, unless specifically noted otherwise, or unless otherwise required by applicable codes including ADA. Verify with the Architectural plans and shop drawings.

   a) Switches: 4'-0" AFF to top
   b) Receptacles: 1'-4" AFF to bottom
   c) Lighting Panels: 6'-6" AFF maximum to centerline of highest breaker/fuse
   d) Phone Outlets: 1'-4" AFF to bottom
   e) ADA Wall Phones: (See part 3.1, Item HH.(4.) below)
   f) Fire Alarm Pull Stations: 4'-0" AFF to top
   g) Fire Alarm Strobe Lights: 80" AFF to bottom of globe or 6" below ceiling to top, whichever is lower

2. Bottoms of outlets and switches above counter tops or base cabinets shall be minimum 2 inch above counter top or backsplash, whichever is highest. Outlets and switches may be raised so that bottom rests on top of concrete block course, but all outlets above counters in same area shall be at the same height. Coordinate outlet locations in relation to all casework shown on Architectural plans, prior to rough-in, regardless of height shown on Electrical drawings.

3. Height of wall-mounted fixtures shall be as shown on the drawings. Fixture outlet boxes shall be equipped with fixture studs when supporting fixtures.
4. Coordinate locations and mounting heights of outlet boxes for all phones with architect, phone system installer and approved shop drawings prior to rough-in. Install as directed, including requirements of ADA. In general, ADA wall phones shall be at a maximum of 54 inch to highest operable part essential to basic operation of telephone with side reach and maximum of 48 inch forward reach as defined by 3.1 HH.1.

HH. Special Purpose Outlets.

1. Locate special purpose outlets as indicated on the drawings for the equipment served. Location and type of outlets shall be coordinated with appropriate trades involved. Coordinate roughing-in locations. Provide plug for each outlet.

II. Outlets in Rated Assemblies and Smoke Barriers.

1. Metallic and approved non-metallic electrical outlet boxes may be installed in vertical fire resistive assemblies or smoke barriers without affecting the classification, provided such openings occur on one side only in each framing space and that openings do not exceed 16 sq. inches.
2. All clearances between such outlet boxes and the gypsum board must be completely filled with joint compound or other approved materials.
3. The wall must be built around outlets of larger size so as not to interfere with the integrity of the wall rating.

3.2 INTERFACE WITH OTHER PRODUCTS

A. Coordinate installation of outlet box for products furnished under all Sections of these specifications.

B. Coordinate locations and sizes of required access doors with applicable sections in these specifications.

C. Locate flush mounting box in masonry wall to require cutting of masonry unit corner only. Coordinate masonry cutting to achieve neat opening.

D. Coordinate mounting heights and locations of outlets mounted above counters, benches and backsplashes.

E. Position outlet boxes to locate luminaires as shown on reflected ceiling plan.

3.3 ADJUSTING

A. Adjust flush-mounting outlets to make front flush with finished wall material.

B. Install knockout closure in unused box opening.

END OF SECTION 26 05 34

SECTION 26 05 35 - PULL AND JUNCTION BOXES

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. Provide and install pull and junction boxes as shown on drawings or as required by the NEC.

B. Provide and install pull and junction boxes wherever required for a complete and operating distribution system whether shown on drawings or not.

C. Where outlet boxes are used for pull and/or junction boxes, they shall meet the requirements of Section 26 05 34 Outlet Boxes.

1.3 REFERENCES

A. ANSI/NEMA FB 1 Fittings and Supports for Conduit and Cable Assemblies

B. ANSI/NEMA OS 1 Sheet-steel Outlet Boxes, Device Boxes, Covers, and Box Supports

C. ANSI/NEMA OS 2 Nonmetallic Outlet Boxes, Device Boxes, Covers and Box Supports

D. ANSI/NFPA 70 National Electrical Code

E. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum)

1.4 REGULATORY REQUIREMENTS

A. Conform to requirements of ANSI/NFPA 70.

B. Furnish products listed and classified by Underwriters Laboratories as suitable for purpose specified and shown.

1.5 SUBMITTALS

A. Submit actual shop drawings of all pull boxes showing:

1. Covers.
2. Dimensions - inside and out.
3. Rating of concrete or gauge of metal.
4. Manufacturer.

1.6 PROJECT RECORD DOCUMENTS

A. Accurately record actual locations and mounting heights of pull and junction boxes.

1.7 PROJECT CONDITIONS

A. Verify field measurements are as shown on Drawings.

B. Verify locations of pull and junction boxes prior to rough-in.

C. Electrical boxes are shown on Drawings in approximate locations unless dimensioned. Install at location required for box to serve intended purpose and to maintain required access.

PART 2 - PRODUCTS

2.1 GENERAL

A. Dimensions of pull and junction boxes shall meet dimensions shown on Drawings or dimensions required by NEC, whichever is largest.

B. Pull and junction boxes shall meet all requirements of UL and NEC.

C. Small pull boxes (i.e. 4" x 4") shall meet the requirements of these Specifications for outlet boxes as a minimum.

D. All boxes (above ground) of 100 cubic inches or more shall be constructed of 14 gauge steel with hot dip galvanized coating.

2.2 SHEET METAL BOXES

A. NEMA OS 1, galvanized steel.

B. Box to be fully weatherproof and watertight where installed outside.

2.3 SURFACE-MOUNTED CAST METAL BOX

A. NEMA 250, Type 4; flat-flanged, surface-mounted junction box.

B. Material: Cast aluminum.

C. Cover: Furnish with ground flange, neoprene gasket, and stainless steel cover screws.

D. Provide all hubs as required for conduit connections.

2.4 IN-GROUND PULL BOXES

A. Material: Precast concrete, or composolite.

B. Bottom: Open with 6" of gravel for drainage.

C. Cover: Meet Florida Dept. of Transportation requirements for installed location (pedestrian, heavy traffic, light traffic).

D. Solid sides constructed to facilitate conduit entries.

PART 3- EXECUTION

3.1 GENERAL

A. Install per NEC.

B. Install electrical boxes as shown on Drawings, and as required for splices, taps, wire pulling, equipment connections and compliance with regulatory requirements.

C. Install electrical boxes to maintain headroom and to present neat mechanical appearance.

D. Install pull boxes and junction boxes above accessible ceilings and in unfinished areas only.

E. Inaccessible Ceiling Areas: Install outlet and junction boxes no more than 6” from ceiling access panel or from removable recessed luminaire.

F. Install boxes to preserve fire resistance rating of partitions and other elements.

G. Align adjacent wall-mounted boxes with each other.

H. Use flush mounting boxes in finished areas.

I. Do not install flush mounting boxes back-to-back in walls; provide minimum 6” separation. Provide minimum 24” separation in acoustic rated walls.

J. Secure flush mounting box to interior wall and partition studs. Accurately position to allow for surface finish thickness.

K. Install flush mounting box without damaging wall insulation or reducing its effectiveness.

L. Pull and junction boxes larger than 25 square inches shall be supported with two 3/8" all-thread rod hangers minimum.

M. Pull and junction boxes used for Systems Divisions 27, 28 larger than 25 square inches shall be hinged cover type.

N. Do not fasten boxes to ceiling support wires.

O. Support boxes independently of conduit.

P. Large Pull Boxes:

1. Boxes larger than 100 cubic inches in volume or 12” in any dimension:

a) Interior dry locations per NEC with screw covers.

b) Other locations use hinged enclosure under provisions of Section 26 27 16 Cabinets and Enclosures.

Q. Outdoor Locations: All boxes installed outdoors to be NEMA 4, fully weatherproof and watertight.

3.2 IN-GROUND PULL BOXES

A. Provide and install ground rod in each pull box. Connect #2 copper ground wires (counterpoise) to ground rod, run out pullbox 6" over conduits to next pull box; tie to respective building electrical ground rod at each building.

B. Install pull boxes flush with finished grade. Provide extensions as required.

C. In-ground pullboxes to have interior watertight pull box mounted inside in-ground pull box as required by Local Authority Having Jurisdiction.

3.3 INTERFACE WITH OTHER PRODUCTS

A. Coordinate locations and sizes of required access doors with applicable sections in these Specifications.

B. Locate flush mounting box in masonry wall to require cutting of masonry unit corner only. Coordinate masonry cutting to achieve neat opening.

3.4 ADJUSTING

A. Install knockout closure in unused box opening.

END OF SECTION 26 05 35

SECTION 26 05 53 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1- GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Contractual Conditions and Division 01 Specification sections apply to this section.

1.2 SUMMARY

A. This section includes the requirements for provision and installation of identification for electrical equipment.

1.3 DESCRIPTION

A. Provide and install all equipment, labor and material for a complete identification system, including but not limited to:

1. Nameplates and labels.
2. Wire and cable markers.
3. Conduit markers.
4. Identify all new and existing conduits, boxes, equipment, etc. as specified herein.

1.4 REFERENCES AND REGULATORY REQUIREMENTS

A. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for purpose specified and shown.

B. Conform to the requirements of the following:

1. ANSI/NFPA 70 - National Electrical Code.
2. Americans with Disabilities Act ~~-~~ – 1990~~.~~

1.5 ACTION SUBMITTALS

A. Sustainable Design Documentation Submittals: Refer to section 01 8113.14 “Sustainable Design Requirements – LEED V4 BD+C”.

1. Product Data: Documentation for Low Emitting Materials
   a) Low Emitting Materials for Paints and Coatings
   b) Low Emitting Materials for Adhesives and Sealants

PART 2 - PRODUCTS

2.1 NAMEPLATES

A. Nameplates for Life Safety Branch Power shall be laminated red phenolic plastic with chamfered edges and white engraved lettering. Orange phenolic plastic border to be added around nameplate to denote branch.

B. Nameplates for Critical (Legally Required) Branch Power shall be laminated red phenolic plastic with chamfered edges and white engraved lettering. Green phenolic plastic border to be added around nameplate to denote branch.

C. Nameplates for Security Branch Power shall be laminated red phenolic plastic with chamfered edges and white engraved lettering. Purple phenolic plastic border to be added around nameplate to denote branch.

D. Nameplates for Equipment Branch Power shall be laminated red phenolic plastic with chamfered edges and white engraved lettering. Blue phenolic plastic border to be added around nameplate to denote branch.

E. Nameplates for Normal Branch Power shall be laminated black phenolic plastic with chamfered edges and white engraved lettering.

F. Letter Size:

1. 1/8 inch for identifying individual equipment and loads.
2. 1/4 inch for identifying grouped equipment and loads.

G. Nameplates shall adequately describe the function of the particular equipment involved. Where nameplates are detailed on the drawings, inscription and size of letters shall be as shown and shop drawing submitted for approval. Nameplates for panelboards and switchboards shall include the panel designation, voltage and phase of the supply. For example, "Panel A, 120/208V, 3-phase, 4-wire". In addition, provide phenolic label in panel to describe where the panel is fed from. For example, "Fed ~~From~~from MDP-1:3:5". The name of the machine on the nameplates for a particular machine shall be the same as the one used on all motor starters, disconnect and P.B. station nameplates for that machine.

H. The following items shall be equipped with nameplates: All motors, motor starters, motor-control centers, push-button stations, control panels, time switches, disconnect switches, transformers, panelboards, circuit breakers (i.e., all 2 pole, 3 pole C.B.'s), contactors or relays in separate enclosures, power receptacles where the nominal voltage between any pair of contacts is greater than 150V, wall switches controlling outlets that are not located within sight of the controlling switch, high voltage boxes and cabinets, large electrical, and electrical systems junction and pull boxes (larger than 4 11/16"), terminal cabinets, terminal boards, and equipment racks. Nameplates shall also describe the associated panel and circuit number (if applicable).

I. All Electrical System panels, transfer switches, etc. shall be labeled per branch, i.e.: "Panel ABC-Life Safety Branch" (similar for critical or equipment branch).

J. All receptacles shall be clearly labeled with panel/circuit designation.

K. All junction/pull boxes shall receive phenolic labels clearly labeling circuitry/cabling/etc., within.

2.2 WIRE MARKERS

A. Description: Cloth, tape, split sleeve, or tubing type wire markers.

B. Locations: Each conductor at panelboard gutters, pull boxes, outlet and junction boxes, and each load connection.

C. Legend:

1. Power and Lighting Circuits: Branch circuit or feeder number indicated on drawings including neutral conductor.
2. Low voltage circuits (circuits under 120V):

D. Control wire number indicated on schematic and interconnection diagrams on shop drawings.

2.3 CONDUIT/JUNCTION BOX COLOR CODE

A. All conduit system junction boxes (except those subject to view in public areas) shall be color coded as listed below:

Color Code for Junction Boxes	Krylon Paint Number
System Emergency 277/480 volt	Cherry Red K02101
System Emergency 120/208 volt	Zinger Pink S01150
Fire Alarm	Popsicle Orange K02410
Normal Power 277/480 Volt	Leather Brown K02501
Normal Power 120/208 Volt	Glossy Black K01601
Fiber Optics	Plum Purple K01929
Sound System	Daisy Yellow K01813
Clock	Light Blue S01540
Intercom	True Blue K01910
PDS/WIFI	Gold K01701
TV	Glossy White K01501
BAS	Cameo White K04129
FIDS/BIDS	Saddle Tan K03554
Security/CCTV	John Deer Green K01817
Telephone	Clover Green K02012
Grounding	Fluorescent Green K03106
Access Control System	John Deer Green K01817
Lightning Detection & Notification	Global Blue K03546
Elevator Status	Georgia Clay K03531
800 Mhz Radio	Copper Metallic K02203
FCIC	Clover Green K02012
Positron	Clover Green K02012
DC Controls	Clover Green K02012
Duress	Fresh Salmon K03536

Fire Pump Status	Popsicle Orange K02410
Emergency Generator Status	Zinger Pink S01150

B. Conduits (not subject to public view) longer than 20 feet shall be painted with above color paint band 20 ft. on center. Paint band shall be 4" in length. Where conduit are parallel and on conduit racking, the paint bands shall be evenly aligned. Paint shall be neatly applied and uniformed. Paint boxes and raceways prior to installation or tape conduits and surrounding surfaces to avoid overspray. Paint overspray shall be removed.

C. Emergency (Backed by Generator). Conduit shall be painted red 20 ft. on center. Paint band shall be 4” in length. A smaller band, 1” in length, centered over the 4” red band shall be applied to denote Emergency Branch as follows:

Emergency Branch	Color Band
Life Safety	Orange
Critical	Green
Security	Purple
Equipment	Blue

D. Junction boxes and conduit located in public areas (i.e. areas that can be seen by the public) shall be painted to match surface attached to. Provide written request to DESIGNER for interpretation of those public areas which may be in question.

E. Where two colors apply to the same raceway, paint on opposite corners leaving room for panel/ckt./system/etc., labeling in center.

F. The Contractor may utilize conduit banding tape instead of paint, on interior conduits only, where specified colors are available. Surface of conduits shall be thoroughly cleaned prior to tape application, and tape shall be applied in a neat and workmanlike manner. Tape to be manufactured by Seton Identification Products only.

2.4 CONDUIT/JUNCTION BOX MARKER

A. All new and existing junction boxes/cover plates for power, lighting and systems (except those installed in public areas) shall adequately identify its associated systems panel and circuit number. Identification shall be by means of black permanent marker. (Paint one-half cover plate with appropriate color above, and one-half with associated panel/circuit or system as described above.)

2.5 DEVICE COVER PLATE IDENTIFICATION

A. Description: Self-adhesive clear printed labels with Black typed letters (pre-printed, dot matrix, or laser).

B. Locations:

1. Each new receptacle cover plate.
2. Each existing receptacle cover plate in areas of remodel/renovation.

C. Legend:

1. Receptacle plates shall adequately describe its associated panelboard and circuit reference.
2. System plates shall adequately describe its terminal board, or terminal cabinet, termination cable identifier and assigned user code number.

2.6 UNDERGROUND WARNING TAPE

A. Description: 6 inch wide plastic tape, detectable type, colored red with suitable warning legend describing buried electrical lines, one strip per 24” of duct.

PART 3 - EXECUTION

3.1 PREPARATION

A. Degrease and clean surfaces to receive nameplates and labels.

3.2 APPLICATION

A. Install nameplate parallel to equipment lines.

B. Secure nameplate to equipment front using stainless steel pop rivets.

C. Secure nameplate to inside surface of door on panelboard that is recessed in finished locations.

D. Nameplates installed inside on dead front cover shall be self adhesive tape. (Do not drill or install screws in dead front.)

E. Identify new and existing conduit, junction boxes, and outlet boxes using field painting.

F. Identify new underground conduits using underground warning tape. Install one tape per 24 inches of trench at 3 inches below finished grade.

G. Install wire markers at all new and existing connections and terminations.

END OF SECTION 26 05 53

SECTION 26 05 73 – POWER SYSTEMS STUDY WITH ARC FLASH ANALYSIS

PART 1- GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Contractual Conditions and Division 01 Specification sections apply to this section.

1.2 SCOPE

A. The contractor shall furnish short-circuit and protective device coordination studies as prepared by the electrical equipment manufacturer or an approved engineering firm.

B. The contractor shall furnish an Arc Flash Hazard Analysis Study per the requirements set forth in NFPA 70E - Standard for Electrical Safety in the Workplace. The arc flash hazard analysis shall be performed according to the IEEE Std. 1584-2002 equations that are presented in NFPA70E-2009, Annex D.

C. The scope of the studies shall include all new distribution equipment supplied by the equipment manufacturer under this contract as well as all directly affected existing distribution equipment associated with the Project.

1.3 DESCRIPTION

A. Provide all labor, materials, and equipment necessary to properly and completely perform a Power Systems Study for the electrical distribution and control equipment and submit results in a report.

B. Electrical distribution and control equipment is to include all equipment installed under this contract and all existing equipment that this project is connecting to, complete from new equipment to existing power company transformer(s) via all applicable existing power distribution and control equipment.

C. Provide an up to date electrical system single-line diagram as required by NFPA 70E, "Standard for Electrical Safety in the Workplace," as referenced in OSHA 29 CFR 1910 Subpart S, Appendix A. This information shall include nameplate data for electrical components (e.g. transformers, medium voltage switchgear, panelboards, switchboards, motor control centers, etc.) for all portions of the electrical system from the utility intertie through the lowest rated panel~~.~~ or piece of equipment.

D. Cable sizes, types and lengths between electrical equipment components and up to date utility source data shall be provided for an accurate single-line representation of the electrical system. Unique characteristics of the equipment installation shall be provided which may impact the magnitude of the potential hazard (e.g. open space versus enclosure). Overcurrent device settings shall be verified.

E. Data collection may require removal of barriers, opening of front panels, etc. while equipment is energized. The Contractor must provide proof (written documentation) that its employees working on the premises of the Landside Building have been properly trained in the use and application of personal protective equipment (PPE) and the hazards of working on or near energized equipment.

The Contractor must provide its own PPE protection with a minimum arc thermal performance rating (ATPV) of 40 calories/cm2.

F. The contractor shall be responsible for obtaining all required data of all equipment.

G. The study shall verify adequacy of all equipment implemented under these specifications and to verify the correct application of circuit protective devices and other system components specified completely coordinated with the existing system.

H. A comprehensive analysis of the electrical system shall be performed for all equipment up to 480 volts and by a 125kVA or larger transformer based on the up to date single-line diagram provided from “Section A”. This analysis shall include the following:

1. Short Circuit Study – A short circuit analysis shall be performed in accordance with ANSI standard C37 and IEEE standard 141-1993 (Red Book) for each electrical component as defined in “Section A. “
2. Coordination Study – A coordination study shall be performed in accordance with IEEE 242-2001 “Buff” to determine the proper overcurrent device settings that will balance system reliability through selective coordination while minimizing the magnitude of an electrical arc flash hazard incident.
3. Incident Energy Study – An incident energy study shall be done in accordance with the IEEE 1584-2004a, ”IEEE Guide for Performing Arc Flash Hazard Calculations” as referenced in NFPA 70, “Standard for Electrical Safety in the Workplace”, latest revision, in order to quantify the hazard for selection of personal protective equipment (PPE). Tables that assume fault current levels and clearing time for proper PPE selection are not acceptable.

I. Reconcile arc flash protective device setting recommendations with the protective device time-current coordination study.

J. Adjust the System Design to optimize the results of the study as it relates to safety and reliable electrical system operation (e.g. overcurrent device settings, working distances, current limiting devices). This includes mitigation, where possible, of incident energy levels that exceed 40 calories/cm2. A qualified engineer with power systems design experience shall provide this assistance

K. The intent /goal of the protective system included herein is to establish arc flash levels that result in PPE levels of Category 2 or less.

L. Identify locations where Category 2 cannot be achieved.

M. The study shall address the case when the system is being powered from the normal source as well as from the on-site generating source.

N. Minimum as well as maximum possible fault conditions shall be covered in the study.

O. Fault conditions of all motors shall be considered.

1.4 REFERENCES

A. Institute of Electrical and Electronics Engineers, Inc. (IEEE):

1. IEEE 141 – Recommended Practice for Electric Power Distribution and Coordination of Industrial and Commercial Power Systems
2. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
3. IEEE 399 – Recommended Practice for Industrial and Commercial Power System Analysis
4. IEEE 241 – Recommended Practice for Electric Power Systems in Commercial Buildings
5. IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems.
6. IEEE 1584 - Guide for Performing Arc-Flash Hazard Calculations

B. American National Standards Institute (ANSI):

1. ANSI C57.12.00 – Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
2. ANSI C37.13 – Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures
3. ANSI C37.010 – Standard Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
4. ANSI C 37.41 – Standard Design Tests for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories.

C. The National Fire Protection Association (NFPA)

1. NFPA 70 - National Electrical Code, latest edition
2. NFPA 70E – Standard for Electrical Safety in the Workplace

1.5 SUBMITTALS FOR REVIEW/APPROVAL

A. The short-circuit and protective device coordination results shall be submitted prior to receiving final approval of the distribution equipment shop drawings and prior to release of equipment drawings for manufacturing. This preliminary submittal of study data shall be sufficient to ensure that the selection of device and characteristics will be satisfactory.

B. SUBMITTALS FOR CONSTRUCTION

C. The results of the short-circuit, protective device coordination and arc flash hazard analysis studies shall be summarized in a final report. For large system studies, submittals requiring more than five (5) copies of the report will be provided without the section containing the computer printout of the short-circuit input and output data. Additional copies of the short-circuit input and output data, where required, shall be provided on CD in PDF format.

D. For large system studies with more than 200 bus locations, the contractor is required to provide the study project files to the Owner in electronic format. In addition, a copy of the computer analysis software viewer program is required to accompany the electronic project files, to allow the Owner to review all aspects of the project and print arc flash labels, oneline diagrams, etc.

E. The report shall include the following sections:

1. Executive Summary.
2. Descriptions, purpose, basis and scope of the study
3. Tabulations of circuit breaker, fuse and other protective device ratings versus calculated

short circuit duties

4. Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip unit settings, fuse selection
5. Fault current calculations including a definition of terms and guide for interpretation of the computer printout
6. Details of the incident energy and flash protection boundary calculations
7. Recommendations for system improvements, where needed
8. One-line diagram

F. Arc flash labels shall be provided in hard copy ~~only. For large system studies (more than 200 bus locations) arc flash labels shall be provided in hard copy~~ and label images shall be provided in electronic format. Vinyl arc flash labels shall be placed on all pieces of equipment. Separate vinyl label shall show available fault current, date of calculation, and contact information for all panels/switchboards.

G. Report shall include:

1. Available fault current at each equipment location with comparison to equipment rating
2. Overcurrent device settings (e.g. pick-up, time delay, curve), “as found” and “as recommended”
3. Incident energy level (calories/cm2) for each equipment location and recommended PPE
4. Overcurrent device coordination curves including related section of the single-line diagram
5. List of prohibited energized work locations based on arc flash results.

1.6 QUALIFICATIONS

A. The short-circuit, protective device coordination and arc flash hazard analysis studies shall be conducted under the supervision and approval of a Registered Professional Electrical Engineer skilled in performing and interpreting the power system studies.

B. The Registered Professional Electrical Engineer shall be a full-time employee of the equipment manufacturer or an approved engineering firm.

C. The Registered Professional Electrical Engineer shall have a minimum of five (5) years of experience in performing power system studies.

D. The equipment manufacturer or approved engineering firm shall demonstrate experience with Arc Flash Hazard Analysis by submitting names of at least ten actual arc flash hazard analysis it has performed in the past year.

1.7 COMPUTER ANALYSIS SOFTWARE

A. The studies shall be performed using the latest revision of the SKM Systems Analysis Power*Tools for Windows (PTW) software program or prior approved equal.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 STUDIES

A. Contractor to furnish short-circuit and protective device coordination studies as prepared by equipment manufacturer or an approved engineering firm.

B. The contractor shall furnish an Arc Flash Hazard Analysis Study per NFPA 70E - Standard for Electrical Safety in the Workplace, reference Article 130.3 and Annex D.

3.2 DATA COLLECTION

A. Contractor shall furnish all data as required by the power system studies. The Engineer performing the short-circuit, protective device coordination and arc flash hazard analysis studies shall furnish the Contractor with a listing of required data after award of the contract. The Contractor shall expedite collection of the data to assure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to the release of the equipment for manufacturing.

B. Source combination shall include present and future motors and generators.

C. Load data utilized may include existing and proposed loads obtained from Contract Documents provided by Owner, or Contractor when available.

D. Include fault contribution of existing motors in the study. The Contractor shall obtain required existing equipment data, if necessary, to satisfy the study requirements.

3.3 SHORT-CIRCUIT AND PROTECTIVE DEVICE EVALUATION STUDY

A. Use actual conductor impedances if known. If unknown, use typical conductor impedances based on IEEE Standard 141-1993.

B. Minimum transformer design impedances shall be used when test impedances are not available.

C. Provide the following:

1. Calculation methods and assumptions
2. Selected base per unit quantities
3. One-line diagram of the system being evaluated
4. Source impedance data, including electric utility system and motor fault contribution characteristics
5. Tabulations of calculated quantities
6. Results, conclusions, and recommendations.

D. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each:

1. Electric utility’s supply termination point
2. Incoming switchgear
3. Unit substation primary and secondary terminals

4. Low voltage switchgear
5. Motor control centers
6. Standby generators and automatic transfer switches
7. Branch circuit panelboards
8. Other significant locations throughout the system.

E. 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.

F. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short circuit ratings
2. Adequacy of switchgear, motor control centers, and panelboard bus bars to withstand short-circuit stresses
3. Notify Owner in writing, of existing, circuit protective devices improperly rated for the calculated available fault current.

3.4 PROTECTIVE DEVICE COORDINATION STUDY

A. Proposed protective device coordination time-current curves (TCC) shall be displayed on log-log scale graphs.

B. Include on each TCC graph, a complete title and one-line diagram with legend identifying the specific portion of the system covered.

C. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.

D. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.

E. Plot the following characteristics on the TCC graphs, where applicable:

1. Electric utility's overcurrent protective device
2. Medium voltage equipment overcurrent relays
3. Medium and low voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands
4. Low voltage equipment circuit breaker trip devices, including manufacturer's tolerance bands
5. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves
6. Conductor damage curves
7. Ground fault protective devices, as applicable
8. Pertinent motor starting characteristics and motor damage points, where applicable
9. Pertinent generator short-circuit decrement curve and generator damage point
10. The largest feeder circuit breaker in each motor control center and applicable panelboard.

F. Provide adequate time margins between device characteristics such that selective operation is provided, while providing proper protection.

3.5 ARC FLASH HAZARD ANALYSIS

A. The arc flash hazard analysis shall be performed according to the IEEE Std. 1584-2002 equations that are presented in NFPA70E-2009, Annex D.

B. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (switchboards, switchgear, motor-control centers, panelboards, busway and splitters) where work could be performed on energized parts.

C. The Arc-Flash Hazard Analysis shall include all significant locations in 240 volt and 208 volt systems fed from transformers equal to or greater than 125 kVA where work could be performed on energized parts.

D. Safe working distances shall be based upon the calculated arc flash boundary considering an incident energy of 1.2 cal/cm2.

E. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Ground overcurrent relays should not be taken into consideration when determining the clearing time when performing incident energy calculations

F. The short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios must be compared and the greatest incident energy must be uniquely reported for each equipment location. Calculations must be performed to represent the maximum and minimum contributions of fault current magnitude for all normal and emergency operating conditions. The minimum calculation will assume that the utility contribution is at a minimum and will assume a minimum motor contribution (all motors off). Conversely, the maximum calculation will assume a maximum contribution from the utility and will assume the maximum amount of motors to be operating. Calculations shall take into consideration the parallel operation of synchronous generators with the electric utility, where applicable.

G. The incident energy calculations must consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations must take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators should be decremented as follows:

1. Fault contribution from induction motors should not be considered beyond 3-5 cycles.
2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g. contributions from permanent magnet generators will typically decay from 10 per unit to 3 per unit after 10 cycles).

H. For each equipment location with a separately enclosed main device (where there is adequate separation between the line side terminals of the main protective device and the work location), calculations for incident energy and flash protection boundary shall include both the line and load side of the main breaker.

I. When performing incident energy calculations on the line side of a main breaker (as required per above), the line side and load side contributions must be included in the fault calculation.

J. Mis-coordination should be checked amongst all devices within the branch containing the immediate protective device upstream of the calculation location and the calculation should utilize the fastest device to compute the incident energy for the corresponding location.

K. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE Std. 1584-2002 section B.1.2. Where it is not physically possible to move outside of the flash protection boundary in less than 2 seconds during an arc flash event, a maximum clearing time based on the specific location shall be utilized.

3.6 REPORT SECTIONS

A. Input data shall include, but not be limited to the following:

1. Feeder input data including feeder type (cable or bus), size, length, number per phase, conduit type (magnetic or non-magnetic) and conductor material (copper or aluminum).
2. Transformer input data, including winding connections, secondary neutral-ground connection, primary and secondary voltage ratings, kVA rating, impedance, % taps and phase shift.
3. Reactor data, including voltage rating, and impedance.
4. Generation contribution data, (synchronous generators and Utility), including short-circuit reactance (X'd), rated MVA, rated voltage, three-phase and single line-ground contribution (for Utility sources) and X/R ratio.
5. Motor contribution data (induction motors and synchronous motors), including short-circuit reactance, rated horsepower or kVA, rated voltage, and X/R ratio.

B. Short-Circuit Output Data shall include, but not be limited to the following reports:

1. Low Voltage Fault Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable location:

   a) Voltage
   b) Calculated fault current magnitude and angle
   c) Fault point X/R ratio
   d) Equivalent impedance

2. Momentary Duty Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable 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

e) Equivalent impedance

3. Interrupting Duty Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable 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

C. Recommended Protective Device Settings:

1. Phase and Ground Relays:

a) Current transformer ratio
b) Current setting
c) Time setting
d) Instantaneous setting
e) Recommendations on improved relaying systems, if applicable.

2. Circuit Breakers:

a) Adjustable pickups and time delays (long time, short time, ground)
b) Adjustable time-current characteristic
c) Adjustable instantaneous pickup
d) Recommendations on improved trip systems, if applicable.

D. 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. Working distance
6. Incident energy
7. Hazard risk category
8. Recommendations for arc flash energy reduction

3.7 FIELD ADJUSTMENT

A. Adjust relay and protective device settings according to the recommended settings table provided by the coordination study. Field adjustments to be completed by the contractor and/or electrical equipment manufacturer’s field service personnel.

B. Make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.

C. Notify Owner in writing of any required major equipment modifications.

3.8 ARC FLASH WARNING LABELS

A. The contractor of the Arc Flash Hazard Analysis shall provide a 3.5 in. x 5 in. thermal transfer type label of high adhesion polyester for each work location analyzed.

B. All labels will be based on recommended overcurrent device settings and will be provided after the results of the analysis have been presented to the owner and after any system changes, upgrades or modifications have been incorporated in the system.

C. The label shall include the following information, at a minimum:

1. Location designation
2. Nominal voltage
3. Flash protection boundary
4. Incident energy or energy range corresponding to reported Hazard risk category.
5. Working distance
6. Engineering report number, revision number and issue date.

D. Labels shall be machine printed, with no field markings.

E. Arc flash labels shall be provided in the following manner and all labels shall be based on recommended overcurrent device settings.

1. For each 600, 480 and applicable 208 volt panelboard, at least one arc flash label shall be provided.
2. For each motor control center, one arc flash label shall be provided.
3. For each switchboard, one arc flash label shall be provided.
4. For each main switchboard with Utility Service, one flash label shall be provided for each section.

F. Labels shall be field installed by the contractor.

3.9 ARC FLASH TRAINING

A. The contractor of the Arc Flash Hazard Analysis shall train the owner’s qualified electrical personnel of the potential arc flash hazards associated with working on energized equipment (minimum of 4 hours). The training shall be certified for continuing education units (CEUs) by the International Association for Continuing Education Training (IACET) or equivalent.

END OF SECTION 26 05 73

SECTION 26 05 83 - WIRING DEVICES

PART 1- GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Contractual Conditions and Division 01 Specification sections apply to this section.

1.2 SUMMARY

A. This section includes the requirements for provision and installation of wiring devices.

1.3 DESCRIPTION

A. Provide and install all equipment, labor, material, accessories, and mounting hardware for a complete and operating system for the following:

1. Wall switches.
2. Wall dimmers.
3. Receptacles.
4. Device plates and decorative box covers.

1.4 SUBMITTALS

A. Submit Product Data: Provide manufacturer's catalog information showing dimensions, colors, and configurations including all types of wiring devices, plates and engraving.

B. Submit Manufacturer's Instructions:

1. Indicate application conditions and limitations of use stipulated by product testing agency specified under regulatory requirements.
2. Include instructions for storage, handling, protection, examination, preparation, operation and installation of product.

1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum five years experience.

1.6 REFERENCES AND REGULATORY REQUIREMENTS

A. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for purpose specified and shown.

B. Conform to the requirements of the following:

1. ANSI/NFPA 70 - National Electrical Code
2. NEMA WD 1 - General Color Requirements for Wiring Devices.
3. NEMA WD 6 - Wiring Devices Dimensional Specifications.
4. UL 20 - General Use Snap Switches
5. UL 498 - Standard For Attachment Plugs and Receptacles
6. UL 1472 - Solid State Dimming Controls

1.7 EXTRA MATERIALS

A. Provide a minimum of two (2) screw drivers of each type of tamper proof screw used on project. Turn over to OAR. Include receipt in O&M manual.

PART 2 - PRODUCTS

2.1 GENERAL

A. All devices shall be Specification Grade as minimum.

B. General and Special purpose wiring devices shall meet NEMA standard WD 1 and WD 6.

C. All wiring devices shall bear UL labels.

D. All devices of one type shall be by the same Manufacturer.

1. "Hazardous Location" and special purpose devices as may not be available from the same manufacturer shall constitute the only exception to this requirement of single source.

E. Corrosion resistant devices shall be as specified for normal usages, and fabricated of yellow color melamine plastic. Where "Weatherproof" type is indicated for exterior or wet locations, provide matching self-closing cover, with gasketed seals at plate/wall junctions and for cover.

1. Provide factory packaged wiring devices having high impact strength molded plastic bodies.

F. Except where specifically required, the use of interchangeable type or combination switch-receptacle-pilot devices are not acceptable.

2.2 WALL SWITCHES

A. General:

1. Snap switches for general use shall be maintained contact types, and shall be single-pole, double-pole, three-way, or four-way as required for the specific switching arrangements shown on the drawings. They shall be quiet tumbler operation types, having silver alloy contacts, and meeting all NEMA performance standards. Color to match plates unless specifically noted otherwise.
2. Switches shall be toggle or key-operated types, as indicated on the drawings. All key-operated switches shall be keyed alike.
3. Where switches are denoted as having pilot lights, pilot lights shall glow when the switches are "ON". Provide pilot light switch with lamp and miniature step-down transformer. The pilot light shall have a red lens, and the lamp shall be long-life type.

4. Jewels for use with switches controlling motors shall be green, and jewels for other purposes shall be amber. All units shall be front relampable.
5. Snap switches installed in hazardous locations shall be UL listed for the type of location (class and division).
6. Switches connected to emergency power shall have red lighted handles which shall illuminate when the switches are "Off".
7. Voltage and ampere rating of switches shall be marked on switch, and shall conform to voltage of system to which applied.
8. Switches shall have back and side wired screw pressure terminals.

B. Description: Heavy-duty, AC only general-use snap switch.

C. Voltage Rating: 120-277 volts, AC.

D. Current Rating: 20 amperes minimum.

E. Ratings: Match branch circuit and load characteristics.

F. Regulatory Requirements: Comply with applicable NEMA and UL standards/requirements including UL 20 and NEMA WD 1 and 6.

2.3 WALL DIMMERS

A. Description: Semiconductor dimmer for incandescent lamps, type as indicated on Drawings.

B. Device Body: Present, linear slide as called for on drawings.

C. Voltage: 120 volts or 277 volts as required to match application.

D. Power Rating: Match load shown on Drawings; 600 Watts minimum.

E. Accessory Wall Switch:

1. Match dimmer appearance.

F. Same manufacturer and style as dimmer switch.

G. Regulatory Requirements: Comply with applicable NEMA and UL standards/requirements including UL 1472

2.4 RECEPTACLES

A. General:

1. All receptacles shall be of standard NEMA configuration, as indicated on the drawings, and shall comply with the respective ANSI C73 series standard for the NEMA configuration. Color to match plates unless specifically noted otherwise.
2. Duplex receptacles shall have integral UL listed self-grounding clips. Similar, single receptacles shall be provided for plug-in connections of industrial fluorescent light fixtures on the same switching circuit. Receptacle face to be impact resistant nylon.

3. Weatherproof duplex receptacles shall be provided in all exterior locations, and shall be Ground Fault Circuit Interrupting (GFCI) types, with weatherproof stainless steel cover plates.
4. Special purpose receptacles for specific equipment shall be grounding types, having the number of poles, voltage and ampere ratings, and NEMA configurations required by the equipment. For each special purpose receptacle, provide an identical mating plug equipped with cord grip, secured to cord.
5. Duplex receptacles shall have back and side wired screw pressure terminals.
6. Receptacles to be installed in shower rooms, locker rooms, toilet rooms, janitors closets, exterior, elevator pit and machine rooms, escalator pits, within six (6) feet of a sink, and other areas as required by NEC, and OSHA Standards shall be ground fault circuit interrupting (GFCI) type, whether specified or not.
7. Receptacles installed for water coolers shall be GFCI type, or a single receptacle as permitted by NEC.

B. Description: Heavy-duty general use receptacle.

C. Configuration: Heavy-duty, general use type as specified and indicated.

D. Convenience Receptacle: NEMA Type 5-20.

E. GFCI Receptacle: Convenience receptacle with integral ground fault circuit interrupter, and automatic “self-testing feature” to meet regulatory requirements.

F. Controlled Receptacle: Convenience receptacle automatically controlled with NEMA approved controlled receptacle marking pad printed on the face of receptacle for superior abrasion resistance. Half or dual controlled.

G. Regulatory Requirements: Comply with applicable NEMA and UL standards/requirements including UL 498 and NEMA WD 1 and 6.

2.5 COVER PLATES

A. All wiring devices shall be provided with standard size one-piece cover plates of suitable configuration for the number and type of devices to be covered.

B. Metallic cover plates shall be used in interior spaces, except as noted below, and shall be fabricated of corrosion-resistant #302 stainless steel, having a nominal thickness of .04", and a brushed finish. Screws securing the plates shall have flush (when installed) heads with finish to match plates. Metallic cover plates shall meet all requirements of the National Electrical Code and Federal Specifications.

C. Cover plates for switches located in corrosive atmospheres (where vaporproof is not indicated) shall consist of a one piece neoprene boot with matching presswitch.

D. Cover plates for exterior receptacles shall be gasketed covers with hinge allowing plug and cord to be plugged in and activated with cover closed..

E. Cover plate engraving, where required, shall be accomplished by cover plate manufacturer in accordance with instructions given on the drawings. Metallic plates and nylon plates in ivory, beige, gray, and white shall be engraved with black fill. Red, brown, and black nylon plates shall be engraved with white fill.

F. Plates for devices connected to emergency power shall be as specified for devices connected to normal circuits, but shall be engraved reading "Emergency", see drawings for other engraving requirements.

G. Plates for devices connected to computer power panels shall be engraved reading “Computer”. Devices connected to emergency computer power panels shall be red in color.

H. Plates for devices connected to UPS power systems shall be as specified for devices connected to normal circuits, but shall be engraved reading "UPS POWER", see drawings for other engraving requirements.

I. Unless specifically noted otherwise in specs or on drawings all outlets for telephone and other communications and data systems shall be provided with standard size one-piece cover plates having a minimum 3/4 inch diameter, with bushing, in the center unless specifically noted otherwise. Where telephone conductors are installed, plates shall contain telephone type, polarized plug-in receptacles.

J. Device plates located in secure areas, as noted on drawings, shall have security wall plates (10 gauge) with 12 gauge galvanized steel backplate. All device plates shall have tamperproof screws.

K. Regulatory Requirements: Comply with applicable NEMA and UL standards/requirements

2.6 COLOR

A. Wiring devices connected to normal power shall be gray unless specifically noted otherwise.

B. All devices and coverplates in paneled walls shall have finish to match paneling.

C. Devices connected to emergency power shall be red color. (Including devices connected to emergency computer power panels).

D. Devices connected to separate computer power panels shall be black in color.

E. Modify any given catalog numbers as required to procure devices and plates of the proper color.

F. Devices connected to UPS systems shall be orange (isolated ground).

G. Regulatory Requirements: Comply with applicable NEMA and UL standards/requirements

2.7 FLUORESCENT DIMMERS

A. Dimmers shall be electronic type and include a remote control where required. Special dimming ballasts shall be included on fixtures to be dimmed. Ballasts shall be compatible with dimmer being provided.

B. Regulatory Requirements: Comply with applicable NEMA and UL standards/requirements

2.8 LED DIMMERS

A. Dimmers shall be electronic and compatible with light fixtures and drivers provided.

B. Regulatory Requirements: Comply with applicable NEMA and UL standards/requirements

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify outlet boxes are installed at proper height.

B. Verify wall openings are neatly cut and will be completely covered by wall plates.

C. Verify floor boxes are adjusted properly.

D. Verify branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.

3.2 PREPARATION

A. Provide extension rings to bring outlet boxes flush with finished surface.

B. Clean debris from outlet boxes.

3.3 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Install devices plumb and level.

C. Install switches with OFF position down.

D. In general. lighting control switches shall be located at the lock/strike plate side of door(s). If the drawings indicate otherwise, issue a request for clarification prior to rough-in.

E. Install wall dimmers to achieve full rating specified and indicated after derating for ganging as instructed by manufacturer.

F. Do not share neutral conductor on load side of dimmers.

G. Install receptacles with grounding pole on bottom.

H. Where 2 or more switches or receptacles are to be installed adjacent to one another, provide a multi-gang coverplate. Provide proper NEC barriers in boxes which serve devices for both the Normal and Emergency Systems or a combined system voltage of 480 volt.

I. Provide device coverplates for every device installed. Cover plates shall be installed so that they appear straight with no gaps between plate edges and the wall. Maintain vertical and horizontal to within 1/16 of an inch.

J. In finished areas, provide same type of plate for all surface mounted devices as for recessed mounted devices.

K. In any room, where new and existing construction is present, all receptacles, switches, and coverplates which are existing to remain shall be changed, to match new work.

L. Wiring devices shall not be installed in exposed masonry until cleaning of masonry with acids has been completed.

M. All receptacles and switches shall be grounded by means of a ground wire from device ground screw to outlet box screw and branch circuit ground conductor. Strap alone will not constitute an acceptable ground.

N. All wiring devices, relays, contactors, pushbuttons, selector switches, pilot lights, etc. shall be installed in approved enclosures rated for the appropriate NEMA classified environment.

O. All devices shall be installed so that only one wire is connected to each terminal.

P. Once construction is substantially completed, replace all damaged, burned, or scorched wiring devices.

Q. Receptacles shown to be floor mounted shall be installed in floor boxes (with coverplates) which are approved for this use.

R. Connect wiring devices by back wiring conductor into compression terminal.

S. Install protective rings and split nozzle on active flush cover service fittings.

3.4 NEUTRAL CONDUCTOR CONNECTIONS

A. At each receptacle "in" and "out" phase and neutral conductors shall have an additional conductor “pigtail” for connection to device. The practice of "looping" conductors through receptacle boxes shall not be acceptable.

B. Provide and install a neutral conductor for each circuit in all wall switch outlet locations.

3.5 INTERFACE WITH OTHER PRODUCTS

A. Coordinate locations of outlet boxes to obtain specified mounting heights.

3.6 FIELD QUALITY CONTROL

A. Inspect each wiring device for defects.

B. Operate each wall switch with circuit energized and verify proper operation.

C. Verify that each receptacle device is energized.

D. Test each receptacle device for proper polarity.

E. Test each GFCI receptacle device for proper operation.

3.7 ADJUSTING

A. Adjust devices and wall plates to be flush and level.

END OF SECTION 26 05 83

SECTION 26 07 17- SCADA MONITORING AND CONTROL SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies the furnishing, installation, connection and testing of the SCADA Monitoring and Control System.

1.2 RELATED WORK

A. Section 26 05 26, Grounding and Bonding for Electrical Systems

B. Section 26 32 18, Engine Generators

C. Section 26 23 00, Low Voltage Transfer Switchgear

D. Section 26 23 25, Medium-Voltage Emergency Switchgear

1.3 QUALITY ASSURANCE

A. System Responsibility:

1. All equipment specified in this section shall be provided by the Medium-Voltage Switchgear and Controls supplier (as detailed in spec section 26 23 25) to provide for a fully coordinated power system and single source responsibility. The supplier shall be responsible for all coordination of this entire scope including~~,~~ technical interfacing, interconnects, scheduling, testing, training, and documentation.

B. Factory Testing:

1. The 12.47KV Emergency Switchgear lineups shall be manufactured together with the Low Voltage Transfer Switchgear lineups and SCADA System specified herein to provide for single source responsibility for the primary power management system. A complete factory witness test and demonstration shall be performed with ALL of these lineups and components connected to simulate an installed operation. Representatives of the Owner and engineers shall be invited to attend a formal demonstration of the entire system at the factory and prior to shipment to site. Any defects or corrections identified by the Owner's representatives during this witness test shall be corrected and re-demonstrated prior to shipment.
2. The Owner and/or its appointed representatives shall have an option to witness the factory tests. Switchgear and Controls System vendor shall cover all transportation and living expenses for six (6) persons to attend comprehensive factory witness testing prior to shipment. Notify the Owner through the Engineer not less than 30 days prior to making witness tests at the factory.

D. Field Testing:

1. Field tests shall be in accordance with IEEE C37.09 and shall include the following:
   a) Tests After Delivery

b) Field Tests

E. Warranty:

1. All switchgear, controls and SCADA system shall be covered by a 2-year full coverage warranty. Warranty shall commence 6 months after shipment or upon successful completion of startup, commissioning, demonstration and acceptance by the Owner and Engineer, whichever occurs first. Warranty shall cover all parts and on-site labor to repair and/or replace any defective component.

F. SCADA System:

1. System shall be supplied by the manufacturer of the Generator Medium Voltage Switchgear and Controls and as specified in this section.
2. Manufacturer must be able to demonstrate previous experience implementing a site wide SCADA system supporting a central power plant, multiple remote buildings, and major electrical infrastructure. Experience must include a minimum of five (5) previous projects of identical or similar scope as defined herein, including a comprehensive simulator for operator training. Supplier will be required to provide proof of previous experience as a condition for acceptance including project name, description of scope, examples of graphic screens provided for each screen type specified herein, name and phone number of user contact for five (5) projects.
3. SCADA system must be able to completely integrate with various manufacturers of equipment including but not limited to switchgear controls, PLCs, generators, transfer switchgear, digital protective relays, breaker trip units and digital metering/monitoring systems.

1.4 SUBMITTALS: In accordance with Division 26 Section, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, submit the following:

A. SCADA System Shop Drawings and Submittals: Prior to ordering and installation, submit engineering shop drawings and equipment technical information sheets on the SCADA for review by the Engineer. The Shop Drawings and submittal shall be of sufficient detail that they enable the Owner and Engineer to determine if all requirements of the Contract Documents are being met.

1. Shop Drawing and Submittals shall include sufficient detail to enable the design, manufacture, installation and commissioning of all components of the SCADA, including hardware and software, in accordance with the requirements of the Contract Documents.
2. Shop Drawing and Submittals shall comprise all drawings, schematics, equipment schedules, equipment specification sheets, printed descriptions, examples of each screen graphic (color) with detailed description and information in other forms as necessary to fully represent the work to be undertaken by the Contractor.
3. Shop Drawings and Submittals shall include information on all hardware and software elements of the SCADA including, at minimum, the following:
   a) SCADA network architecture schematics showing the interconnection of all PLCs, Workstation Computers, Automatic Transfer Switchgear, 15 KV Switchgear, and devices contained therein.
   b) Full technical specifications for all items of equipment to be furnished under this Contract including quantities and dimensions.
   c) Complete information regarding the installation of all equipment.
   d) Descriptions of all software, firmware and applications packages furnished under this Contract.
   e) Narrative of all sequences of operation.

f) Complete information on wiring to be provided under this Contract including, at minimum, details of cable function, cable type, cable size, coloring coding and identification.
g) Descriptions and diagrams of software and hardwired interlocks.
h) Representation of each screen as specified herein in full color.
i) Equipment ~~Naming~~naming convention spreadsheet listing each: Building, Switchgear, Device, Feeder, Alarm point.
j) Alarm convention spreadsheet listing each: Alarm, Warning, Time-Date Stamp.
k) Automated Load Bank Testing

C. A submittal review conference will be held at the manufacturer's facility. The Contractor, SCADA factory representative, Engineer and Owner shall be in attendance.

D. Provide "as-built" record documents for the entire system suitable for instruction, operation, procurement, installation and maintenance. Include descriptions of all unique devices, circuitry, software or applications.
1. Periodically update all documentation in order to reflect all SCADA changes made during design, construction, and commissioning.
2. All SCADA changes made during testing shall be incorporated into the final record documents.

E. Emergency Power Supply System Controls: Submit a complete sequence of operation for the entire system. The sequence of operation shall be specific for this project and include all functions of the system (i.e. single utility failure, two or more utility failures, site wide outage, load testing, load demand, load shed, manual operation, load bank testing, etc.) generic control sequences are not acceptable. Include all set points for the generator load demand mode.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by the basic designation only.

C37.55-89	Switchgear-Metal-Clad Switchgear Assemblies Conformance Test Procedures
C39.1-81	Electrical Analog Indicating Instruments,
C37.20.2-99	Standard for Metal-Clad Switchgear
C37.90-89	Standard for Relays and Relay Systems Associated with Electric Power Apparatus
C57.13-93	Standard Requirements for Instrument Transformers

Elements in Metal-Enclosed Switchgear Assemblies - Conformance Test Procedures

LA 1-92	Surge Arrestors
SG 4-00	Alternating-Current High-Voltage Circuit Breakers
NFPA 70	National Electrical Code (NEC)

PART 2 - PRODUCTS

2.1 DESCRIPTION-SCADA SYSTEM

A. This Section specifies the requirements for the following elements of the Supervisory Control and Data Acquisition System (herein referred to as the SCADA) which are to be provided as part of this Contract:
   1. Central Workstations.
   2. Programmable Logic Controllers, remote I/O modules, Ethernet modules.
   3. Software and firmware as necessary to perform the monitoring, control and other functions as specified.
   4. Communications Networks, Ethernet / Fiber Optic.
   5. Interfaces between the SCADA and the Medium and Low Voltage Transfer Switchgear, Generator Sets and Auxiliary Systems.
   6. Simulator System.
   7. Owner training.
   8. Record documentation.

B. Refer to contract drawings for additional information on equipment locations, routings, and diagrams.

2.2 SYSTEM OVERVIEW

A. The SCADA system shall consist of an integrated network of a Server PC, Operator Workstations, Operator Interface Terminals, Mimic PC's, Remote I/O and networking hardware as shown on the SCADA drawings.

B. All hardware, software and accessory equipment shall be consistent throughout the system.

C. The SCADA communication network shall pass data in digital format only using token-passing protocols.

D. The SCADA shall be configured such that all PLC monitoring and control functions are maintained in the event of workstation computer component failure, including the transfer of data from PLC.

2.3 OPERATOR WORKSTATIONS (OWS)

A. The Operator Workstations shall each be comprised of a computer, together with Operator terminals, i.e. printers, monitors, and communication devices. Each OWS shall be a fully integrated node on the SCADA network. One OWSs shall be located in the Switchgear Control Room and one OWS shall be located in the Engineering Office. The OWS (located in the Switchgear Control Room) shall serve as the server. The remaining OWSs shall be clients. All OWS shall include:
   1. 24" LCD Color Monitor (16 x 9 aspect ratio)
   2. Alarm printer (total of two (2) shared by both OWS at each location)
   3. Report printer (total of two (2) shared by both OWS at each location)
   4. Ethernet network communications
   5. Keyboard
   6. Mouse

B. Each workstation computer shall consist of a computer-based central processing unit together with the associated storage, operational, arithmetic, interfacing, power conditioning, operator communication and software facilities, as required to meet the requirements of these Contract Documents.

C. Each workstation computer, at minimum, shall provide the following services to the SCADA networked configuration:

1. Storage, analysis and presentation of data and information.
2. Operator capability to modify, add and delete workstation computer and PLC database elements, schedules and displays, etc.
3. Real-time observation of events monitored and controlled by the SCADA, which require workstation computer involvement in the annunciation and/or archiving of these events when applicable.

D. The server computer provided shall be a computer system as required to meet the requirements of the Contract Documents and, at minimum, shall be comprised the following (NOTE: this is a minimum standard, supplier is responsible to select equipment capable of the performance required in these specifications):
1. Dual Quad Core Xeon E544 Intel CPUs with minimum 2.83 GHz clock speed.
2. Minimum 16 Gbyte SDRAM memory
3. (2) 500 GB, 7200 RPM Hard Disk Drive
4. Ethernet Port 1 GB
5. 512MB nVidia Quadro FX1700, dual monitor DVI capable graphics card
6. Internal chassis speaker with audio output
7. 16x DVD-ROM, Cyberlink Power DVD8.1
8. Microsoft Windows Server
9. USB Keyboard, USB optical mouse

E. The OWS client computers provided shall be a personal computer system as required to meet the requirements of the Contract Documents and, at minimum, shall be comprised the following:
1. Core 2 Duo E8500 Intel CPUs with minimum 3.16 GHz clock speed.
2. Minimum 4 Gbyte SDRAM memory
3. (2) 73 GB, 3.0 Gbps, 15k RPM Hard Disk Drives
4. Ethernet Port 1 GB
5. 256MB nVidia NVS 290, dual monitor DVI capable graphics card
6. Audio output port
7. 48x CD-RW/DVD-ROM, Cyberlink Power DVD
8. Microsoft Windows Server 2008
9. USB Keyboard, USB optical mouse

2.4 MIMIC PANEL PC

A. The mimic client computers provided shall be a personal computer system as required to meet the requirements of the Contract Documents and, at minimum, shall be comprised the following:
1. Core 2 Duo E8500 Intel CPUs with minimum 3.16 GHz clock speed.
2. Minimum 2 Gbyte SDRAM memory
3. (2) 80 GB, 3.0 Gbps, with NCQ and 8MB DataBurst Cache
4. Ethernet Port 1 GB
5. 256MB nVidia NVS 290, dual monitor DVI capable graphics card
6. Audio output port
7. 48x CD-RW/DVD-ROM, Cyberlink Power DVD
8. Microsoft Windows latest edition
9. MX3200 cordless laser Keyboard and mouse

B. The Mimic PC will drive a 42” monitor located in each Switchgear Control lineup. The monitor shall be LCD flat panel, 1280 x 1024 resolution, 120 VAC.

2.5 OPERATOR INTERFACE TERMINALS (OIT)

A. The Operator Interface Terminals (located within each Master cubicle in the Switchgear Controls) shall be a client to the SCADA and shall consist of the following:

1. 21” color touch screen panel
2. Intel Pentium CPU, 1.1 GHz
3. 1 GB RAM
4. 40 GB Hard Drive
5. Windows XP

B. The OITs shall be networked such that any loss in communications with the SCADA SHALL NOT affect the ability of the OITs to continue to communicate with the Switchgear Control PLCs and perform all functions associated with control, monitoring and graphic displays of the Normal and Emergency Switchgear.

C. Loss of communication with the SCADA shall only result in the loss of the ability to display those graphical screens that rely on data input from the remote SCADA SRTC’s.

2.6 WORKSTATION PERIPHERALS

A. Provide a color laser report printer, shared at each of two locations (Gen CEP Control room and Engineering Office), that meets the following specifications:
   1. Minimum print speed of 8 pages per minute.
   2. Adjustable fonts and scaling.
   3. Operated via a standard parallel, USB or network interface.
   4. Printer shall accept screen dumps including graphics from associated monitor in black and white and in color as selected by the Operator.

B. Provide a monitor for each workstation that shall meet the following specifications:
   1. Minimum screen diagonal measurement as listed above.
   2. Capable of displaying both schematic and alphanumeric data at the same time.
   3. Minimum of two hundred fifty-six (256) discrete colors shall be available for display selection.

C. Provide a local self-contained UPS module to provide backup power for each SCADA workstation/monitor.

2.7 SCADA REMOTE COMMUNICATIONS

A. Provide status input monitoring and control of all the points as identified in the SCADA Points List. Refer to the Drawings for system architecture. All communications shall be via either Ethernet/Fiber Optic and/or RS 232/485 communications integrated into the SCADA network or hard-wired directly to a network connected redundant PLC I/O card within a switchgear cubicle. Provide Ethernet switch, serial to Ethernet bridges, fiber patch panel, fiber-to-copper media converter, interconnecting cabling, power supplies, and wiring terminations for field connections.

C. The system shall consist of components designed specifically for the environment that the system is to be installed.

D. All components of the controllers and modules shall be identified using permanent labels which indicate the manufacturer's catalog number, product manufacturing date code, UL and CSA certifications and are cross referenced on the as-built wiring diagrams. Provide complete wiring diagrams of the controllers or monitoring modules.

E. Power for the Scada Communication components shall be from local critical branch 120v, 20amp circuits to rack mounted UPS modules as specified. Provide sufficient receptacle output for each piece of equipment served.

F. Terminal blocks shall be easily removable, and common to all discrete and analog I/O to allow for convenient pre-wiring of field devices. Each I/O module shall contain a hinged, clear plastic, terminal block cover (door) with a removable label. The inside of the label shall have the module description, catalog number, and circuit wiring diagram for that module type, and the outside of the label shall have a user legend space to record circuit identification information.

G. The SCADA communications network shall be separate from the PLC control network.

2.8 COMMUNICATION NETWORK

A. Provide all communication and control wiring as required by the SCADA system. All communication wiring shall be installed in dedicated conduits.

B. Communication between switchgear PLC's and each workstation computer shall be at a minimum transmission speed of 153 kbaud.

C. The SCADA communication networks shall be Ethernet / Fiber Optic. All communication wiring external to each building shall be fiber optic. Signals and data within a specific building can be copper wire. Serial Modbus to Ethernet bridges shall be provided as necessary. Ethernet switches shall be equipped with the necessary number of ports, including fiber optic ports as needed for all building to building transmissions. All devices shall be DC powered from 2 sources (A&B). The local DC supplies shall be powered by the local UPS.

D. SCADA network communications shall utilize Modbus TCP Ethernet protocol and allow the facility power management system to communicate with Circuit Monitors, Power Meters, protective relays, trip units, and engine generator set controllers.

2.9 INTERFACE BETWEEN SCADA AND GENERATOR SET, AND SWITCHGEAR SYSTEMS

A. As part of this contract, interface Control Switchgear PLC’s with SCADA System such that all data and screens available at the switchgear OITs can also be viewed on the SCADA workstations. This integration shall include all points, database and graphical display information as detailed herein.

B. All engine generator monitoring points and alarms shall be interfaced with the SCADA System.

2.10 SCADA SOFTWARE

A. Where reference is made to functions that can be performed by an Operator, these functions shall be protected by multi-level password access control.

B. All operator monitoring and/or control procedures shall be graphical and user interactive. Procedures shall not require a knowledge or previous use of the SCADA control language.

C. Provide Operator definable analog input engineering unit alarms on a per point basis. These shall comprise, at minimum; input high alarm limit, approach input high alarm limit, input low alarm limit, approach input low alarm limit and defective sensor. All alarm set points shall be capable of being set at each workstation computer, given proper password authorization.

D. Provide dead band limits or time limits on analog alarm points in order to minimize the occurrence of nuisance alarms. Dead bands and/or time limits shall be operator definable on a per point basis.

E. Each input point on the SCADA shall be in one of the following three (3) possible operator manually selected, or automatically programmed states:
   1. ENABLED - Point with monitoring and alarm annunciation active.
   2. DISABLED - Point with alarm annunciation disabled.
   3. ALARM LOCKOUT - Point with alarm annunciation disabled.

F. Each enabled output point on the SCADA shall be in one of the following two (2) possible operator selected, or automatically programmed states:
   1. MANUAL - Scanning, alarm monitoring and associated interlock protection operational. Programmed control actions not to be automatically applied to controlled points with the exception of protection interlocks. Digital output and analog output changes to be executed manually by SCADA operator; subject to protection interlocks.
   2. AUTOMATIC - All automatic scanning, alarm monitoring, interlock and control software features functioning under program control. Digital output and analog output changes not executable manually by operator. All automatic protection interlocks functioning. It shall not be possible to place an output in automatic mode when the output is software dependent on any point that is disabled, in alarm or "sensor bad".

G. Workstation software and graphical operator interface shall be In-Touch Wonderware software.

H. Provide one (1) full development software license. Also, provide additional runtime licenses to be installed on the operator workstations, Mimic computer and Operator Interface Terminals in the Switchgear Controls.

2.11 OPERATOR WORKSTATION CAPABILITY

A. Reports shall be produced on demand when requested by the Operator. Selected reports shall be generated on a scheduled basis. Schedules shall be entered by the Operator using an interactive procedure. The time and date shall be recorded on all reports.

B. The Operator Interface shall be in the English language, using readily understood English language abbreviations, mnemonics and cursor (mouse) control.

C. The SCADA shall annunciate a sensed alarm within one (1) second of the alarm being detected. Operator access to the SCADA shall be available within one (1) second of the Operator initiating the access process for any function.

D. All operator initiated equipment energize/de-energize, ON/OFF, OPEN/CLOSE, etc. and commands or changes to the data base such as set points, alarm limits, schedules, etc., shall be executed within two (2) seconds from the completion of the entry by the Operator.

E. The operator interface shall require minimal Operator referencing to instruction manuals. Help menus or directories of both available commands and details of their use shall be available, on-line.

F. When an alarm occurs it shall be annunciated on the alarm printer and shall be displayed on the monitor at the workstation by one of two methods:

1. A description of the alarm shall appear in a dedicated area of the monitor. When the Operator acknowledges the alarm it will be replaced by the next alarm of highest priority. The monitor display of graphics, trends, etc. shall not be affected by this alarm display. A means shall be provided to indicate when an alarm is awaiting acknowledgment.
2. An alarm icon shall indicate when an alarm is awaiting display. This icon shall allow the Operator to acknowledge alarms, access alarms and return to the previous display.

G. Provide password access control as protection against unauthorized access to SCADA operations from any Operator I/O device.

H. Provide automatic annunciation to Operators of internal SCADA component/system/ communication/software failures via an approved worded message on monitor and printer.

I. All SCADA alarm messages, at minimum, shall contain:
1. Time and date of occurrence.
2. Full, clear, unique and concise details of the alarm condition.
3. Associated point/system address and expanded descriptors if applicable.
4. Other information as defined in the submittal process.

J. A report shall be available to the Operator on a scheduled basis and on an on-demand basis detailing existing alarms. The report shall clearly identify alarms that have not been acknowledged by the Operator. All reports shall be displayed and/or printed out in Excel spreadsheet format.

K. Reports shall be available including, at minimum:
1. Point report showing all of the points in the system and their current value.
2. Complete point definition reports showing all of the points in the system and their current configuration (alarm limits, address, etc.).
3. Alarm disables status reports.
4. Alarm summary reports.
5. EPSS Testing Report.
6. Transfer Testing of LV Transfer Switchgears.

L. Provide real-time color monitor graphic schematic displays. One schematic, at minimum, shall be provided for the following systems:
1. Each generator set; PLC and display of all points identified within the SCADA Points List and individual generator kilowatts.
2. All 15 KV Switchgear, unit substations, and all downstream LV Transfer Switchgears, including main bus kilowatts, circuit breaker status, source status, front views for 15 KV switchgear complete with individual elevation of each cubicle.
3. System one-line diagram of the entire system and all downstream LV transfer switchgears, indicating system transfer and retransfer conditions, system load shed and load add set points, system overload set points, load shed and bypass control, load demand engine selection and generator engine start/stop control. System diagram shall indicate by color the flow of power and the position of all circuit operating devices.
4. Graphic screens indicating all points monitored as identified in the SCADA Points List.

M. The graphical displays shall be configured to emulate the physical layout of each 15KV control switchgear cubicle door, and generator arrangement. Each display shall have active control and monitoring capability.

N. The graphical schematics shall be displayed in their completed form with all dynamic data within three (3) seconds of the display command being entered by the Operator.

O. Submit graphical system schematics to the Engineer and Owner as a shop drawing for approval.

P. Provide modem and email interface to send email alarm/status messages or trouble codes.

2.12 SCADA SCREENS

A. Each workstation and operator interface terminal shall be programmed with the following graphic user interface screens:

1. Navigation/Status Bar: This shall be present on all displays. A status bar shall be present across the top of the display to show date, time, operator, access level, general status of the Normal and Emergency Power System:
   - Status of each Utility source
   - Load Test on/off
   - Master Controls: auto/manual
   - Load Bank Test: on/off
   - Load Control mode: auto/manual
   - Retransfer mode: auto/manual
   - Gen Demand Mode: on/off
   - On-line Test: active/off

   A Navigation bar shall be present down the left side of the display to allow the user to navigate to other screens with an easy to use menu. A legend shall also be displayed to indicate status of symbols used on the graphics such as color and symbol for breaker open, breaker closed, engine locked out, etc.
2. Security/log screen - allows five (5) levels of password-protected access to the SCADA system for different levels of authorized personnel.
3. System Single-line Diagram screen - a single-line diagram of the system including detail as shown on the drawings including down to each building main transfer switchboard. The single line shall change color for energized or de-energized condition. Energized shall be red, de-energized shall be green and a locked out breaker or one with an active alarm shall be displayed as flashing yellow. Clicking on the icon for any breaker (generator, utility, distribution, Substation Main, etc), or transfer switchgear shall display a pop-up window with all monitored values as currently be seen by that device. Monitored values shall be instantaneous values monitored by the multifunction relays, circuit breaker trip units, power monitors and generator SCADA interface. The screen may use a separate block to represent the continuation of the one line to a specific remote building. Clicking on that block will bring up another window that displays the one line for that building only. Remote building one-lines are to be active using the same color coding as noted above.
4. Active Alarm Window Screen lists all active unacknowledged alarms, time stamped to the millisecond that requires immediate attention.
5. Event Log Screen’s screen shall provide a running log of all monitored and alarm events, both acknowledged and unacknowledged. This shall include all of generator, switchgear, and system alarms as well as breaker positions etc. Events include test operations, changes to timers or set points, and power losses. Each event or alarm shall be time stamped with the exact time of the

event or alarm. System events and alarms shall be saved to the hard drive and shall capable of being downloaded in report form to the system printer.

6. System Control Screens highest level of security access screen capable of initiating all manual functions and load test sequences. Provide a minimum of two steps with a confirmation of each action to initiate any system control or to terminate any operation. All manual control shall be enabled via the local PLC so SCADA cannot put the system in an unacceptable configuration by overriding each piece of equipment local interlocks. Include the following individual System Control Screens:
   a) MASTER CONTROL and Set points Screen:
      Includes buttons and controls as provided on the Master cubicle door plus a listing of set points associated with system operation.
   b) GENERATOR DEMAND Control Screen:
      Includes buttons and displays to perform the following functions:
      When the system is running in the emergency mode and the generator demand mode button is in the select position and at least two (2) generator breakers are closed, the controls continuously monitor the total load on the generator bus and controls load and generation.
   c) LOAD CONTROL MODE Screen:
      Includes buttons and displays to perform the following plus a listing of set points associated with these functions:
      Auto load control mode is accomplished by controlling the breakers in the transfer switchgear. During a normal power failure, after the required engine-generators have synchronized to the generator bus the generator main breaker(s) are closed. The transfer switchgear distribution breakers are sequenced back on based on their priority. The priority of distribution breakers can be adjusted through the load priority screen. Bypassing the load control mode would require manually adding or shedding of load.
      The LOAD ADD / LOAD SHED buttons provide the following operations:
      Lower priority loads can be programmed for smaller steps (i.e. 2A, 2B, 2C ...) while using the load add and load shed non-essential load push buttons. This enables more flexibility in loading up the generators while in bypass mode of operation. Pressing the load add push button on the SCADA screen adds lower priority load to the emergency generator system. Each time the push button is pressed the next priority is added. Pressing the load shed push button on the SCADA screen immediately sheds load of the next lowest priority. Each time the push button is pressed the next priority load is shed. This button remains functional in both manual and automatic operation; however, in the automatic mode, any shed load is re-added once the button is released, provided the bus is capable of increased load. Load priority set points shall be settable from this screen to assign priority and expected KW for each step.
   d) LOAD BANK TEST SCREEN
      Provide separate screen to select any generator or combination of generators for load test using the permanently installed load bank. Once generators are selected, a start pushbutton will automatically start the selected generators and close/parallel them to the generator bus. The load bank breaker will be closed and the operator can add load using the soft keys on the screen. If utility fails during load bank test, then the load bank breaker will open and the Gen Main breakers will close for immediate transfer of priority one loads, followed by the resumption of adding additional generators and loads as per the same sequence as a utility failure when no gens are running.
   e) ADDITIONAL SETPOINT SCREENS
      Provide individual screens to allow adjust of set points for the following:

Utility Timers Under voltage failure, Voltage available, Open Transition time, Engine Set points Cool down time, Fail to Sync time, Any set point change will initiate a pop-up window requiring operator to save changes or to reload default values in the PLCs.

7. Engine Metering Screen: Provide screen with individual pop-up window for each Engine Generator which displays analog meter simulations for Oil Pressure, Water Temp, RPM, Power Factor, Frequency, KW, Battery Voltage, Generator Voltage with phase to phase selector buttons, Current with phase selector buttons. Also display total accumulated operating hours for the unit.
8. Relay Metering Screens: Provide an individual pop-up window that displays all of the power monitoring data available from each and every protective relay in the 15KV Emergency Switchgear as shown on the drawings. Access to a specific pop-up shall be by either of two methods. First, by clicking on the associated breaker on the one-line graphic, or second by clicking on the device as shown on the switchgear virtual elevation front views of each lineup as available in the SCADA.
9. Power Metering Screens - Provide an individual pop-up window that displays all of the power monitoring data available from each and every Power Meter in the Emergency Switchgear, and in the downstream LV Transfer Switchgear. Access to a specific pop-up shall be by either of two methods. First, by clicking on the associated lineup on the one-line graphic, or second by clicking on the device as shown on the switchgear virtual elevation front views of each lineup as available in the SCADA.
10. LV Transfer Switchgear Status Screen Selectable from the main menu bar, this screen will display a summary of each Transfer Switchgear in the facility. The following status shall be displayed in a table for each Transfer Switchgear:
    Source connected (normal/emergency)
    Start Signal Present
11. LV Transfer Switchgear Data Screen - Provide an individual pop-up window that displays all of the data available from each and every Transfer Switchgear in the facility, as shown on the drawings. Window shall display power monitoring data, source voltages, load in amperes and kW, source breakers position, and including a live one-line graphic of the switchgear and its associated load breakers showing current status of each breaker (open or closed). Access to a specific pop-up shall be by either of two methods. First, by clicking on the associated Transfer Switchgear on the one-line graphic, or second by clicking on the specific Transfer Switchgear as listed on the Transfer Switchgear Status Screen listed above.
12. Plan View Site: Provide a main screen that is a complete plan view of the entire Site with each building outlined in a color with the name and building number displayed within each buildings outline. This will serve as another means to navigate to specific screens associated with each building. When the cursor is moved within a building outline, that outline will highlight and clicking the mouse will bring up the associated main electrical one line of that building as described in the One-Line Screen above. The one line will include each Transfer Switchgear contained within the building. Clicking on any transfer switchboard main breaker, power meter or ATS will bring up the Data Screen listed above.
13. Plan View CEP: Provide a plan view of the CEP building showing all rooms with outlines of all generators, switchgear, controls, and any other major electrical equipment. Highlighting any piece of equipment, such as a generator of switchgear lineup, will bring up a screen associated with that unit. For example, clicking on a generator will bring up the Generator metering screen for that unit. Clicking on a switchgear lineup will bring up the virtual front view of that lineup.
14. Virtual Switchgear Front View Interactive Screens Front view elevations shall be provided for each 15 KV (13.2 KV) switchgear line-up (Normal & Emergency) and each Switchgear Controls Lineup. Each virtual representation shall replicate

exactly the actual appearance of particular equipment including all controls, meters, annunciators, switches, pushbuttons, relays, and labeling. Colors shall replicate the actual colors of the gear and each door mounted device. From the main front view of any lineup, it shall be possible to zoom into the lineup at several levels. First, highlighting and clicking on any cubicle will bring up a view of that cubicle only. From any cubicle front view, it shall be possible to highlight small groups of devices (such as meters or control switches or an annunciator) and click to display a close up of that group of devices only. The displays shall show replications of each device (analog meter, selector switch, annunciator panel, etc.) and the actual state of that device in a live presentation. Analog meters shall show actual current readings. Switches shall be shown in their actual positions at any time. Annunciators shall show lighted windows in the same color as is currently being displayed on the actual equipment.

15. All other screens as listed in the Emergency Switchgear specifications as required for the Master OIP shall be duplicated on the Scada Operator Workstations.

B. Screens shall function in real-time with a maximum update time of 1.0 second.

C. Screen functions shall not be capable of overriding any safety functions.

2.13 ADVANCED TRAINING AND FAULT ANNALYSIS SIMULATOR

A. Provide a standalone workstation and PLC with system software for training, failure analysis and simulation of entire Emergency Power System. The workstation will consist of a PC based workstation, desk top type, with a separate PLC mounted to the Display stand and all required accessories, including power supply and connections to the workstation.

B. Simulator hardware and software shall match the SCADA Operator Workstations (OWS) including (3) 24" flat screen monitors in workstation configuration and including a desktop stand. The monitor shall display as follows:

Left screen: shall display an active one line of the system plus all of the menu screens as available on the actual system OIP
Center screen: Animated Virtual front views of the entire Switchgear and Controls lineup, showing every cubicle detail and door mounted device
Right screen: Simulator Control Screen where the operator can enter simulation variables (fail a breaker coil, change setpoints, etc)

Power flow shall be displayed by color changes in the single line graphic. An open breaker and a de-energized bus is to be green, a closed breaker and an energized bus shall be red, and a locked out breaker condition shall be displayed in yellow. The simulator PLC shall be the same make and model as being provided in the Generator System Master controls. Control functions of the low voltage switchgear shall not be included in simulator system program.

C. Provide the ability to simulate real operating conditions and failure scenarios for entire 13.2 KV Emergency Power System. These simulations will be performed off-line and in no way affect the real-time operations of the systems. Operators shall be able to initiate all functions as if they were standing in front of the actual switchgear and controls, using the virtual front view graphic screens. They shall be able to push buttons, move switches and enter parameters with real time simulation to show the actual results of their actions under normal and abnormal conditions.

D Simulator shall have security log on protection, Menu driven pop-up windows for different operational scenario screens shall be provided. Multicolored graphical displays that change colors to reflect different operational conditions, such as open and closed breaker operation, energized and de-energized buses and sources.

E. Simulate, using duplicate switchgear Operator Interface Panel (OIP) controls, operation and control of the paralleling switchgear and allow operator interaction with setting adjustments and interjecting failures to see how the system will react to different events such as breaker failure, engine/generator failure, power failure, etc. Operator shall be able to create specific failure conditions such as, breaker close coil failure, breaker trip coil failure, breaker lock-out, engine failure, & power failures. The simulator will then run the system in the same manner as it would on the actual gear given the induced failures being present. Operators can then learn “work around” solutions to a given scenario.

F. Simulate and display data and functions for each individual generator such as engine start/stop and monitoring that is performed by the system PLC including but not limited to: all pre-alarms; alarms; engine status; engine selector switch status and control; generator circuit breaker position and generator volts; amps; kilowatts, and frequency. Simulation of generator load bank testing shall also be provided.

G. Simulate and display the operational functions of the control system including but not limited to: system annunciation; generator bus voltage; generator bus kilowatts; generator bus frequency; load demand setpoint and timer settings; manual/auto selector switch position and all remaining master control settings. The complete manual operation of the switchgear controls shall be simulated, including manual generator start, manual synchronizing of generators to the bus, manual open & closing of breakers, and manual transfers.

H. All simulated data displayed by the SDS shall appear as it would be seen on the actual system. Simulated operations when using the training simulator shall include:

- various system tests (load/no load, load bank)
- set point adjustment
- frequency meter switch interlocking (keyed removable switch can be moved among generator controls)
- synchroscope meter switch interlocking & manual sync control
- manual breaker control hardwired interlocks
- metering for all hardwired analog meters
- generator demand enable/disable and setpoint adjustments
- load shed and block transfer controls
- utility source failure and restoration
- individual generator disabling
- external tripping of circuit breakers
- protective relay or breaker initiated trip of circuit breakers
- individual generator control (pre-alarm, shutdown, cooldown, not in auto)

I. A simulated system log shall provide a history of alarm; kilowatt consumption, control and setup events including data and time stamp the same as the event log would be displayed on the actual system operator interface panel.

The simulated data shall be displayed in daily, weekly, monthly or quarterly intervals.

J. The Simulator System shall consist of a Dell Precision T5810 personal computer and PLC and must include the following basic minimum features:

Intel Xeon Processor E5-1603 v3 (4C, 2.8GHz, 10M, 140W)
16GB (2x4GB) 2133MHz DDR4 RDIMM ECC
Dual AMD FirePro W5100 4GB (2 cards, 2 DP each) (1 DP to SL-DVI adapter)
500GB 3.5" Serial-ATA (7,200 RPM) Hard Drive
C1 SATA 3.5 Inch, 1-2 Hard Drives
US English (QWERTY) Dell KB212-B QuietKey USB Keyboard Black
Dell MS111 USB Optical Mouse
Integrated Intel AHCI chipset SATA controller (6 x 6.0Gb/s) - SW RAID 0/1/5/10
8x Slimline DVD-ROM Drive
Precision Tower 5810 Resource DVD

(3) Dell 23” touch screen monitor with 3 year warranty
Ergotech Horizontal Monitor stand with PLC mounting plate
Display Port to 4K HDMI Converter
4K UHD High Speed HDMI – 10ft
Fellowes Gel Crystal - Mouse pad with wrist pillow – blue
32GB USB Flash Drive
Stereo Speaker System

Include the following software loaded and fully configured for simulator operation:

Windows 10 Professional
Microsoft Office Trial
Windows 10 Recovery – USB
InTouch 2014R2 Runtime 60K Tag with I/O
3 Year ProSupport Warranty

The SDS shall also include a GE RX3i PLC equivalent to the PLCs used for the critical medium voltage system including:

universal backplane
7-slot rack
Ethernet interface module with (2) 10Base-T/100Base-TX Ethernet cards 300 watt power supply.

D. The simulator will serve as the training tool for current and future operators and shall be comprehensive in its scope and abilities. Final acceptance of the proposed simulator will be upon demonstration conducted by the vendor, and acceptance by the engineer, that the simulation system meets all of the requirements as stated in this specification~~..~~.

2.14 PROTECTIVE RELAYS METERING UNITS

A. Protective relay metering units shall be capable of communicating on four wire MODBUS networks without software interfaces (black boxes) or by Ethernet over 8 wire UTP.

2.15 ETHERNET SOLUTIONS

A. Power Circuit Monitors and circuit breaker trip units shall be connected to the campus wide power monitoring and control system.

1. LC fiber optic connection for multimode fiber (100BaseFX) The ECC shall have an embedded web server inside the unit, capable of serving HTML pages with dynamic meter data displays.

2. The protocol used over Ethernet shall be Modbus/TCP an international industry standard which is an open and well defined protocol.
3. All Ethernet cabling shall be Category 6 rated for 100baseT, or Fiber Optics rated for 100baseFX.
4. Coordinate specific needs with Eaton Powernet System

PART 3 - EXECUTION

3.1 INSTALLATION

A. Furnish and install all communications wiring and conduit to provide a complete and operational monitoring system.

3.2 INSPECTION AND TESTING

A. Components and operation of the SCADA shall be thoroughly tested and inspected as follows:
1. Factory Witness Testing: Prior to delivery to the site, all transfer switchgears and 15 KV switchgear systems, shall be inspected and tested with the SCADA system in one location by the Engineer and the Owners designated representatives. The Owner, Commissioning Agent and Engineer shall schedule and witness a comprehensive factory simulation test that shall simulate the actual operation of the transfer swithgears, 15 KV switchgear and all their components. Provide a digital relay and MODBUS to Fiber Optic converters to simulate and demonstrate communications and control functionality. Provide a minimum of three (3) business days for witness testing. Travel and living expenses for up to six (6) owners' representatives shall be furnished by the SCADA manufacturer.
2. On-site Progress Testing: During installation on site, the Contractor shall test all sub-systems and sub-components of the SCADA and shall furnish reports to the Owner and Engineer of the results of testing. Contractor shall provide 30 days notification to Owner and Engineer to permit observation of partial system testing.
3. Final Acceptance Testing: Prior to acceptance by Owner, the entire SCADA systems control and monitoring functions shall be demonstrated to the Owner and Engineer, complete with the 15 KV switchgear and transfers switchgears. Submit detailed testing procedures for approval by the Engineer.

3.3 FACILITY MONITORING SYSTEM (SCADA) POINTS LIST

A. The SCADA Points List indicates the input and output points that will be monitored by the SCADA. Complete monitoring and integration of all SCADA points is required as part of this contract. The SCADA system shall also duplicate all generators, paralleling system and fuel system alarms as indicated on the drawings.

B. The designations within the SCADA Point List are as follows:
1. Point Name: Indicates the variable to be monitored.
2. Digital Input (DI): Indicates the variable will be monitored as a digital input.
3. Analog Input (AI): Indicates the variable will be monitored as an analog input.
4. Remarks: Provides additional information associated with the point.
5. Building Management System (BMS): Indicates a common alarm point to be terminated on a separate terminal block designated BMS to be monitored by the Owners facility/building management system.

B. ~~C.~~ Provide all wiring, tubing/piping, sensing equipment, sensors, transducers, transmitters, power supplies, interposing and control relays and interconnection facilities except where the device code indicates that the device is provided by another contract. Provide additional DI and AI provisions as required to provide the required monitoring and control. The points list is as follows:

POINTS	DI	AI	REMARKS
Commercial Power Fail	X		One for each utility service at each transfer switchgear
Switchgear, Current, Voltage, Watts, VARS, Power Factor Frequency, THD		X	Typical for each switchgear medium voltage emergency bus
Generator, Current, Voltage, Watts, VARS Power Factor Frequency, THD		X	Typical for each engine generator
Generator Winding Temperature		X	Typical for each generator
Generator Bearing Temperature		X	Typical for each generator
Engine RPM, Fuel Pressure, Oil pressure, Coolant Temp		X	Typical for each engine
Generator Battery Starting System Alarm	X		Typical for each engine generator
Generator Alarms		X	Typical for each engine generator (BMS)
Generator Pre-Alarms		X	Typical for each engine generator (BMS)
Switchgear Control Alarms		X	
Generator Neutral Grounding Resistor Failure	X		Typical for each engine generator
Switchgear and Generator Control Set Points		X	All available set points as required for system operation
15 KV Circuit Breaker Trip Unit – All Available Functions and Power Monitoring Parameters		X	Typical for each 15 KV circuit breaker protective relay
Breaker Position Open-Closed-Trip	X		Typical for each 15KV breaker, low voltage draw out breaker (transfer switchgear), and prepared space

Station Battery System Alarms	X		Typical for each battery/charging system
Switchboard Main Breaker Open	X		Typical for all LV transfer switchgears (BMS)
Power Monitoring Current, Voltage, Watts, VARS, Power Factor, THD, 30-day kW Demand		X	Typical for each power meter shown on the drawings
Emergency Power Switchboard Ground Fault Alarm	X		Typical for each transfer switchgear
Main Switchboard TVSS Alarm	X		Typical for each transfer switchgear
Critical Low Fuel	X		Typical for each fuel storage tank (BMS)
Critical High Fuel	X		Typical for each fuel storage tank (BMS)
Interstitial Leak	X		Typical for each fuel storage tank
Fuel Tank Level		X	Typical for each fuel storage tank (BMS)
Fuel Pump Running		X	Typical for each fuel transfer pump
Fuel Pump Alarm		X	Typical for each fuel transfer pump (BMS)
Pump Run Time		X	Typical for each fuel transfer pump
Current, Voltage, Watts, Power factor, THD, 30-day kW Demand		X	Typical for each Transfer Switchgear
Gear connected to Alternate Source		X	Typical for each Transfer Switchgear (BMS)
Utility Source Available		X	Typical for each Transfer Switchgear
Emergency Source Available		X	Typical for each Transfer Switchgear

3.4 INSTALLATION

A. Install equipment in accordance with the NEC, manufacturer's recommendations and instructions.

B. Anchor terminal cabinets to the concrete floor by cadmium plated bolts, nuts and washers, not less than 13 mm (1/2-inch) diameter. Furnish 100 mm (4-inch) channel iron sills for new concrete floors and level flush into the floor.

3.5 TECHNICAL SERVICES DURING INSTALLATION AND FIELD TESTING

A. An authorized representative of the SCADA manufacturer shall technically supervise and conduct all of the field adjustments and tests. Major adjustments and field tests shall be completed prior to demonstration. The completed system demonstration shall be witnessed by the Engineer and owner prior to acceptance.

B. When any defects are detected, make corrections and repeat all tests as requested by the Engineer, at no additional cost to the Owner.

3.6 INSTRUCTIONS AND FINAL INSPECTION

A. A complete set of operating instructions for the SCADA shall be included in the O&M manuals.

B. Conduct a final inspection, in the presence of an Owner's representative, to assure that the switchgear and SCADA operate properly in all respects.

C. Furnish the services of a factory-trained engineer for two, 8-hour training periods for instructing personnel in the maintenance and operation of the equipment, on the dates requested by the Owner.

3.7 TRAINING

A. Provide training directed towards the requirements of the Owner. Provide, at minimum, one week (five 8-hr days) of formal training for the entire system, including SCADA and Simulator at the site.

B. Submit proposed training schedule, format, content, location and name and position of training personnel to the Engineer and Owner for comment at least three (3) weeks prior to the proposed commencement of the training session. Provide all equipment and supplies to execute the training program.

END OF SECTION 27 07 17

SECTION 26 08 00 - Cx OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Owner's Project Requirements (OPR) and the Basis of Design (BOD) documentation are included by reference for information only.

C. Division 01 Section 01 81 13 Sustainable Design Requirements – LEED v4 BD+C for additional LEED v4 requirements related to commissioning.

D. ASHRAE standard 90.1-2010 and ASHRAE Guideline 0-2005 (The Commissioning Process) and ASHRAE Standard 202-2013 Commissioning Process for Buildings and Systems.

1.2 SUMMARY

A. This section includes commissioning process requirements for Electrical systems, assemblies, and equipment.

B. Related Sections:

1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.

1.3 DESCRIPTION

A. Refer to Division 01 Section "General Commissioning Requirements" for the description of commissioning.

1.4 DEFINITIONS

A. Refer to Division 01 Section "General Commissioning Requirements" for definitions.

1.5 SUBMITTALS

A. Refer to Division 01 Section "General Commissioning Requirements" for CxA's role.

B. Refer to Division 01 Section "Submittal Procedures" for specific requirements. In addition, provide the following:

C. In addition, provide the following:

1. Certificates of readiness
2. Certificates of completion of installation, prestart, and startup activities.
3. O&M manuals
4. Test reports

1.6 QUALITY ASSURANCE

A. Test Equipment Calibration Requirements: Contractor will comply with test manufacturer's calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

1.7 COORDINATION

A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to coordination during the commissioning process.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the Contractor for the equipment being tested. For example, the electrical contractor of Division 26 shall ultimately be responsible for all standard testing equipment for the electrical systems and controls systems in Division 26. A sufficient quantity of two-way radios shall be provided by each contractor.

B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price to the Owner and left on site, except for stand-alone data logging equipment that may be used by the CxA.

C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.

D. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

PART 3 - EXECUTION

3.1 GENERAL DOCUMENTATION REQUIREMENTS

A. With assistance from the installing contractor, the CxA will prepare construction Verification Checklists for all commissioned components, equipment, and systems, the contractor shall execute the Verification Checklists.

B. Red-lined Drawings:

1. The contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawings.
2. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing.
3. Changes, as a result of Functional Testing, must be incorporated into the final as-built drawings, which will be created from the red-lined drawings.
4. The contracted party, as defined in the Contract Documents will create the as-built drawings.

C. Operation and Maintenance Data:

1. The CM at Risk will provide a copy of O&M literature within 45 days of each submittal acceptance for use during the commissioning process for all commissioned equipment and systems.
2. The CxA and the A/E will review the O&M literature once for conformance to project requirements.
3. The CxA will receive a copy of the final approved O&M literature once corrections have been made by the CM at Risk and the Contractor.

D. Demonstration and Training:

1. CM at Risk and the subcontractor will provide demonstration and training as required by the specifications.
2. A complete training plan and schedule must be submitted by the CM at Risk and the Subcontractor to the CxA a minimum of four (4) weeks prior to any training.
3. A training agenda for each training session must be submitted by the CM at Risk and the Subcontractor to the CxA, the A/E and the OR a minimum of one (1) week prior the training session.
4. The CxA shall be notified at least 72 hours in advance of scheduled tests so that testing may be observed by the CA and Owner's representative. A copy of the test record shall be provided to the CxA, the A/E, and the OR.
5. Engage a Factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specific equipment.
6. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, trouble shooting, servicing, and maintaining equipment.
7. Review data in O&M Manuals.

E. Systems Manual requirements:

1. The Systems Manual is intended to be a usable information resource containing all of the information related to the systems, assemblies, and Commissioning Process in one place with indexes and cross references.
2. The CM at Risk shall include final approved versions of the following information for the Systems Manual:

a. As-Built System Schematics
b. Verified Record Drawings
c. Test Results (not otherwise included in Cx Record)
d. Periodic Maintenance Information for computer maintenance management system
e. Recommendations for recalibration frequency of sensors and actuators
f. A list of contractors, subcontractors, suppliers, architects, and engineers involved in the project along with their contact information
g. Training Records, Information on training provided, attendees list, and any on-going training

3. This information shall be organized and arranged by building system, such as electrical panels, etc.
4. Information should be provided in an electronic version to the extent possible. Legible, scanned images are acceptable for non-electronic documentation to facilitate this deliverable.

F. CM at RISK & SUBCONTRACTOR'S RESPONSIBILITIES

G. Perform commissioning tests at the direction of the CxA.

H. Attend construction phase controls coordination meetings.

I. Participate in Electrical systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.

J. Provide information requested by the CxA for final commissioning documentation.

K. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.

L. Prepare preliminary schedule for Electrical system orientations and inspections, operation and maintenance manual submissions, training sessions, equipment start-up and task completion for owner. Distribute preliminary schedule to the CM at Risk and the CxA.

M. Update schedule as required throughout the construction period.

N. During the startup and initial checkout process, execute the related portions of the verification checklists for all commissioned equipment.

O. Assist the CxA with all verification and functional performance tests.

P. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

Q. Gather operation and maintenance literature on all equipment, and assemble in binders as required by the specifications. Submit to the A/ E and the CxA within 45 days after submittal acceptance.

R. Coordinate with the CxA to provide 48-hour advance notice so that the witnessing of equipment and system start-up and testing can begin.

S. Notify the CxA and the A/E a minimum of two weeks in advance of the time for start of the testing and balancing work. Attend the initial testing and balancing meeting for review of the official testing and balancing procedures.

T. Participate in, and schedule vendors and contractors to participate in the training sessions.

U. Provide written notification to the CxA and the A/E that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and sub-system are operating as required.

1. Electrical equipment including switchgear, panel boards, motor control centers, lighting, receptacles, and all other equipment furnished under Division 26.
2. Lighting control systems
3. ATS switches and emergency power systems.
4. Fire / Smoke alarm system

V. The equipment supplier shall document the performance of his equipment.

W. Provide a complete set of red-lined drawings to the CxA and the A/E prior to the start of Functional Performance Testing.

X. Provide training of the Owner's operating staff using expert qualified personnel, as specified.

Y. Equipment Suppliers

1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner, to keep warranties in force.
2. Assist in equipment testing per agreements with contractors.
3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.

Z. Refer to Division 01 Section "General Commissioning Requirements" for additional Contractor responsibilities.

3.2 OWNER'S RESPONSIBILITIES

A. Refer to Division 01 Section "General Commissioning Requirements" for Owner's Responsibilities.

3.3 DESIGN PROFESSIONAL'S RESPONSIBILITIES

A. Refer to Division 01 Section "General Commissioning Requirements" for Design Professional's Responsibilities.

3.4 Cx AUTHORITY'S RESPONSIBILITIES

A. Refer to Division 01 Section "General Commissioning Requirements" for CxA's Responsibilities.

3.5 TESTING PREPARATION

A. Certify in writing to the A / E and the CxA that Electrical systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify in writing that testing procedures have been completed and that testing reports have been submitted, discrepancies corrected, and corrective work approved.

C. Place systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

D. Inspect and verify the position of each device and interlock identified on checklists.

E. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

F. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.6 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.

B. Scope of Electrical testing shall include the entire Electrical installation, from the incoming power equipment throughout the distribution system. Testing shall include measuring, but not limited to resistance, voltage, and amperage of system(s) and devices.

C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. The CxA, along with the CM at Risk, the Electrical contractor and other contracted subcontractors, including the fire alarm & controls Subcontractor, shall prepare detailed testing plans, procedures, and checklists for Electrical systems, subsystems, and equipment.

E. Tests will be performed using design conditions whenever possible.

F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

G. The CxA may direct that set points be altered when simulating conditions is not practical.

H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

I. If tests cannot be completed because of a deficiency outside the scope of the Electrical system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.7 ELECTRICAL SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

A. Equipment Testing and Acceptance Procedures: Testing requirements are specified in individual Division 26 sections. Provide submittals, test data, inspector record, infrared camera and certifications to the CxA.

B. Electrical Instrumentation and Lighting Control System Testing: Field testing plans and testing requirements are specified in Division 26 Section "Lighting Control Devices". Assist the CxA with preparation of testing plans.

C. Emergency Power Testing and Acceptance Procedures: Provide technicians, load banks, infrared cameras, instrumentation, tools and equipment to test performance of designated systems and devices at the direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each piece of equipment.

D. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:

1. Automatic temperature controls integrated with the electrical systems
2. Coordination and functionality with the Building Automation System / DDC Controls System
3. Emergency Generator(s)
4. Lift-Net
5. Lighting Controls
6. Power Xpert
7. Security access control systems
8. Transfer Switches – Automatic and Manual
9. Smoke / Fire Alarm interfaced with HVAC & Life Safety systems
10. Video surveillance systems

3.8 DEFICIENCIES/NON-CONFORMANCE, COST OF RETESTING, FAILURE DUE TO MANUFACTURER DEFECT

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deficiencies/non-conformance, cost of retesting, or failure due to manufacturer defect.

3.9 APPROVAL

A. Refer to Division 01 Section “General Commissioning Requirements” for approval procedures.

3.10 DEFERRED TESTING

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deferred testing.

3.11 OPERATION AND MAINTENANCE MANUALS

A. The Operation and Maintenance Manuals shall conform to Contract Documents requirements as stated in Division 01.

B. Refer to Division 01 Section “General Commissioning Requirements” for the A/E and CxA roles in the Operation and Maintenance Manual contribution, review and approval process.

3.12 TRAINING OF OWNER PERSONNEL

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to training. All training shall be videotaped for future use.

B. Electrical Contractor. Shall have the following training responsibilities:

1. Provide the CM at Risk with a training plan for review by the CxA, the A/E, and the OR a minimum of two (2) weeks before the planned training.
2. Provide designated Owner personnel with comprehensive training in the understanding of the systems and the operation and maintenance of each major piece of commissioned electrical equipment or system.
3. Training shall start with classroom sessions, if necessary, followed by hands on training on each piece of equipment, which shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.
4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
5. The appropriate trade or certified factory manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer’s representative. Practical building operating expertise, as well as in-depth knowledge of all modes of operation of the specific piece of equipment, is required. More than one party may be required to execute the training.
6. The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.
7. Training shall include:

   a. Use the printed installation, operation and maintenance instruction material included in the O&M manuals.
   b. Include a review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.
   c. Discuss relevant safety issues and concerns.
   d. Discuss warranties and guarantees.
   e. Cover common troubleshooting problems and solutions.

f. Explain information included in the O&M manuals and the location of all plans and manuals in the facility.
g. Discuss any peculiarities of equipment installation or operation.

8. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and preventative maintenance of all pieces of equipment.
9. The electrical contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.
10. Training shall occur after functional testing is complete, unless approved otherwise by the Owner's.

END OF SECTION 26 08 00

SECTION 26 08 13 - TESTS AND PERFORMANCE VERIFICATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Contractual Conditions and Division 01 Specification sections apply to this section.

1.2 SUMMARY

A. This section includes the requirements for the furnishing of all labor, materials, equipment and services necessary to test and prove performance of the electrical system.

1.3 DESCRIPTION

A. Operate system for a 3-day period. Do performance verification work as required to show that the system is operating correctly in accordance with design. Supply instruments required to read data. Adjust system to operate at the required performance levels.

PART 2 - PRODUCTS – (not applicable)

PART 3 – EXECUTION

3.1 TESTS

A. System:

1. General: After installation of all conductors, and before final acceptance, make required tests to determine proper function of all circuits. Furnish all necessary instruments required to make tests, and correct any deficiencies found. Prior to energizing, circuits shall be tested to verify opens, intentional and non-intentional grounds, and continuity and detect short circuits by approved constant "megger".
2. Procedure:

    a. Insulation resistance of all circuit conductors shall be tested. This is to include all new conductors and all existing conductors that are connected or extended. Each conductor shall have its insulation resistance tested after the installation is completed and all splices, taps, and connections are made except connection to source and point of final termination at distribution or utilization equipment.
    b. Insulation resistance of conductors that are to operate at 600 volts or less shall be tested by using a megohmmeter at not less than 1000 volts DC. Resistance shall be measured from each conductor to all other conductors and from each conductor to conduit (ground).Test duration shall be one minute. Investigate any values which deviate from similar connections by more than 50 percent of the lowest value. Testing methodology shall conform to National Electrical Testing Association (NETA). Acceptable insulation resistance of conductors rated at 600 volts shall not be less

than the recommended wire manufactures accepted values and test equipment manufacture, or 50 megohms, which ever is greater.

c. Conductors that do not satisfy test requirements (b. above) shall be removed, replaced, and testing repeated on new cable, at no additional costs to the Owner. All tests shall be performed by a licensed electrician trained in the use of the test instrument.

d. Contractor shall furnish all instruments and personnel required for tests, shall tabulate readings observed and complete "Conductor Insulation Resistance Test" form (found in Division 01) and submit five (5) copies to Designer/OAR for approval. Test shall be witnessed by OAR and designer (if designer so desires). Final approval data is to be submitted in O&M Manual.

e. Test reports shall identify each feeder conductor tested, date, time, and result of test, weather conditions, and range, test voltage, and serial number of the megger instrument used. Any conductor or splice that is found defective shall be promptly removed and replaced, and additional test shall be performed.

f. Observe all safety instructions set by testing equipment manufacturer to minimize risk of electric shock and sparking.

3. Take readings of voltage and amperage at building main disconnect switch and at main for each panel (panelboard, distribution panel, switchboard), at primary and secondary side of each transformer, at each major item of equipment, and at the end of the longest branch circuit at each panel. The above readings shall be taken (1) "no load" conditions and (2) "full load" conditions with all equipment using electricity. Tabulate readings, complete "TABULATED DATA VOLTAGE AND AMPERAGE READINGS" form included in Division 01. Final approved data is to be submitted in O & M manual.

B. Motors:

1. Test run each motor via motor's control unit in both manual mode and automatic mode. Verify proper operation and voltage.

2. Test run each motor furnished in the Work and all existing motors specifically noted in the Contract Documents to be tested:

a. With the system energized, line-to-line voltage and line current measurements shall be made at the motors under full load conditions. Should measured values deviate +/- 5% from the nameplate ratings, the condition shall be corrected. Notify the designer immediately should deviations occur.

b. Record results of existing motors tested and submit values to OAR in writing.

c. Tabulate readings, complete "Motor Test Information" form included in Division 01 of the General Requirements. Final approved data is to be submitted in O & M manual.

C. Grounds:

1. Test each raceway for raceway continuity as called for in Section 26 05 26.
2. Test each grounding system used in the project as called for in Section 26 05 26
3. Submit "GROUND TEST INFORMATION" form included in Division 01 of the General Requirements for each and every grounding system in the project including but not limited to: each ground rod installation; each water pipe and ground installation (test water pipe to ground and test water pipe to building service equipment); and each building steel ground connection (test building steel to ground and test building steel to building service equipment). Final approved data is to be submitted in O & M manual.
4. Grounding resistance shall be as called for in Section 26 05 26.
5. Testing shall be three (3) point method in accordance with IEEE recommended practice.

D. Communications:

1. See specific sections of these specifications for requirements.

E. Equipment:

1. Equipment items requiring check-out memos are all major items of equipment such as (but not limited to):

   a. Panelboards, switchboards.
   b. Paralleling Low-Voltage Switchgear.
   c. Transformers.
   d. UPS equipment.
   e. Generator equipment.
   f. Checkout and test any other equipment the designer/OAR deems necessary to insure system integrity and safety during construction, regardless if previous testing has been performed.

2. At completion of construction after all performance verification and testing information has been gathered, submitted, and approved, provide one copy of this information to the authorized manufacturer's representative of the equipment.

   a. Manufacturer's authorized representative must be trained by the manufacturer and authorized to inspect, adjust, test, and repair equipment.

3. Manufacturer’s authorized representative shall examine the performance verification information, check the equipment in the field while it is operating, and sign a check-out memo for a record.

   a. Check out of equipment is to include examining performance and certifying equipment has been installed per manufacturer's recommendations, that all necessary adjustments have been performed and that equipment is operating properly.

4. Submit memo on each major item of equipment. Approved memos shall be scanned and copied onto each O & M CD with the performance verification information and submittal data. Memos shall be submitted and approved before instruction to Owner or a request for final inspection.

5. Do not submit Check-out Memo form at the time Submittal Brochures are submitted.

6. Completion of Construction “Check Out Memo” form included in Division 01.

3.2 DATA PROCESSING

A. Tabulate data for submission.

B. Submit data on 8 1/2" x 11" sheets with date and name of checker with one copy for each operation and maintenance CD.

C. Where specific performance verification information is called for in the specifications, use copies of the sheets provided for recording readings.

D. Data shall be submitted and approved before Check Out memos are signed or a request for final inspection is made.

END OF SECTION 26 08 13

SECTION 26 12 19 – OIL-FILLED PAD MOUNTED TRANSFORMERS

PART 1 – GENERAL

1.1 REFERENCES

A. The publications listed below form a part of this specification to the extent referenced. The publication is referred to in the text by the basic designation only.

1. American National Standards Institute (ANSI):

   a) ANSI C2 National Electrical Safety Code

   b) ANSI C57.12.26: Transformers - Pad-Mounted, Compartmental-Type, Self-Cooled, Three Phase Distribution Transformers for use with Separable Insulated High-Voltage Connectors, High Voltage, 34 500 GrdY/19, 920 Volts and Below; 2500 kVA and Smaller.

   c) ANSI C57.12.28: Switchgear and Transformers - Pad-Mounted Equipment - Enclosure Integrity

2. American Society for Testing and Materials (ASTM):

   a) ASTM A 167: Stainless and Heat-Resisting Chromium Nickel Steel Plate, Sheet, and Strip.

   b) ASTM D 117: Electrical Insulating Oils of Petroleum Origin.

   c) ASTM D 1535: Specifying Color by the Munsell System.

   d) ASTM D 3487: Mineral insulating Oil Used in Electrical Apparatus.

3. Institute of Electrical and Electronics Engineers, Inc. (IEEE):

   a) IEEE 386: Separable Insulated Connectors System for Power Distribution Systems Above 600 V

   b) ANSI/IEEE, C57.12.00: General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers

   c) ANSI/IEEE, C57.12.80: Terminology for Power and Distribution Transformers

   d) IEEE C57.12.90: Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers and Guide for Short-Circuit Testing of Distribution and Power Transformers

   e) ANSI/IEEE, C62.11: Metal Oxide Surge Arrestors for Alternating Current Power Circuits.

4. International Electrical Testing Association (NETA):

   a) NETA ATS: Electrical Power Distribution Equipment and Systems.

5. National Fire Protection Association (NFPA):

   a) NFPA 70: National Electrical Code.

b) NFPA 70B: Electrical Equipment Maintenance.

1.2 RELATED REQUIREMENTS

A. Section Common Work Results applies to this section, with the additions and modifications specified herein.

1.3 SUBMITTALS

A. Submit the following:

1. Data:

a) Transformer loss calculations.

2. Manufacturer's Catalog Data:

a) Pad-mounted transformers, dead-front.

b) Insulated high-voltage load-break connectors.

c) Insulated high-voltage dead-break connectors

d) Load-break switch.

e) Surge arresters.

f) Current-limiting fuses.

g) Bushing well inserts.

h) Insulated standoff bushings.

i) Insulated protective caps.

3. Drawings:

a) Pad-mounted transformers, dead-front.

b) Contents:

1. Overall dimensions, front view, and sectional views.

2. Ratings and sizes of lugs, impedance, and taps.

3. One-line diagram.

4. Reports:

a) Pad-mounted transformer routine and other tests.

b) Pad-mounted transformer design tests.

c) Submit certified copies of the following ANSI/IEEE C57.12.00 and IEEE C57.12.90 transformer tests.

d) Routine and Other tests: Routine and other tests shall be performed by the manufacturer on the actual transformer prepared for this project to ensure that the design performance is maintained in production. Submit test reports, by serial number, for the following tests and receive acceptance before delivery of equipment to the project site:

1. Resistance measurements.

2. Ratio.

3. Polarity and phase relation.
4. No-load losses (NLL) and excitation current.
5. Impedance voltage and load loss (LL).
6. Low frequency dielectric.
7. Leak.
8. Pressure.
9. Lightning impulse test
   (a) State test voltage levels.
   (b) Submit photo copies of output wave shapes.
   (c) Test one of three transformers provided by this contract, as selected by the Engineer.

e) Design Tests: ANSI/IEEE C57.12.80, Section 5.1.2 states that "design tests are made only on representative apparatus of basically the same design." Submit design test reports with catalog data and drawings for one of the three specified transformers. Design tests must have been conducted within five years of the date of award of this contract:

1. Tests shall be certified and signed by a registered professional engineer.
2. ANSI/IEEE C57.12.00 and ANSI/IEEE C57.12.90 tests performed on a prototype transformer will be acceptable.
3. Temperature Rise: "Basically the same design" for the temperature rise test means a pad-mounted transformer with the same coil construction (strip, layer, or disk), the same kVA, and the same insulating liquid as the transformer specified.
4. Lightning Impulse Test Report: "Basically the same design" for the lightning impulse dielectric test means a pad-mounted transformer with the same BIL, the same coil construction (strip, layer, or disk), and a tap charger (if specified).
   (a) ANSI/IEEE C57.98 and ANSI/IEEE C57.12.90.
   (b) State test voltage levels.
   (c) Provide oscillograms with test report.
5. Lifting and Moving Devices: "Basically the same design" for the lifting and moving devices test means a pad-mounted transformer in the same weight range as the transformer specified.

f) Corrosion Resistance: Manufacturer shall supply written information describing the paint system and material that will be used. Descriptions of tests and test results that are performed to prove the durability of the system used shall be included in this information. Documentation shall demonstrate that transformer is protected from corrosion for 30 years.

5. Field Test Reports:

a) Submit report of results of Acceptance checks and tests specified by paragraph entitled "Field Quality Control."

b) Ground Resistance Test Reports: Upon completion and before final acceptance of the work, submit the measured ground resistance of each ground rod and grounding system, and soil condition at the same time the measurements were taken.

6. Certificates:

a) PCB Content: Submit manufacturer's certificate that each transformer contains less than 1 ppm of PCB at shipment for this contract.

7. Records:

a) Transformer Test Schedule.

b) Source Quality Control: The Engineer reserves the right to witness tests. Provide transformer test schedule for tests to be performed at the manufacturers test facility. Submit required reports and notify the Engineer 30 days before scheduling test date. Notify Engineer 15 calendar days in advance of changes to scheduled dates and locations for testing.

8. Operation and Maintenance Manuals:

a) Submit completed operation and maintenance manuals on pad-mounted transformers.

9. Accepted Manufacturers:

a) ABB

b) Cooper Power Systems

PART 2 - PRODUCTS

2.1 THREE PHASE PAD MOUNTED TRANSFORMERS, DEAD-FRONT

A. ANSI C57.12.26 and ANSI C57.12.28 with separate high and low voltage compartments, primary switching and fuses, and accessories.

B. Transformer:

1. Oil insulated two winding, 60 hertz, 65 degrees C. rise above a 30 degrees C. average ambient, self-cooled type. Transformer shall be rated as shown on drawings, 95 kV BIL, high voltage of 12,470 GRD Y/7,200 primary, with four 2 1/2 percent full capacity taps, two above and two below rated primary voltage. Secondary voltage shall be 480Y/277 volts unless otherwise noted on drawings. Tap changer shall be externally operated, manual type for changing tap setting when the transformer is de-energized. Accessories shall include drain and sampler valve, filler connection, liquid level gage, grounding pads, top filter press connection, lifting lugs, provisions for jacking under base, diagrammatic nameplate, pressure relief valve, pressure-vacuum gage, and dial type thermometer with maximum temperature indicator. The transformer base shall be of the fabricated type and suitable for using rollers or skidding in any direction. Provide transformer top with an access handhole. The transformer shall have an insulated low voltage neutral bushing with lugs for ground cable, and with removable ground strap.

2. Compartments:

a) Divide high and low voltage compartments into sections with steel isolating barriers extending the full height and depth of the compartment. The primary and secondary sections shall have separate doors, which can be secured with one padlock. The primary door is to have an additional provision to padlock it within the secondary section. Each door shall have an open door holder. All hinges, pins, and protective pentahead bolt cylinder shall be stainless steel. The enclosure shall conform to the latest American National Standard C57.12.28. Pentahead bolts shall be used to secure the primary side door and the locking mechanism on the main door.

3. High Voltage: High voltage compartment shall contain the incoming line, insulated high voltage load-break connectors, six high-voltage bushing wells with inserts configured for loop feed application, connector parking stands with insulated standoff bushings, protective caps, dead-front surge arresters, load break switch handles, access to oil immersed fuses, tap changer, and ground pad. Provide oversized primary compartment to accommodate devices specified.

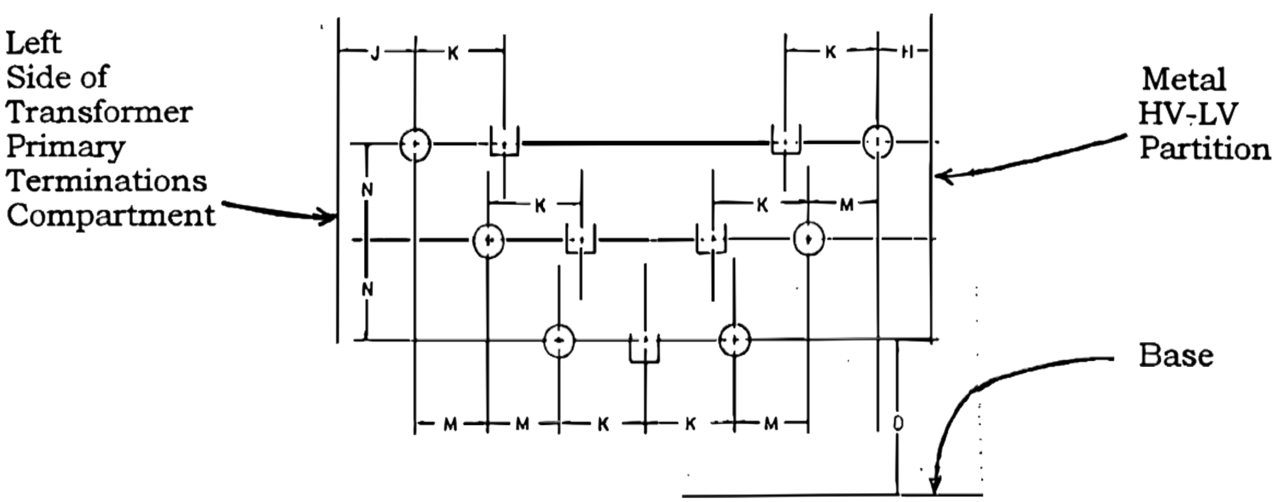
   a) Insulated high voltage load-break connectors: IEEE 386 rated 125 kV BIL, 15 kV. Current rating: 200 amperes rms continuous. Short time rating: 10,000 amperes rms symmetrical for a time duration of 0.17 seconds. Connectors and inserts shall be the product of a single manufacturer. Connector shall have a steel reinforced hook-stick eye, grounding eye, test point and arc-quenching contact material. Provide stainless steel hold down bail assembly.

   b) Replace 200 amp load break connectors with 600 amp dead break connectors when directed by Engineer or required due to circuit configuration. Transformers shall support field conversion between 600 amp and 200 amp connectors.

   c) High voltage entrance shall be via 200 Amp bushing wells with removable studs, compatible with Elastimold type bushing well inserts and bolted tap connectors. The wells shall be externally replaceable, of clamp and gasket design, and arranged in a vee pattern with the parking stands also in a vee pattern.

   (This is a variation of Specific Dimensions for Loop-Feed Transformers of ANSI C57.12.26. Three parking stands are omitted and dimensions are slightly more restrictive - dimension H has a maximum.) Dimensions of the “V” pattern are shown in the diagram on the next page. All five parking stands shall be welded directly to the tank wall (omitting any extension bracket). This will cause them to extend about 7/8 inch from the wall. Any external attachments including reinforcement for the tank wall shall be located so as not to interfere with bushing insert/arrester units or bolted tap connectors when installed in any of the six wells. This requires that no exterior tank bracing be installed for a distance of at least 10 inches below the center of the lowest bushing well. For another 6 inches downward, any reinforcement used must not protrude more than 1.5 inches from the face of the tank wall containing the wells.

   d) The diagram below shows the spacing for the 15kV class.



H	J	K	M	N	D
3.5 to 4.5	3.5 min .	5.0	4.5	6.0	27

e) HO Bushing: An Ho bushing shall be provided on the high voltage side with a removable external copper-grounding strap. Ho also shall be located so as not to interfere with bushing insert/arrester units or bolted tap connectors.

f) Load Break Switches: Two under oil, three phase ganged switches shall be connected in series between the bushing wells - with the feeds to the fuses/coils between the switches. These two independent (ON/OFF) switches shall be of the same type with minimum ratings of 200 amp continuous load and loadbreak current and 6,000 amp symmetrical/9,000 amp asymmetrical currents in any fault situation at 34.5 kV. The tee blade switch is not acceptable because a service interruption - no matter how short - is not acceptable. Switch handles must be readily accessible and operable by a standard hook-stick. The locations shall not be over 60" high or in any area below the entrances or the parking stands.

g) Provide bayonet oil-immersed, expulsion fuses in series with oil-immersed, partial range current-limiting fuses. Coordinate protection with expulsion fuse clearing low-current faults and current-limiting fuse clearing high-current faults.

1. Bayonet Oil-Immersed Expulsion Fuses: Bayonet shall be Cooper Power Systems High Ampere Overload Bay-O-Net which has silver plated contacts along with its inner holder and silver plated integral fuse cartridge (which has a staked end plug). The catalog number for the Silver Plated Bay-O-Net with inner fuse holder is 4038804B03M. Since the entire integral fuse cartridge--not just the element inside the cartridge--must be replaced when the bayonet element melts, the catalog number in the table is for the entire cartridge. The same size is used for all five designs needing this high current cartridge even though the 25 kV class 2500 kVA could use a slightly smaller fuse. 150 kV BIL; 3,500 amperes symmetrical interrupting rating.

2. Oil-Immersed Partial Range Current-Limiting Fuses: ANSI C37.47; 50,000 amperes symmetrical interrupting rating Electrical location of the CL fuse shall be immediately after the switch bus. The nameplate schematic shall include indication of the two fuses and their relationship to each other. Ratings of the CL fuses shall be appropriate for the voltage being used with a maximum asymmetrical interrupting current of 50,000A.

3. Transformer fusing shall comply with the following table:

	Bayonet Fuse or Cartridge		Under Oil CL Fuse	
Trans kVA	Cooper Cat #	Rated Current	ELSP Cat #	#/Rated Current
75	4000353C06B	10	CBUC15030C100	1-30
150	4000353C08B	15	CBUC15050C100	1-50
300	4000353C10B	25	CBUC15100C100	1-100
500	4000353C12B	40	CBUC15150D100	1-150
750	4000353C14B	65	CBUC15150D100	1-150
1000	4000353C16B	100	CBUC15180D100	1-180
1500	4000353C16B	100	CBUC15180D100	1-180

2000	4038361C05CB	125	CBUC15125C100	2-125
2500	4038361C05CB	125	(HiTech) HTDS342125	2-125
3000				

h) Surge arresters: ANSI/IEEE C62.11, rated 18 kV, fully shielded, dead-front, elbow type suitable for plugging into feedthrough inserts. Provide six arresters for loop feed circuits.

i) Bushing Well Inserts: IEEE 386, 200 amp, 25 kV Class. Provide an insert for each bushing well.

j) Protective Caps: IEEE 386, 200 amp, 25 kV Class. Provide insulated protective caps (not shipping caps) for insulating and sealing out moisture from unused bushing inserts and insulated standoff bushings.

k) Parking Stands: Provide a parking stand near each bushing well. Provide insulated standoff bushings for parking of energized loadbreak connectors on parking stands.

4. Low Voltage: Low-voltage compartment shall contain gages, valves, thermometers, drains, cable lugs, low voltage bushings, pressure relief valve, filling provisions, stainless steel transformer nameplate, and ground pad.

a) Pressure Relief: A hook-stick operable automatic pressure relief device is to be provided. This device shall vent at 10 p.s.i.g. and automatically reseal after venting. It shall be able to release at least 50 s.c.f.m., at 15 p.s.i.g. (Qualitrol 202-032-01, BETA 1750K, 1720K & 1712K qualify).

b) Bushings/Spades: The four low voltage bushings shall be externally clamped and gasketed, and arranged in a staggered configuration. Height to center of lower bushings shall be 31 inches on 75 through 500 kVA and 46 inches for larger units. The minimum distance from the center of the higher bushings to the cover shall be 8 inches. The neutral (Xo or X4) bushing shall be fully insulated the same as the phase bushings. The neutral spade shall be bonded through an externally removable copper strap. secondary spades shall be made of copper or bronze, tinned, with minimum dimensions and holes as shown in the table below. Bolt holes below refer to the total number of NEMA spaced holes for bolting connector lugs. Minimum compartment depth (Min. C.D. in the table) is from tank wall to door on the secondary side.

c) For 1000 kVA and larger, spacing of the secondary bushings shall be 8 inches vertically and shall be at least 8.4 inches horizontally center to center with at least 4.5 inches between the compartment left and right walls and the closest bushings to allow extra working space for the installation of cable limiters on each conductor. For 300 kVA and larger, a strip of insulating board shall be attached to the end of each spade and above it as a support to hold the spades against upward and downward forces.

Trans kVA	Min. C.D.	Secondary Voltage	Min. # of Bolt Holes	Minimum Size of Spades
75	18	480 or below	4	3.5 x 5.0 x 0.25
150	18	480 or below	6	3.5 x 6.7 x 0.25
300	24	480 or below	8	4.0 x 8.5 x 0.37

500	24	208 or 240	10	4.0 x 10.2 x 0.37
500	24	480	8	4.0 x 8.5 x 0.37
750	30	208 or 240	12	4.0 x 13 x 0.50
750	30	480	10	4.0 x 10.2 x 0.50
1000	30	208	16	4.0 x 14.7 x 0.50
1000	30	480	10	4.0 x 10.2 x 0.50
1500	30	480	16	4.0 x 14.7 x 0.50
1500	30	480	10	4.0 x 10.2 x 0.50
2000	30	480	12	4.0 x 13 x 0.50
2500	30	480	16	4.0 x 14.7 x 0.50
3000	30	480	20	4.0 x 18.6 x 0.75

d) Drain Valve:

1. A one-inch combination oil drain valve/sampling device shall be installed on the primary side. The drain plug shall be made of brass.

e) Thermometer:

1. On 1000 kVA and larger, a dial type thermometer shall also be provided. On 750 kVA and larger, a dial type magnetic oil level gauge shall also be provided. These shall not obstruct the oil fill hole or conflict with secondary conductors.

C. Nameplates:

1. The location of the nameplate shall be so that it will be easily readable after installation of secondary conductors. The nameplate shall include manufacturer name, month and year of manufacture, transformer kVA, primary and secondary voltages, impedance, BIL, weight, PCB content of mineral oil, gallons of oil capacity, serial number and a schematic. Separate PCB and schematic plates may be used.

D. Impedance:

1. Impedance shall be high enough to limit secondary fault current to a maximum of 65,000 Amps except on a 1500 kVA unit with 208Y/120V secondary, which can have a maximum of 75,000 Amps.

E. Corrosion Protection:

1. Bases and cabinets of transformers shall be corrosion resistant and shall be fabricated of stainless steel conforming to ASTM A 167, Type 302 or 304. Form cabinets of stainless steel sheets no less than No. 13 U.S. gage.

2. The entire unit is to be painted Munsell 7.0 GY 3.29/1.5 (green). The paint system shall conform to the latest American National Standard C57.12.28.

F. Insulating Liquid:

1. Mineral Oil: ASTM D 3487, Type II, tested in accordance with ASTM D 117. Provide identification of transformer as "non-PCB" on the nameplate.

G. Warning/Danger:

1. All labels must meet the latest ANSI Z535 requirements. A standard 4.5” X 8” NEMA “Warning” label (using 3M paper with ultraviolet resistance) shall be centered on the

outside upper portion of the primary door. A standard 4.5” X 8” NEMA “Danger” label (using 3M paper with ultraviolet resistance) shall be placed on the inside of the primary and secondary doors.

H. Transformer Loss Calculations (500 kVA)

1. "A" and "B" are given loss factors. A = 8.712, B = 3.136.

2. "C" is the cost of losses. C = $14,975.

3. "NLL" and "LL" are the transformer no-load losses and load-losses, respectively. See Paragraph titled: "Routine and Other Tests".

I. Transformer Loss Calculations (1,000 kVA)

1. "A" and "B" are given loss factors. A = 8.712, B = 3.136.

2. "C" is the cost of losses. C = $29,863.

3. "NLL" and "LL" are the transformer no-load losses and load-losses, respectively. See Paragraph titled: "Routine and Other Tests".

J. Transformers of sizes larger than 1000 kVA shall be compared to figures scaled on the basis of kVA. Transformers of sizes smaller than 500 kVA shall be compared to figures scaled on the basis of kVA. 750 kVA shall be compared to the average of the 1000 kVA and 500 kVA figures.

K. Deduct Clause:

1. After factory test results are available, Contractor shall calculate actual transformer losses (D) using test result values for NLL and LL, and values specified above for A and B. Calculate using equation D = A(NLL) + B(LL).

a) If $D \leq C$: No adjustment will be made to contract price.

b) If D > C: A unilateral contract modification will be issued in the amount of difference between C and D for each transformer.

c) If D > 1.25(C): The transformer is unacceptable.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Electrical installations shall conform to ANSI C2, NFPA 70 and to the requirements specified herein. Provide new equipment and materials unless indicated or specified otherwise.

3.2 GROUNDING

A. NFPA 70 and ANSI C2, except that grounds and grounding systems shall have a resistance to solid earth ground not exceeding 5 ohms.

1. Grounding Electrodes:

a) Provide driven ground rods as specified on electrical detail drawings. Connect ground conductors to the upper end of the ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

A. Install and connect pad-mounted transformers furnished under this section as indicated on project drawings, the accepted shop drawings, and as specified herein.

3.4 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

A. Mount transformer on concrete slab. Unless otherwise indicated, the slab shall be at least 8 inches thick, reinforced with a 6 x 6 - W2.9 x W2.9 mesh placed uniformly 4 inches from the top of the slab. Slab shall be placed on a 6 inch thick, well compacted gravel base. The top of the concrete slab shall be approximately 4 inches above the finished grade. Edges above grade shall have 1/2" chamfer. The slab shall be of adequate size to the project at least 8 inches beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water and oil-resistant caulking or sealant. Cut off and bush conduits 3 inches above slab surface.

3.5 FIELD QUALITY CONTROL

A. Performance of Acceptance Checks and Tests:

1. Perform in accordance with the manufacturer's recommendations, NFPA 70B, NETA AT8, and referenced ANSI standards. Perform visual and mechanical inspections and electrical tests specific to liquid filled transformers and grounding system in accordance with NETA ATS.

B. Follow-up Verification:

1. Upon completion of acceptance checks and tests, the Contractor shall show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. As an exception to requirements stated elsewhere in the contract, the Engineer shall be given 5 working days advance notice of the date and time of checking and testing.

END OF SECTION 26 12 19

SECTION 26 12 33 – GROUNDING TRANSFORMERS

PART 1 - GENERAL

1.1 REFERENCES

A. The publications listed below form a part of this specification to the extent referenced. The publication is referred to in the text by the basic designation only.

1. American National Standards Institute (ANSI):
    a) ANSI C2 National Electrical Safety Code
    b) ANSI C57.12.26: Transformers - Pad-Mounted, Compartmental-Type, Self-Cooled, Three Phase Distribution Transformers for use with Separable Insulated High-Voltage Connectors, High Voltage, 34 500 GrdY/19, 920 Volts and Below; 2500 kVA and Smaller.
    c) ANSI C57.12.28: Switchgear and Transformers - Pad-Mounted Equipment - Enclosure Integrity
2. American Society for Testing and Materials (ASTM):
    a) ASTM A 167: Stainless and Heat-Resisting Chromium Nickel Steel Plate, Sheet, and Strip.
    b) ASTM D 117: Electrical Insulating Oils of Petroleum Origin.
    c) ASTM D 1535: Specifying Color by the Munsell System.
    d) ASTM D 3487: Mineral insulating Oil Used in Electrical Apparatus.
3. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
    a) IEEE 386: Separable Insulated Connectors System for Power Distribution Systems Above 600 V
    b) ANSI/IEEE, C57.12.00: General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
    c) ANSI/IEEE, C57.12.80: Terminology for Power and Distribution Transformers
    d) IEEE C57.12.90: Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers and Guide for Short-Circuit Testing of Distribution and Power Transformers
    e) ANSI/IEEE, C62.11: Metal Oxide Surge Arrestors for Alternating Current Power Circuits.
4. International Electrical Testing Association (NETA):
    a) NETA ATS: Electrical Power Distribution Equipment and Systems.
5. National Fire Protection Association (NFPA):
    a) NFPA 70: National Electrical Code.
    b) NFPA 70B: Electrical Equipment Maintenance.

1.2 RELATED REQUIREMENTS

A. Section Common Work Results applies to this section, with the additions and modifications specified herein.

1.3 SUBMITTALS

A. Submit the following:

1. Data:
    a) Transformer loss calculations.
2. Manufacturer's Catalog Data:
    a) Pad-mounted transformers, dead-front.
    b) Insulated high-voltage load-break connectors.
    c) Insulated high-voltage dead-break connectors
    d)
    e) Bushing well inserts.
    f) Insulated standoff bushings.
    g) Insulated protective caps.
3. Drawings:
    a) Pad-mounted grounding transformers, dead-front.
    b) Contents:
        1. Overall dimensions, front view, and sectional views.
        2. Ratings and sizes of lugs.
        3. One-line diagram.
        4. Instrumentation diagrams.
4. Reports:
    a) Pad-mounted transformer routine and other tests.
    b) Pad-mounted transformer design tests.
    c) Submit certified copies of the following ANSI/IEEE C57.12.00 and IEEE C57.12.90 transformer tests.
    d) Routine and Other tests: Routine and other tests shall be performed by the manufacturer on the actual transformer prepared for this project to ensure that the design performance is maintained in production. Submit test reports, by serial number, for the following tests and receive acceptance before delivery of equipment to the project site:
        1. Resistance measurements.
        2. Polarity and phase relation.
        3. Low frequency dielectric.
        4. Leak.
        5. Pressure.
        6. Lightning impulse test
            (a) State test voltage levels.
            (b) Submit photo copies of output wave shapes.
            (c) Test one of three transformers provided by this contract, as selected by the Engineer.
    e) Design Tests: ANSI/IEEE C57.12.80, Section 5.1.2 states that "design tests are made only on representative apparatus of basically the same design." Submit

design test reports with catalog data and drawings for one of the three specified transformers. Design tests must have been conducted within five years of the date of award of this contract:

1. Tests shall be certified and signed by a registered professional engineer.
2. ANSI/IEEE C57.12.00 and ANSI/IEEE C57.12.90 tests performed on a prototype transformer will be acceptable.
3. Temperature Rise: "Basically the same design" for the temperature rise test means a pad-mounted transformer with the same coil construction (strip, layer, or disk), the same kVA, and the same insulating liquid as the transformer specified.
4. Lightning Impulse Test Report: "Basically the same design" for the lightning impulse dielectric test means a pad-mounted transformer with the same BIL, the same coil construction (strip, layer, or disk), and a tap charger (if specified).
   (a) ANSI/IEEE C57.98 and ANSI/IEEE C57.12.90.
   (b) State test voltage levels.
   (c) Provide oscillograms with test report.
5. Lifting and Moving Devices: "Basically the same design" for the lifting and moving devices test means a pad-mounted transformer in the same weight range as the transformer specified.

f) Corrosion Resistance: Manufacturer shall supply written information describing the paint system and material that will be used. Descriptions of tests and test results that are performed to prove the durability of the system used shall be included in this information. Documentation shall demonstrate that transformer is protected from corrosion for 30 years.

5. Field Test Reports:
   a) Submit report of results of Acceptance checks and tests specified by paragraph entitled "Field Quality Control."
   b) Ground Resistance Test Reports: Upon completion and before final acceptance of the work, submit the measured ground resistance of each ground rod and grounding system, and soil condition at the same time the measurements were taken.
6. Certificates:
   a) PCB Content: Submit manufacturer's certificate that each transformer contains less than 1 ppm of PCB at shipment for this contract.
7. Records:
   a) Transformer Test Schedule.
   b) Source Quality Control: The Engineer reserves the right to witness tests. Provide transformer test schedule for tests to be performed at the manufacturers test facility. Submit required reports and notify the Engineer 30 days before scheduling test date. Notify Engineer 15 calendar days in advance of changes to scheduled dates and locations for testing.
8. Operation and Maintenance Manuals:
   a) Submit completed operation and maintenance manuals on pad-mounted transformers.
9. Accepted Manufacturers:

a) Pacific Crest Transformers

PART 2 - PRODUCTS

2.1 THREE PHASE PAD MOUNTED GROUNDING TRANSFORMERS, DEAD-FRONT

A. ANSI C57.12.26 and ANSI C57.12.28 with separate high voltage and gauge compartments, and accessories.

B. Grounding Transformer:

1. Oil insulated Zig Zag Grounding Transformer, 60 hertz, 65 degrees C. rise above a 30 degrees C. average ambient, self-cooled type. Transformer shall be rated as shown on drawings, 95 kV BIL, high voltage of 12,470 GRD Y/7,200 primary. Accessories shall include drain and sampler valve, filler connection, liquid level gage, grounding pads, top filter press connection, lifting lugs, provisions for jacking under base, diagrammatic nameplate, pressure relief valve, pressure-vacuum gage, and dial type thermometer with maximum temperature indicator. The transformer base shall be of the fabricated type and suitable for using rollers or skidding in any direction. Provide transformer top with an access handhole.

2. Compartments:

a) Divide high voltage and gauge compartments into sections with steel isolating barriers extending the full height and depth of the compartment. The high voltage and gauge sections shall have separate doors, which can be secured with one padlock. The high voltage door is to have an additional provision to padlock it within the secondary section. Each door shall have an open door holder. All hinges, pins, and protective pentahead bolt cylinder shall be stainless steel. The enclosure shall conform to the latest American National Standard C57.12.28. Pentahead bolts shall be used to secure the primary side door and the locking mechanism on the main door.

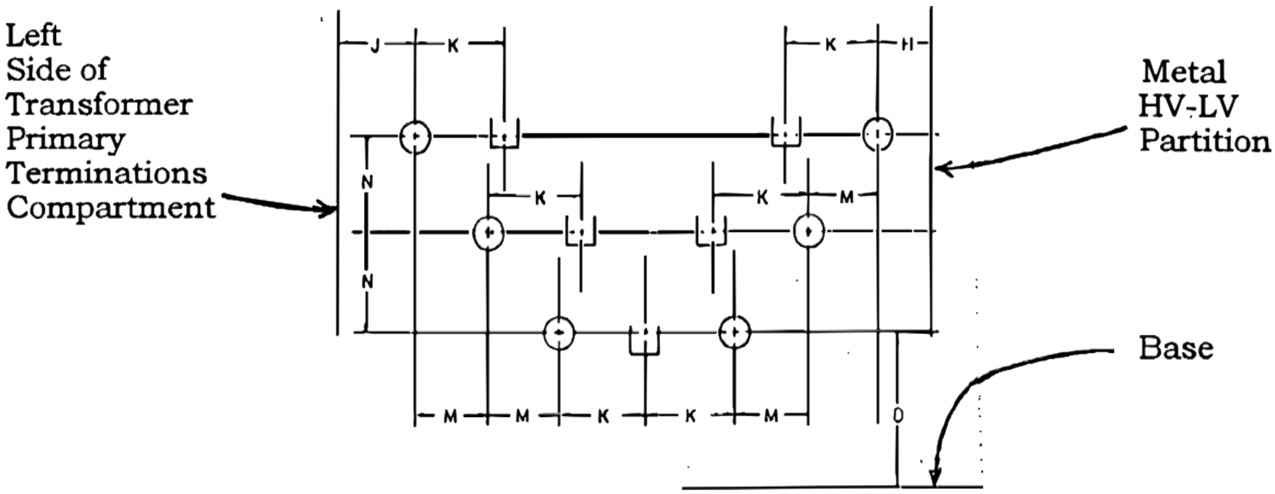
3. High Voltage Compartment: High voltage compartment shall contain the incoming line, insulated high voltage load-break connectors, six high-voltage bushing wells with inserts configured for loop feed application, connector parking stands with insulated standoff bushings, protective caps, dead-front surge arresters, and ground pad. Provide oversized primary compartment to accommodate devices specified.

a) Insulated high voltage load-break connectors: IEEE 386 rated 125 kV BIL, 15 kV. Current rating: 200 amperes rms continuous. Short time rating: 10,000 amperes rms symmetrical for a time duration of 0.17 seconds. Connectors and inserts shall be the product of a single manufacturer. Connector shall have a steel reinforced hook-stick eye, grounding eye, test point and arc-quenching contact material. Provide stainless steel hold down bail assembly.

b) High voltage entrance shall be via 200 Amp bushing wells with removable studs, compatible with Elastimold type bushing well inserts and bolted tap connectors. The wells shall be externally replaceable, of clamp and gasket design, and arranged in a vee pattern with the parking stands also in a vee pattern.

(This is a variation of Specific Dimensions for Loop-Feed Transformers of ANSI C57.12.26. Three parking stands are omitted and dimensions are slightly more restrictive - dimension H has a maximum.) Dimensions of the “V” pattern are shown in the diagram on the next page. All five parking stands shall be welded directly to the tank wall (omitting any extension bracket). This will cause them to extend about 7/8 inch from the wall. Any external attachments including reinforcement for the tank wall shall be located so as not to interfere with bushing insert/arrester units or bolted tap connectors when installed in any of the six wells. This requires that no exterior tank bracing be installed for a distance of at least 10 inches below the center of the lowest bushing well. For another 6 inches downward, any reinforcement used must not protrude more than 1.5 inches from the face of the tank wall containing the wells.

c) The diagram below shows the spacing for the 15kV class.



H	J	K	M	N	D
3.5 to 4.5	3.5 min .	5.0	4.5	6.0	27

d) HO Bushing: An Ho bushing shall be provided on the high voltage side with a removable external copper-grounding strap. Ho also shall be located so as not to interfere with bushing insert/arrester units or bolted tap connectors.

e) Surge arresters: ANSI/IEEE C62.11, rated 18 kV, fully shielded, dead-front, elbow type suitable for plugging into feedthrough inserts. Provide six arresters for loop feed circuits.

f) Bushing Well Inserts: IEEE 386, 200 amp, 25 kV Class. Provide an insert for each bushing well.

g) Protective Caps: IEEE 386, 200 amp, 25 kV Class. Provide insulated protective caps (not shipping caps) for insulating and sealing out moisture from unused bushing inserts and insulated standoff bushings.

h) Parking Stands: Provide a parking stand near each bushing well. Provide insulated standoff bushings for parking of energized loadbreak connectors on parking stands.

4. Gauge Compartment: This compartment shall contain gages, valves, thermometers, drains,, pressure relief valve, filling provisions, stainless steel transformer nameplate, and ground pad.

a) Pressure Relief: A hook-stick operable automatic pressure relief device is to be provided. This device shall vent at 10 p.s.i.g. and automatically reseal after venting. It shall be able to release at least 50 s.c.f.m., at 15 p.s.i.g. (Qualitrol 202-032-01, BETA 1750K, 1720K & 1712K qualify).

b) Drain Valve:

1. A one-inch combination oil drain valve/sampling device shall be installed on the primary side. The drain plug shall be made of brass.

c) Sampler Valve:

d) Liquid Level Gauge:

1. A dial type liquid level gauge with (2) form C contacts shall be provided.

e) Pressure Gauge:

1. A dial type pressure gauge with contacts shall be provided.

f) Sudden Pressure Rise Relay (ANSI 63):

1. 2 form C contacts that are interfaced with grounding transformer feeder protective relaying.

g) Thermometer:

1. A dial type thermometer with 2 form C contacts shall be provided.

C. Nameplates:

1. The location of the nameplate shall be so that it will be easily readable after installation of secondary conductors. The nameplate shall include manufacturer name, month and year of manufacture, transformer ratings, primary voltage, impedance, BIL, weight, PCB content of mineral oil, gallons of oil capacity, serial number and a schematic. Separate PCB and schematic plates may be used.

D. Corrosion Protection:

1. Bases and cabinets of transformers shall be corrosion resistant and shall be fabricated of stainless steel conforming to ASTM A 167, Type 302 or 304. Form cabinets of stainless steel sheets no less than No. 13 U.S. gage.

2. The entire unit is to be painted Munsell 7.0 GY 3.29/1.5 (green). The paint system shall conform to the latest American National Standard C57.12.28.

E. Insulating Liquid:

1. Mineral Oil: ASTM D 3487, Type II, tested in accordance with ASTM D 117. Provide identification of transformer as "non-PCB" on the nameplate.

F. Warning/Danger:

1. All labels must meet the latest ANSI Z535 requirements. A standard 4.5” X 8” NEMA “Warning” label (using 3M paper with ultraviolet resistance) shall be centered on the outside upper portion of the primary door. A standard 4.5” X 8” NEMA “Danger” label (using 3M paper with ultraviolet resistance) shall be placed on the inside of the primary and secondary doors.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Electrical installations shall conform to ANSI C2, NFPA 70 and to the requirements specified herein. Provide new equipment and materials unless indicated or specified otherwise.

3.2 GROUNDING

A. NFPA 70 and ANSI C2, except that grounds and grounding systems shall have a resistance to solid earth ground not exceeding 5 ohms.

1. Grounding Electrodes:

a) Provide driven ground rods as specified on electrical detail drawings. Connect ground conductors to the upper end of the ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

A. Install and connect pad-mounted transformers furnished under this section as indicated on project drawings, the accepted shop drawings, and as specified herein.

3.4 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

A. Mount transformer on concrete slab. Unless otherwise indicated, the slab shall be at least 8 inches thick, reinforced with a 6 x 6 - W2.9 x W2.9 mesh placed uniformly 4 inches from the top of the slab. Slab shall be placed on a 6 inch thick, well compacted gravel base. The top of the concrete slab shall be approximately 4 inches above the finished grade. Edges above grade shall have 1/2" chamfer. The slab shall be of adequate size to the project at least 8 inches beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water and oil-resistant caulking or sealant. Cut off and bush conduits 3 inches above slab surface.

3.5 FIELD QUALITY CONTROL

A. Performance of Acceptance Checks and Tests:

1. Perform in accordance with the manufacturer's recommendations, NFPA 70B, NETA AT8, and referenced ANSI standards. Perform visual and mechanical inspections and electrical tests specific to liquid filled transformers and grounding system in accordance with NETA ATS.

B. Follow-up Verification:

1. Upon completion of acceptance checks and tests, the Contractor shall show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. As an exception to requirements stated elsewhere in the contract, the Engineer shall be given 5 working days advance notice of the date and time of checking and testing.

END OF SECTION 26 12 33

SECTION 26 22 13 - DRY TYPE TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This section includes the requirements for provision and installation of dry type transformers.

1.3 DESCRIPTION

A. Provide and install all equipment, labor, material, accessories, and mounting hardware for a complete and operating system for dry type transformers.

1.4 SUBMITTALS

A. Product Data: Provide outline and support point dimensions of enclosures and accessories, unit weight, voltage, kVA, and impedance ratings and characteristics, tap configurations, insulation system type, and rated temperature rise.

1.5 QUALIFICATIONS

A. Manufacturer: Same as for products specified in Section 26 24 16 Panelboards.

1.6 REFERENCES AND REGULATORY REQUIREMENTS

A. Furnish products listed and tested by UL as suitable for purpose specified and shown.

B. Conform to requirements of the following:

1. ANSI/NFPA 70 - National Electrical Code
2. NECA - Standard of Installation
3. NEMA ST 1 - Specialty Transformers
4. NEMA ST 20 - Dry Type Transformers for General Applications

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store, protect, and handle products per manufacturer’s recommendations.

B. Deliver transformers individually wrapped for protection and mounted on shipping skids.

C. Accept transformers on site; inspect for damage.

D. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

E. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to internal components, enclosure, and finish.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

1. Landside Building
2. Westinghouse/Cutler Hammer, or approved substitutions.

2.2 TWO-WINDING TRANSFORMERS

A. Description:

1. NEMA ST 20, factory-assembled, air cooled dry type transformers, ratings as indicated.

2. Transformers serving computer loads (whether shown on drawings or not) shall be Non-Linear load K-13 rated.
3. Other Non-Linear load transformers shall be as scheduled and noted on drawing.
4. Isolation and shielded type transformers (if applicable) shall be as scheduled and noted on drawings.

B. Insulation system and average winding temperature rise for rated kVA as follows:
1. 1-15 kVA: Class 185 with 115 degrees C rise.
2. 16-500 kVA: Class 220 with 115 degrees C rise.

C. Case temperature: Do not exceed 35 degrees C rise above ambient at warmest point.

D. Winding Taps:
1. Transformers Less than 15 kVA: Two 5 percent below rated voltage, full capacity taps on primary winding.
2. Transformers 15 kVA and Larger: NEMA ST 20.

E. Sound Levels: NEMA ST 20.

F. Basic Impulse Level: 10 kV.

G. Ground core and coil assembly to enclosure by means of a visible flexible copper grounding strap.

H. Mounting: Suitable for wall, floor, or trapeze mounting, except transformers larger than 30 kVA, suitable for floor or trapeze mounting.

I. Coil Conductors: Continuous windings with terminations brazed or welded.

J. Transformer windings shall be continuous wound copper (98% conductivity) construction.

K. Enclosure: NEMA ST 20; Type 1 or Type 3R ventilated as indicated. Provide lifting eyes or brackets.

L. Isolate core and coil from enclosure using vibration-absorbing mounts.

M. Nameplate: Include transformer connection data.

N. Lugs: Suitable for terminating conductors sized for full load ampacity of transformer unit. Transformer lugs and mounting hardware shall be furnished by Manufacturer of transformer and shall be grade 5 with beveled washers. Hardware shall be of suitable size of pad opening per NEMA Standards.

2.3 SOURCE QUALITY CONTROL

A. Provide production testing of each unit in accordance with NEMA ST 20.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify site condition. Do not install NEMA 1 equipment until building has reached the “dried-in” stage.

B. Verify that surfaces are suitable for installing transformer supports.

3.2 PREPARATION

A. Concrete Pad: Design per manufacturer’s requirements plus three inches on all sides.

3.3 INSTALLATION

A. Install Products in accordance with manufacturer's instructions.

B. Set transformer plumb and level.

C. Maintain clearances around enclosure for ventilation in accordance with manufacturer's instructions.

D. Use flexible conduit, under the provisions of Section 26 05 33 Conduit, 1 foot minimum length, for connections to transformer case. Make conduit connections to side panel of enclosure.

E. Mount transformers on vibration isolating pads suitable for isolating the transformer noise from the building structure.

F. Provide grounding and bonding in accordance with Section 26 05 26.

G. Ground per NEC 250.26 and to meet local codes as applicable. Grounding lugs shall be multi-conductor type UL listed for quantity and size of conductors terminated.

H. Wall Mounted Transformers: Wall brackets shall be securely attached to concrete or masonry construction only and have supplemental support by means of all-thread rod hangers from superstructure above. Wall mounted transformers at non structural walls shall be supported from superstructure above with all-thread rod hangers, angle iron channel site manufactured structural stand, or combination thereof.

1. Installation of wall mounted transformers shall be installed to maintain clear space about/above panels as defined by NEC.

I. Conduit or piping systems that contain water or liquid of any kind shall not be installed over the top of any electrical equipment, transformers, racks, cabinets, or enclosures without prior written approval from the Owner.

3.4 FIELD QUALITY CONTROL

A. Install field inspect and test per manufacturer recommendations prior to energizing.

B. Measure primary and secondary voltages and make appropriate tap adjustments.

END OF SECTION 26 22 13

SECTION 26 23 00 - LOW VOLTAGE TRANSFER SWITCHGEAR (SGEMSB1)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Contractual Conditions and Division 1 Specification sections apply to this section.

B. See specifications Section 26 32 13.06 for Standby Emergency Generator – Radiator Cooled Engine specifications.

C. See specifications Section 26 24 13 for Switchboard specifications.

D. See specifications 26 07 17 for Scada interface requirements

E. See specification 26 23 25 for control interface requirements

1.2 SUMMARY

A. This section includes the requirements for provision and installation of low voltage transfer switchgear and associated controls.

1.3 DESCRIPTION OF WORK

A. Low Voltage Transfer Switchgear shall consist of (but not be limited to):

1. New Switchgear Lineups as shown on the drawings (65 KAIC rated)
2. Automatic controls as described herein, integral to the switchgear
3. All devices, equipment, components, controls, wiring, conduit, feeders, circuits, etc associated with above and as noted herein and below.

B. Switchgear shall be factory-assembled, metal-enclosed switchboard(s) for distribution and control of power from incoming line terminals to outgoing feeder terminals, installed and tested in place.

1. Switchboard shall include all protective devices and equipment as listed on drawings or as included in these specifications, with necessary interconnections, instrumentation, and control wiring.
2. Switchboard shall comply with all requirements of Section 26 24 13 for Switchboard construction, components, equipment, and devices, except as modified herein.

C. Provide and install all equipment, labor, material, accessories, coordination, supervision and testing, including but not limited to the following, as required to perform functions as noted and/or as called for in these specifications and/or drawings:

1. Controls, wiring, conduit, etc.
2. Distribution equipment, devices, wires, conduit, etc.
3. Branch circuit equipment, devices, wires, conduit, etc.
4. Programming, adjustment, etc. of control switchgear.
5. Remote monitoring of each switchgear as described herein.

1.4 FUNCTION/OPERATION

A. All system operation and control functions shall be coordinated and integrated such that during automatic and/or manual operation, no unsafe condition shall occur, no malfunction of intended operation shall occur, and the highest possible reliability of operation shall be maintained.

B. Coordinate and integrate the functions and circuitry of all selector switches to ensure that the various settings available do not cause a malfunction of the intended system operation.

C. The Transfer Switchgear Controls including all metering, monitoring and annunciation shall be designed and integrated with the other specified control components to provide a completely functional total system which shall automatically perform the following generally described sequence of operations:

1. Automatic/Standby (Utility) Mode
   a) The utility mains are closed serving utility power to the bus.
   b) The generator mains are open.
   c) The automation is standing by to act in response to an independent utility failure as sensed at the Transfer Switchgear Main Breaker.

2. Emergency (Generator) Mode (Loss of Utility Service). (Open Transition)
   a) Respective utility protective relaying at switchgear main breaker senses utility voltage or frequency out of tolerance.
   b) Initiate an adjustable time delay of .5 - 10 seconds.
   c) Upon expiration of the time delay, initiate an automatic start sequence.
   d) Respective utility main is Opened.
   e) All load/distribution breakers fed from the respective failed utility service normal main are Opened, except for those breakers feeding Priority One (Life Safety) loads which shall remained closed.
   f) Power for breaker operation is to come from automatically selected best battery source selector system.
   g) A run request is sent to the generator system.
   h) Upon sensing acceptable Emergency Power at the Generator Main breaker, the Generator Main Breaker will close.
   i) Unless a block transfer signal is present from the remote Emergency Generator Switchgear, all remaining load breakers will close. If a block transfer signal is present, then the remaining feeder breakers will close as permitted by their assigned priority level as additional generator capacity becomes available.
   j) All Life Safety (Level 1, Priority 1) breakers remain closed to the bus, so the generator system provides power to these loads within 10 seconds of loss of the normal utility power service.
   k) All Critical (Level 2, Priority 2) loads are to be closed to the bus so the generator system provides power to these loads within 60 seconds of loss of the normal utility power service. If at any time, the generator on line capacity develops an overload condition (or out of tolerance condition) after the level 2, priority 2 loads are connected, the load control system shall shunt trip the level 2 priority 2 loads and wait until additional generator capacity is on line before attempt is made to reconnect these loads to the active generator system bus. Load management

signals to the transfer switchgear will come for the main Emergency Generator Paralleling Switchgear controls located in the CEP.

l) All Security (Priority 3) loads are to be closed to the bus so the generator system provides power to these loads after all Level 1, Priority 1 and Level 2, Priority 2 loads have been connected successfully to the generator system active bus. If at any time, the generator capacity on line develops an overload condition after the Priority 3 loads are connected and fed from the generator system, (drop in voltage or drop in frequency), the load control system shall trip the Priority 3 loads and wait until additional generator capacity is on line before attempt is made to reconnect these loads to the active generator system bus. The Level 2, Priority 2 loads are to remain on line.

m) All feeder breaker priority section/assignment of loads shall be field programmable/selectable by owner at the transfer switchgear OIP. This assignment be capable of being modified in the field at any time.

3. Utility Restoration and Exit from Emergency Mode (Open Transition)

a) Respective utility protective relaying senses utility voltage and frequency within tolerance.

b) Following an adjustable 5 to 30-minute time delay (which can be abbreviated by the operator) to assure that the utility power source is stable, the Transfer Switchgear Controls shall transfer to the utility source via open transition. The Generator Main Breaker will open followed immediately by closing of the Utility Main Breaker.

c) The generators are allowed to run for their programmed cool down period.

d) The Transfer Switchgear is now in Automatic/Standby (Utility) Mode.

4. Load Test Mode

a) Load Test Sequence (Actual Building Load) - Open Transition Load Assumption and Return: Provide interconnecting control circuits to produce the following normal operating function when the "Test Normal" switch on the Transfer Switchgear is selected to the "Load Test" position.

1. Initiate an automatic start sequence.
2. After the engine generators are operating, the standby system shall be capable of assuming bus load.
3. With the engine generators able to assume the entire power requirements of the load bus under test, the main utility breaker shall open and, after an adjustable time delay (0 to 10 seconds), the generator main breaker shall close (open transition).
4. Should a power failure occur while in this condition, the emergency system will continue to operate the emergency load.
5. When the "Test-Normal" switch is returned to the "Normal" position after a power failure has occurred and the generators are supplying the load, the system shall revert to the automatic loss of utility sequence as described above under Emergency (Generator) Mode.
6. When the "Test-Normal" switch is returned to the "Normal" position, and a power failure has not occurred, the generator main breaker shall open and, after an adjustable time delay (0 to 10 seconds), the main utility breaker shall close, providing a break-before-make (open transition) transfer to the utility sources.

7. After the load has been transferred back to the utility, the engine generator shall continue to run no load for an adjustable period of time from 0-30 minutes before complete shutdown.

D. Load Management

1. Provide interface with the Emergency Generator Paralleling Switchgear Controls located in the central CEP. Based on available generator capacity, the paralleling switchgear controls will provide control signals to each remote Low Voltage Transfer Switchgear system to ADD/SHED load breakers based on the breaker's priority level assignment.

E. Monitoring. Low Voltage Transfer Switchgear System shall have a complete monitoring system mounted within the lineup and also provide a remote communications interface for remote monitoring at OIP's at the generator building Operators station and the GOAA engineering office. As a minimum, the Transfer Switchgear OIP shall have the following metering/monitoring:

1. Local/Remote Monitoring and Control System (with annunciation and control)
   a) The OIP shall be independent of the existing Electrical Metering and Monitoring System (EMMS).
   b) Basis of design for this system is a Russelectric 23" color touchscreen Operator Interface Panel (OIP) with Wonderware In-Touch graphic software.
   c) The system is to be a PC based OIP and shall be provided to monitor breaker status, alarms, metering, annunciation and other operating parameters. All control functions, displays, metering and other information described herein these specifications shall be available to the operator of the OIP.
   d) The OIP shall be designed such that its operation will not in any way impede the selected automatic operation of the Transfer System Control. Any failure of the OIP shall have no impact to the automatic operation of the Transfer System Control and operation.
   e) The OIP shall communicate with the Transfer System Control via Ethernet speed network. The OIP shall have a security login screen with assignable access levels for each individual operator.
   f) The PC based Remote Monitoring and Control System shall be provided with color graphic screen presentations as listed below:
      1. Utility Metering Screen that shall contain all of the electrical metering functions listed above utilizing analog meter graphical presentation.
      2. System Metering Screen that shall contain all of the electrical metering functions listed above utilizing analog meter graphical presentation.
      3. System One Line Screen (for LV Transfer Switchgear lineup and any downstream extensions of that lineup) showing breaker position, bus & feeder energization via color, pop-up window for each selected breaker showing all available power data.
      4. PLC Comms Screen: quick reference to show if PLC is faulting or has lost communications to any device
      5. Alarm & Event History Screen: displays the last 1024 alarms or events and allow an operator access to logged alarm/event files which can be stored indefinitely

6. System/Utility Annunciation Screen that shall contain all of the Status and Alarm points above.
7. Transfer Control Screen which shall contain Set point entries for all timers
8. Breaker Priority Screen which shall contain a table to enter a priority level for every feeder breaker

F. Hard Wired Controls. The generator paralleling switchgear controls shall have a complete set of hard wired meters, control switches, indicating lights and other devices to enable complete manual operation of the emergency generator paralleling switchgear without availability of any PLC or HMI or network communications. The minimum instrumentation requirements are listed in 2.16 below. In addition, all necessary hard wired interlocks shall be included to prevent possible operator error while in manual operation. Use of a backup OIP DOES NOT SATISFY THIS REQUIREMENT.

G. Annunciation. System shall have a complete annunciation system as required by all applicable codes and standards. As a minimum, the Transfer Control Switchgear system shall have the following annunciation:

1. Individual LED annunciation windows, 1.5” x 1.5” backlit with engraved lenses in a 3-window cluster for each and every breaker showing “Open” (Green) – “Closed” (Red) – “Withdrawn” (Amber
2. Primary LED annunciation windows, 1.5” x 1.5” backlit with engraved lenses in a 14-window cluster, located above the OIP, to indicate: “System NOT in Auto”(R), “Arc Flash Mode Active”(R), “Retransfer Mode Not in Auto”(R), “Utility Available”(G), “Emergency Power Available”(R), “System on Generator Power ”(R), “System on Normal Power”(G), “SPD Alarm”(R), “Load Test Active”(R), “Bus Ground Fault Alarm”(R), (4) spares

1.5 SUBMITTALS

A. Product data shall be submitted on each basic Switchboard construction type, showing manufacturer’s standard construction data, including:

1. Cabinet construction/dimensions.
2. Bus construction.
3. UL labeling.
4. Each overcurrent device.
5. Each component.
6. Provide electrical characteristics including voltage, frame size and trip ratings, fault current withstand ratings, and time-current curves of all equipment and components.
7. Provide data on trip units, IQ Analyzer 6600 and all associated metering/monitoring components, devices, equipment, etc.
8. Installation information.
9. Certified production test reports.
10. SPD (TVSS) equipment.

B. Submit Shop Drawings: Indicate electrical characteristics and connection requirements on all components, equipment, controls, remote equipment, etc including but not limited to:

1. Master drawing index
2. Front view, side view, and plan view of the assembly showing all components including metering, breakers, etc with dimensions.

3. Plan view and Elevation drawings with dimensions, width, height, depth for each section, shipping splits and switchboard as a whole.
4. Schematic diagram. Submit single line diagrams in accordance with ANSI Y332.2 indicating connections and controls.
5. Nameplate schedule and nomenclature
6. Component list
7. Conduit space locations within the assembly. Conduit entrances and available space
8. Assembly ratings including mains and all bus rating:
    a) Short-circuit rating
    b) Voltage
    c) Continuous current rating
    d) Material
9. Major component ratings including all breaker and device ratings:
    a) Voltage
    b) Continuous current rating
    c) Interrupting ratings
    d) Frame size
    e) Trip settings
    f) Trip options provided
10. Each circuit breaker amperage rating, circuit number and position/location in Switchboard.
11. Interrupting capacity of minimum rated breaker.
12. Show all accessories, options, etc included. Submittal to be job specific.
13. Cable terminal sizes
14. Field control wiring diagrams
15. Wiring diagrams of all devices complete with terminal strips, controls. Wire marking/identification, showing interior connections and external connections.
16. Sequence of operation description
17. Busway connections
18. Bus size, arrangement and spacing.
19. Mimic bus size and color.
20. All metering and monitoring equipment.
21. All annunciation equipment.
22. Elevations of each section of switchgear complete with all components shown.
23. SPD (TVSS) equipment.
24. Key interlock scheme drawing and sequence of operations
25. Bus duct connections and sections
26. Concrete pad dimensions.
27. All OIP screen shots for this project.

C. Submit Test Reports: Indicate results of performance testing.

D. Submit Manufacturer's Certificate: Certify that Products meet or exceed specified requirements.

E. Submit Manufacturer's Field Reports: Indicate procedures and findings.

F. Submit Manufacturer's Instructions: Indicating application conditions and limitations of use stipulated by product testing agency specified under regulatory requirements. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.

G. Submit coordination drawings of all electrical rooms, showing all electrical (and mechanical) equipment. Comply with requirements of Section 26 05 01.

1.6 PROJECT AS-BUILT DOCUMENTS

A. Record actual locations of switchboards on red lined as-built documents indicating actual circuit arrangement.

B. The drawings shall include the same drawings as the construction drawings and shall incorporate all changes made during the manufacturing and installation process.

1.7 OPERATION AND MAINTENANCE DATA

A. Equipment operation and maintenance manuals shall be provided with each assembly shipped, and shall include instruction leaflets and instruction bulletins for the complete assembly and each major component

B. Submit spare parts data including source and current prices of replacement parts and supplies; and recommended maintenance procedures and intervals.

C. Submit Operation Data: Include instructions for normal operation.

D. Submit Maintenance Data: Include instructions for routine maintenance requirements, and emergency maintenance procedures.

1.8 QUALITY ASSURANCE

A. Perform Work in accordance with NFPA 110.

1.9 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum twenty five years documented experience and with a *Factory employed* service technician permanently based within 25 miles of the Project.

B. For the equipment specified herein, the manufacturer shall be ISO 9001 or 9002 certified.

C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

1.10 REFERENCES AND REGULATORY REQUIREMENTS

A. The switchgear shall bear a UL 1558 label

B. Furnish Products listed and classified by Underwriters Laboratories as suitable for purpose specified and indicated.

C. Conform to all the requirements of the following:

1. NEMA MG1 - Motors and Generators.
2. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum.)
3. NFPA 30 - Flammable and Combustible Liquids Code.
4. NFPA 70 - National Electrical Code.
5. NFPA 101 - Life Safety Code.
6. NFPA 110 - Emergency and Standby Power Systems.
7. UL 2200 Stationary Engine Generator Assemblies
8. UL 1004 Electric Motors
9. ANSI-C37.20 – Switchgear assemblies
10. ANSI-C37.13 – Low voltage power circuit breakers
11. ANSI-C37.17 – Trip devices
12. NEMA SG-5 – Switchgear assemblies
13. NEMA SG-3 – Low voltage power circuit breakers
14. UL 1558

1.11 DELIVERY, STORAGE, AND HANDLING

A. Deliver in 35 inch maximum width (or dimension required to fit section through doors), individually wrapped for protection and mounted on shipping skids.

B. Accept switchboards on site. Inspect for damage.

C. Store in a clean, dry space as designated by OAR. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

D. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to switchboard internal components, enclosure, and finish.

1.12 ENVIRONMENTAL REQUIREMENTS

A. Conform to NEMA SG-5 service conditions during and after installation of switchboards.

1.13 FIELD MEASUREMENTS

A. Coordinate field measurements with manufacturer’s requirements.

1.14 MAINTENANCE MATERIALS

A. Provide two of each key.

B. Provide two fuse pullers.

1.15 EXTRA MATERIALS

A. Provide three of each size and type of fuse installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis of Design: Russelectric (Breakers must be Cutler Hammer type specified herein and in Section 26 24 13 Switchboards)

B. Approved Substitution: Eaton/ISO (if in full compliance with these specifications)

C. NO others manufacturers are allowed.

2.2 RATINGS

A. Voltage rating shall be as indicated on the drawings. The entire assembly shall be suitable for 600 volts maximum AC service.

B. The assembly shall be rated to withstand mechanical forces exerted during short-circuit conditions when connected directly to a power source having available fault current 65,000 amperes symmetrical at rated voltage.

C. The bus system shall have a minimum ANSI 4-cycle short-circuit withstand rating of 100,000 amperes symmetrical.

D. All circuit breakers shall have a minimum symmetrical interrupting capacity of 65,000 amperes. To ensure a fully selective system, all circuit breakers shall have 30 cycle short-time withstand ratings equal to their symmetrical interrupting ratings through 42,000 amperes, regardless of whether equipped with instantaneous trip protection or not.

E. All ratings shall be tested to the requirements of ANSI C37.20.1, C37.50 and C37.51 and UL witnessed and approved.

2.3 CONSTRUCTION

A. The switchgear shall consist of the required number of vertical sections bolted together to form a rigid assembly. The sides shall be covered with removable bolt-on covers. All edges of front covers or hinged front panels shall be formed. Provide ventilators located on the top of the switchgear over the breaker and bus compartments to ensure adequate ventilation within the enclosure. Hinged rear doors, complete with lockable door handles, shall be provided.

B. The assembly shall be provided with adequate lifting means and shall be capable of being moved into installation position and bolted directly to the floor without the use of floor sills providing the floor is level to 1/8 inch per 3-foot distance in any direction. Provisions shall be made for jacking of shipping groups, for removal of skids or insertion of equipment rollers. Base of assembly shall be suitable for rolling directly on pipes without skids. The base shall be equipped with slots in the base frame members to accommodate the use of pry bars for moving the equipment to its final position.

C. Each vertical steel unit forming part of the switchgear line-up shall be a self-contained housing having one or more individual breaker or instrument compartments, a centralized bus compartment and a rear cable compartment. Each individual circuit breaker compartment, or cell, shall be segregated from adjacent compartments and sections by means of steel barriers to the maximum extent possible. It shall be equipped with drawout rails and primary and secondary disconnecting contacts. Removable hinge pins shall be provided on the breaker compartment door hinges. Current transformers for feeder instrumentation, where shown on the plans, shall be located within the appropriate breaker cells and be front accessible and removable.

D. The stationary part of the primary disconnecting devices for each power circuit breaker shall be breaker mounted and consist of a set of contacts extending to the rear through a glass polyester insulating support barrier; corresponding moving finger contacts, suitably spaced, shall be furnished on the power circuit breaker studs which engage in only the connected position. The assembly shall provide multiple silver-to-silver full floating high pressure point contacts with uniform pressure on each finger maintained by springs. Each circuit shall include the necessary three-phase bus connections between the section bus and the breaker line side studs. Load studs shall be equipped with copper load extension buses terminating in solderless type terminals in the rear cable compartment of each structure. Bus extensions shall be silver-plated where outgoing terminals are attached.

E. The circuit breaker door design shall be such that the following functions may be performed without the need to open the circuit breaker door: lever circuit breaker between positions, operate manual charging system, close and open circuit breaker, examine and adjust trip unit, and read circuit breaker rating nameplate.

F. The secondary disconnecting devices shall consist of floating terminals mounted on the stationary unit and engaging mating contacts at the front of the breaker. The secondary disconnecting devices shall be gold-plated and engagement shall be maintained in the “connected” and “test” positions.

G. The removable power circuit breaker element shall be equipped with disconnecting contacts and interlocks for drawout application. It shall have four positions, “connected,” “test,” “disconnected” and “removed.” The breaker drawout element shall contain a worm gear levering “in” and “out” mechanism with removable lever crank. Levering shall be accomplished via the use of conventional tools. Mechanical interlocking shall be provided so that the breaker is in the tripped position before levering “in” or “out” of the cell. The breaker shall include an optional provision for key locking open to prevent manual or electric closing. Padlocking shall provide for securing the breaker in the connected, test, or disconnected position by preventing levering.

H. An insulating flash shield shall be mounted above each circuit breaker to prevent flashover from the arc chutes to ground.

I. The switchgear shall be suitable for use as service entrance equipment and be labeled in accordance with UL requirements.

J. Each section of switchgear shall be compartmentalized and totally separate and isolated from adjacent section.

K. Provide a rear compartment barrier between the cable compartment and the main bus to protect against inadvertent contact with main or vertical bus bars.

L. Provide in the cell when the circuit breaker is withdrawn, a safety shutter which automatically covers the line and load stabs and protects against incidental contact.

M. Provide a glass polyester full height and depth barrier between adjacent vertical structures in the bus compartment with appropriate slots for main bus.

2.4 BUS

A. All bus bars shall be silver-plated copper. Bus sizing shall be based on ANSI standard temperature rise criteria of 65 degrees C over a 40 degrees C ambient (outside the enclosure).

B. Provide a full capacity neutral bus where a neutral bus is indicated on the drawings.

C. A copper ground bus shall be furnished firmly secured to each vertical section structure and shall extend the entire length of the switchgear. The ground bus short-time withstand rating shall meet that of the largest circuit breaker within the assembly.

D. All hardware used on conductors shall be high-tensile strength and zinc-plated. All bus joints shall be provided with Belleville-type washers.

2.5 WIRING/TERMINATIONS

A. Small wiring, necessary fuse blocks and terminal blocks within the switchgear shall be furnished as required. Control components mounted within the assembly shall be suitably marked for identification corresponding to the appropriate designations on manufacturer's wiring diagrams.

B. Provide a front accessible, isolated vertical wireway for routing of factory and field wiring. Factory provisions shall be made for securing field wiring without the need for adhesive wire anchors.

C. Front access to all circuit breaker secondary connection points shall be provided for ease of troubleshooting and connection to external field connections without the need of removing the circuit breaker for access.

D. All control wire shall be type SIS. Control wiring shall be minimum 14 gauge for control circuits and minimum 12 gauge for shunt trip and current transformer circuits. Wire bundles shall be secured with nylon ties and anchored to the assembly with the use of pre-punched wire lances or nylon non-adhesive anchors. All current transformer secondary leads shall first be connected to conveniently accessible shorting terminal blocks before connecting to any other device. Shorting screws with provisions for storage shall be provided. All groups of control wires leaving the switchgear shall be provided with terminal blocks with suitable numbering strips and provisions for #10 AWG field connections. Each control wire shall be clearly identified by means of a heat embossed vinyl sleeve markers at each end. Labeling tape wire markers are not acceptable. Wire numbers shall match the Manufacturer's interconnection, schematic and wiring drawings. Plug-in terminal blocks shall be provided for all shipping split wires. Terminal connections to remote devices or sources shall be front accessible via doors above each circuit breaker.

E. Mechanical type pressure lugs shall be provided for all line and load terminations suitable for copper cable rated for 75 degrees C of the size indicated on the drawings.

F. Lugs shall be provided in the incoming line section for connection of the main grounding conductor. Additional lugs for connection of other grounding conductors shall be provided as indicated on the drawings.

2.6 CIRCUIT BREAKERS

A. All protective devices shall be low voltage power circuit breakers. All breakers shall be UL listed for application in their intended enclosures for 100% of their continuous ampere rating.

B. All power circuit breakers shall be constructed and tested in accordance with ANSI C37.13, C37.16, C37.17, C37.50, UL 1066 and NEMA SG-3 standard. The breaker shall carry a UL label.

C. Breakers shall be provided in drawout configuration. The 800, 1600, and 2000 ampere frame power circuit breakers shall be provided in the same physical frame size, while 3200, 4000 and 5000 ampere frame power circuit breakers shall be provided in a second physical frame size. Both physical frame sizes shall have a common height and depth.

D. Power circuit breakers shall utilize a two-step stored-energy mechanism to charge the closing springs. The closing of the breaker contacts shall automatically charge the opening springs to ensure quick-break operation.

E. All circuit breaker shall be electrically operated and equipped with auxiliary contacts, bell alarm contacts, and microprocessor based trip units.

F. Breakers shall have 24Vdc shunt trip, powered from best battery system integral to switchgear system.

G. Breakers shall be electrically operated (EO) with 120V AC motor operators. The charging time of the motor shall not exceed 6 seconds.

H. To facilitate lifting, the power circuit breaker shall have integral handles on the side of the breaker.

I. The power circuit breaker shall have a closing time of not more than 3 cycles.

J. The primary contacts shall have an easily accessible wear indicator to indicate contact erosion.

K. The power circuit breaker shall have three windows in the front cover to clearly indicate any electrical accessories that are mounted in the breaker. The accessory shall have a label that will indicate its function and voltage.

2.7 TRIP UNITS

A. Each low voltage power circuit breaker shall be equipped with a solid-state tripping system consisting of three current sensors, microprocessor-based trip device and flux-transfer shunt trip. Current sensors shall provide operation and signal function. The trip unit shall use microprocessor-based technology to provide the basic adjustable time-current protection functions. True RMS sensing circuit protection shall be achieved by analyzing the secondary current signals received from the circuit breaker current sensors and initiating trip signals to the circuit breaker trip actuators when predetermined trip levels and time delay settings are reached. Interchangeable current sensors with their associated rating plug shall establish the continuous trip rating of each circuit breaker. The basis of design is Cutler-Hammer type Digitrip 1150.

B. The trip unit shall have an information system that provides LEDs to indicate mode of trip following an automatic trip operation. The indication of the mode of trip shall be retained after an automatic trip. A reset button shall be provided to turn off the LED indication after an automatic trip.

C. The trip unit shall be provided with a display panel, including a representation of the time/current curve that will indicate the protection functions. The unit shall be continuously self-checking and provide a visual indication that the internal circuitry is being monitored and is fully operational.

D. The trip unit shall be provided with a making-current release circuit. The circuit shall be armed for approximately two cycles after breaker closing and shall operate for all peak fault levels above 25 times the ampere value of the rating plug.

E. Trip unit shall have selectable thermal memory for enhanced circuit protection.

F. Complete system selective coordination shall be provided by the addition of the following individually adjustable time/current curve shaping solid-state elements:

1. All circuit breaker shall have adjustments for long delay pickup and time.
2. All circuit breakers shall have individual adjustments for short delay pickup and time, and include I^2t settings and adjustable instantaneous pickup.
3. All circuit breakers shall have individually adjustable ground fault current pickup and time, and include I^2t settings or ground alarm only. GF alarm only on priority one (life safety) feeders, GF trip on all other feeders.
4. All circuit breakers on emergency designated switchboards shall have individually adjustable ground fault alarm (LSIA).

G. The trip unit shall have provisions for a single test kit to test each of the trip functions.

H. The trip unit shall provide zone interlocking for the short-time delay and ground fault delay trip functions for improved system coordination. The zone interlocking system shall restrain the tripping of an upstream breaker and allow the breaker closest to the fault to trip with no intentional time delay. In the event that the downstream breaker does not trip, the upstream breaker shall trip after the present time delay. Factory shall wire for zone interlocking for the power circuit breakers within the switchgear.

I. The trip unit shall have an information system that utilizes battery backup LEDs to indicate mode of trip following an automatic trip operation. The indication of the mode of trip shall be retained after an automatic trip operation. The indication of the mode of trip shall be retained after an automatic trip. A test pushbutton shall energize a LED to indicate the battery status

J. The trip unit shall have a 4-character LCD display showing phase, neutral, and ground current. The accuracy of these readings shall be +/- 2% of full scale

K. The trip unit shall be equipped to permit communication via twisted pair for remote monitoring and control by existing and new PowerNet system. The trip unit shall include a power/relay module which shall supply control to the readout display. Following an automatic trip operation of the circuit breaker, the trip unit shall maintain the cause of trip history and the mode of trip LED indication as long as its internal power supply is available. An internal relay shall be programmable to provide contacts for remote ground alarm indication.

L. The trip unit shall include a voltage transformer module, suitable for operation up to 600V, 50/60 Hz. The primary of the power relay module shall be connected internally to the line side of the circuit breaker through a dielectric test disconnect plug.

M. An internal relay shall be programmable to provide contacts for remote ground alarm indication.

N. Utility Main, Generator Main and circuit breakers serving Life Safety Loads shall have individually adjustable ground fault alarm only. Circuit breakers serving equipment loads shall have ground fault trip only.

O. The trip unit shall be equipped to permit communication via a network twisted pair for owners remote PowerNet system.

P. The display for the trip units shall be a 24 character LED display.

Q. Metering display accuracy of the complete system, including current sensors, auxiliary CTs, and the trip unit, shall be +/- 1% of full scale for current values. Metering display accuracy of the complete system shall be +/- 2% of full scale for power and energy values.

R. The unit shall be capable of monitoring the following data:

1. Instantaneous value of phase, neutral and ground current.
2. Instantaneous value of line-to-line voltage.
3. Minimum and maximum current values.
4. Watts, vars, VA, watt-hours, var-hours, and VA hours.

S. The energy-monitoring parameter values (peak demand, present demand, and energy consumption) shall be indicated in the trip unit’s alphanumeric display panel

T. The trip unit shall display the following power quality values:

1. Crest Factor.
2. Power Factor.
3. Percent total harmonic distortion.
4. Harmonic values of all phases through the 31st harmonic.

U. The main breaker trip unit shall have the following advanced features integral to the trip unit:

1. Adjustable undervoltage release.
2. Adjustable overvoltage release.
3. Reverse load and fault current.
4. Reverse sequence voltage alarm.
5. Under frequency.
6. Over frequency.
7. Voltage phase unbalance and phase loss during current detection.

V. An adjustable high load alarm shall be provided, adjustable from 50 to 100% of the long delay pickup setting.

W. The trip unit shall contain an integral test pushbutton. A keypad shall be provided to enable the user to select the values of test currents within a range of available settings. The protection functions shall not be affected during test operations. The breaker may be tested in the TRIP or NO TRIP test mode.

X. Programming may be done via a keypad at the faceplate of the unit or via the existing communication network.

Y. System coordination shall be provided by the following microprocessor-based programmable time-current curve shaping adjustments. The short-time pickup adjustment shall be dependant on the long delay setting.

1. Programmable long-time setting
2. Programmable long-time delay with selectable I^2T or I^4T curve shaping
3. Programmable short-time setting
4. Programmable short-time delay with selectable flat or I^2T curve shaping, and zone selective interlocking
5. Programmable instantaneous setting
6. Programmable ground fault setting trip or ground fault setting alarm
7. Programmable ground fault delay with selectable flat or I^2T curve shaping and zone selective interlocking.
8. The trip unit shall offer a three-event trip log that will store the trip data, and shall time and date stamp the event

2.8 ENCLOSURE TYPE 1 – GENERAL PURPOSE

A. Align sections at front and rear.

B. Switchboard Height: 96 inches, excluding floor sills, lifting members and pull boxes.

C. Mimic Bus: Show bussing, connections and devices in single line form on the front panels of the switchboard using black color plastic strips, fastened flat against the panel face with screws or rivets.

D. Provide hinged rear doors with provisions for padlocking.

2.9 SURGE SUPPRESSION DEVICE (SPD)

A. Each lineup of switchgear shall include a door mounted surge protector(s). The SPD unit(s) shall be rated Type 1 UL1449, fourth edition. SPD shall be equipped with a fused disconnect for isolation when servicing. Use of a breaker is not acceptable as the breaker limits the surge capacity of the SPD. SPD shall be mounted in an open section nearest to the main incoming power source section with lead length kept to a minimum. The display unit shall be connected via ribbon cable to the main unit and mounted so as to be visible when the door is closed.

B. See specification section 26 43 13 on SPD for additional information.

C. Provide SPD for each bus as shown on the drawings.

2.10 POWER QUALITY METER AND ANALYZER METERS

A. Each lineup of switchgear shall include a Cutler-Hammer IQ Analyzer 6600 with Poni card (or approved substitution) wired with #18 gauge twisted pair shielded cable. Belden 9463 family in a daisy chain and connected to the Digitrip trip units on each circuit breaker to the existing Cutler-Hammer Powernet System. All communications cabling is to be factory installed and terminated to a terminal block for continuation to the Powernet System.

B. Provide meters with appropriate multiplier tags.

2.11 METERING TRANSFORMERS

A. Current Transformers; ANSI C57.13; 5 ampere secondary, primary/ secondary ratio as required, burden and accuracy consistent with connected metering and relay devices, 60 Hertz.

B. Potential Transformers: ANSI C57.13; 120 volt disconnecting type with integral fuse mountings, primary/secondary ratio as required, burden and accuracy consistent with connected metering and relay devices, 60 Hertz.

2.12 ACCESSORIES

A. Circuit Breaker Lifting Device: Carriage and track on top of each switchboard with lifting device to serve draw-out circuit breakers in switchboard.

2.13 NAMEPLATES

A. Engraved nameplates, mounted on the face of the assembly, shall be furnished for all main and feeder circuits as indicated on the drawings. Nameplates shall be laminated plastic, white characters on red background, and secured with screws. Characters shall be 3/16-inch high, minimum.

B. Furnish master nameplate giving switchgear designation, voltage ampere rating, short-circuit rating, and manufacturer’s name.

C. Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturer’s drawings

2.14 FINISH

A. All exterior and interior steel surfaces of the switchgear shall be properly cleaned and provided with a rust-inhibiting phosphatized coating. Color and finish of the switchgear shall be ANSI 61

2.15 TRANSFER SWITCHGEAR CONTROL SYSTEM

A. A Transfer Switchgear Control System shall be provided to facilitate overall system operation including automatic transfer control, monitoring of the available power sources, engine start command, alarm/fault monitoring, breaker control and monitoring and communication to remote Generator Building CEP controls and remote OIP locations.

B. The Switchgear Control System shall utilize redundant fiber optic communication networks, in ring configuration, to communicate with the redundant PLC controls located in the Generator Building CEP main emergency switchgear controls. Redundant I/O drops shall be provided within each 480V Transfer Switchgear to interface with breakers, meters, annunciators, control switches and other devices as required. The CEP Switchgear Control System shall provide all functions and operations as specified in these specifications and as listed or noted on drawings.

C. Coordination of 480V Transfer Switchgear Controls with the Generator CEP control system shall be the responsibility of the 480V transfer switchgear supplier. Update of the Generator Building Control and SCADA screens, logic software and communication hardware, that may be required for this Transfer Control Switchgear shall be provided by the Transfer Control Switchgear provider. All documentation updates of the Main Generator Switchgear controls and SCADA system that are necessary for implementation and support of the Transfer Switchgear shall also be provided.

D. A third fiber-optic pair shall be provided for SCADA communications between the Generator Building Main Controls and the transfer switchgear.

2.16 HARD WIRED METERING/CONTROLS

A. Each Utility Main Breaker shall have the following discrete hard wired metering:

1. Analog Voltmeter (4”) with phase selector switch
2. Analog Ammeter (4”) with phase selector switch
3. Crompton Integra Multi-function meter (4”) to display selectable values: KW, PF, Freq, THD, etc.

B. Each Feeder Breaker shall have the following discrete hard wired metering and control devices.

1. Analog Voltmeter (4”) with phase selector switch
2. Crompton Integra Multi-function meter (4”) to display selectable values: KW, Amps, PF, Freq, THD, etc.
3. Breaker control switch.
4. The above shall be grouped together on door of the ”B” cubicle compartment for each feeder breaker vertical section together with the 3-lie breaker annunciator (specified elsewhere herein) and breaker control switch. A common lamp test push button shall also be included on the door.

C. Fault Tolerance:

1. Redundant PLC’s -- The Transfer Switchgear Control System shall be designed using redundant PLC’s with redundant I/O drops. In addition it shall be provided with redundant fiber optic communications to the redundant PLC’s in the Generator switchgear controls located in the central generator building. The Transfer Switchgear redundant PLC’s shall provide bumpless transfer on fault and using redundant distributed I/O networks to maximize system fault tolerance.
2. Hard wired manual backup – As described herein, there shall be hard wired manual controls and instrumentation that allow full operation of the system WITHOUT availability of any PLC or OIP. Hard wiring shall include necessary interlocks to prevent operator error.
3. Best Source DC – All DC sources shall be constantly evaluated for suitability to power the System and Generator set control and protection. As standard, this DC system shall include all Generator set batteries and a System Station battery with regulated charger. Should any battery fail, the system shall switch to the next viable DC source with no interruption of operation. All control, operator interface, and protection shall be powered by this system.
4. Supervisory Control Network – To insure the integrity of the supervisory control network, fiber optic cable shall be used wherever the supervisory network leaves the protection of the switchgear. To assure network fault tolerance, this fiber optic cable is to be in a self-healing ring configuration.

D. Human Machine Interface (OIP)

1. A 23-inch *minimum* (diagonal), color TFT industrial display shall be provided for operator interface panel(s) as standard equipment. This display shall support a minimum resolution of 1280 x 1024 pixels. Interface shall be accomplished via a key protected touch screen permanently affixed to the display. The touch screen shall be clear glass, with light transmission of 95% or better, furnished with a Surface Acoustic Wave touch interface. Resistive or Capacitive touch interfaces are not acceptable. Navigation and operation shall be intuitive such that Help Screens are not required. The Operator Interface will access to system operating parameters, set points, graphical displays and other information as defined elsewhere in this specification.

2.17 ARC REDUCTION MODE (ARM’s)

A. Provide Arc Flash Reduction Mode capability for all breakers in the switchgear. A common ARM switch shall be mounted below the OIP and shall illuminate an annunciator window when active.

2.18 BUS GROUND FAULT

A. Provide a Bus Ground Fault Differential scheme for each load bus using ITI (or equivalent) BGFL relays and zero sequence CT's. A detected GF shall not trip any source breakers, rather it will sound an alarm horn on the gear and illuminate an annunciator window when active.

2.19 IR WINDOWS

A. Provide Cutouts in rear doors to accommodate 4" IR windows per GOAA standards, as described on the drawings. Windows shall be provided and factory installed.

2.20 STATION BATTERY SYSTEM

A. Provide 24 VDC Nicad Station Battery System for Switchgear controls that will be connected to the best battery selector

B. Minimum battery capacity shall be 150 amp-hr @ 8-hour rate.

C. Provide rack, cell connectors and power lugs

D. Furnish wall mount charger, 120 VAC input, 25 amp @24 VDC output with AC input breaker, DC output breaker, DC volt meter, DC amp meter, equalizing timer, alarms lights for AC failure, DC failure, High VDC, Low VDC, positive & negative ground fault and common alarm contact

PART 3 – EXECUTION

3.1 PREPARATION/INSPECTION/EXAMINATION

A. Verify that surface is suitable for switchboard installation.

B. Check that concrete pads are level and free of irregularities

C. Examine area to receive switchboard to assure adequate clearance for switchboard installation.

D. Verify that National Electrical Code clearances will be maintained after installation. Rework equipment locations as required to provide required clearances.

E. Start Work only after unsatisfactory conditions are corrected.

3.2 INSTALLATION

A. Install all switchboard enclosures in accordance with the manufacturer's written instructions, NECA's "Standard of Installation", the applicable requirements of the National Electrical Code, and recognized industry practices.

B. Mount switchboard on 3” concrete base extending 3” outside all sides.

C. Provide rubber insulating mats on floor in front of board for entire length of board, minimum 4 feet wide.

D. Install switchboards plumb. Provide supports in accordance with Section 26 05 29.

E. Provide doors for unused spaces in switchboards.

F. Install switchboards so that proper working clearances shall be maintained at every switchboard location, both front and back.

G. Clean the interior of each switchboard before installing conductors. At all times, keep the interior trim and exterior surfaces of the switchboard free of rust and debris. Repaint finishes if necessary.

H. Coordinate all raceways and conductors with their respective switchboards so that all connections and conductors routing present an orderly appearance. Conductors in the switchboards shall be laced and arranged in orderly manner.

I. Provide a separate 24vdc circuit as required to power any shunt-trip function/device.

J. All necessary hardware to secure the assembly in place shall be provided by the Contractor.

K. The equipment shall be installed and checked in accordance with the manufacturer’s recommendations. This shall include but not limited to:

1. Checking to ensure that the pad location is level to within 0.125 inches per three foot of distance in any direction.
2. Checking to ensure that all bus bars are torqued to the manufacturer’s recommendations.
3. Assembling all shipping sections, removing all shipping braces and connecting all shipping split mechanical and electrical connections.
4. Securing assemblies to foundation or floor channels.
5. Measuring and recording Megger readings phase-to-phase, phase-to-ground, and neutral-to-ground (four wire systems only).
6. Inspecting and installing all circuit breakers in their proper compartments.

L. MONITORING/METERING

1. Provide/install all components, wiring, cable (fiber optic and copper), raceways, hubs, switches, patch panel modules, pc cards, communication network devices, converters, etc., as required to connect switchgear to remote OIP’s that will be located in Electrical Maintenance Shop/Office and in the CEP.
2. All revisions to software, programming, etc., are to be by manufacturer of the switchgear.

M. IDENTIFICATION

1. Refer to Section 26 05 53 for products and content.

2. Provide engraved plastic nameplates under the provisions of 26 05 53.

N. Conduit or piping systems that contain water or liquid of any kind shall not be installed over the top of any electrical equipment, transformers, racks, cabinets, or enclosures without prior written approval from the Owner.

3.3 FACTORY TESTING

A. The switchgear shall be completely assembled, wired, adjusted and tested at the factory. After assembly, the complete switchgear shall be tested to ensure the accuracy of the wiring and the functioning of all equipment. The main bus system shall be given a dielectric test of 2200 volts for one minute between live parts and ground and between opposite polarities.

B. The wiring and control circuits shall be given a dielectric test of 1500 volts for one minute, or 1800 volts for one second, between live parts and ground, in accordance with ANSI C37.20.1.

C. A certified test report of all standard production tests shall be shipped with each assembly.

D. Testing at factory is to include all interlocking and breaker control functions.

E. Certification of this test must be provided prior to delivery of this equipment.

3.4 MANUFACTURER'S CERTIFICATION

A. A qualified factory-trained manufacturer's representative shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations.

B. The Contractor shall provide three (3) copies of the manufacturer's representative's certification before final payment.

3.5 FIELD QUALITY CONTROL

A. Perform field inspection and testing.

B. Provide full load test utilizing portable test bank, for four hours minimum. Simulate power failure including operation of transfer between sources, automatic starting cycle, automatic shutdown and return to normal.

C. Record in 20 minute intervals during four hour test:

1. Kilowatts.
2. Amperes.
3. Voltage.
4. Coolant temperature.
5. Room temperature.
6. Frequency.
7. Oil pressure.

D. Test alarm and shutdown circuits by simulating conditions.

E. Provide the services of a qualified factory-trained manufacturer’s representative to assist the Contractor in installation and start-up of the equipment specified under this section for a period of not less than 10 working days. The manufacturer’s representative shall provide technical direction and assistance to the contractor in general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained therein.

F. The manufacturer’s representative shall provide inspection of the final installation. The manufacturer’s representative shall perform site start-up and functional checkout of the Switchgear. Upon completion of the manufacturer's start-up and checkout, the manufacturer shall demonstrate to the customer all the automated sequences of operation as specified herein.

G. The Contractor shall provide three (3) copies of the manufacturer’s field start-up report.

H. Measure steady state load currents at each switchboard feeder; rearrange circuits to balance the phase loads to within 20 percent of each other. Maintain proper phasing for multi-wire branch circuits.

I. Visual and Mechanical Inspection: Inspect for physical damage, proper alignment, anchorage, and grounding. Check proper installation and tightness of connections for circuit breakers, fusible switches, and fuses.

J. All circuits shall be operated to establish a good working order and checked for shorts.

K. All panel directory circuit numbers shall be checked to verify accuracy of the number.

L. Measure insulation resistance of each bus section phase to phase and phase to ground for one minute each, at test voltage of 1000 volts; minimum acceptable value for insulation resistance is 2 megohms. Disconnect all electronic circuitry and TVSS units prior to test.

M. Check tightness of accessible bolted bus joints using calibrated torque wrench.

N. Physically test key interlock systems to insure proper function.

O. Tests:

1. Test Switchboards and switchboard feeders per requirements of Section 26 08 10.
2. Test all operational features of switchboard including interlocking, remote controls, touch screen, remote computer PC control, etc.
3. Feeder conductors shall be checked by approved means to establish the absence of shorts to ground; insulation value, etc. and the result recorded and submitted to the Designer.
4. Submit Conductor Insulation Resistance Test per requirements of Section 26 08 10.
5. Submit Tabulation Data Voltage and Amperage Readings per requirements of Section 26 08 10.

P. Equipment Checkout:

1. When requested by Designer/OAR provide (during construction):

a) Inspection of equipment by authorized equipment manufacturer technician complete with submittal of statement of findings by technician, and providing any adjustments deemed necessary for a complete and operating system.

2. Submit Equipment Checkout Memo per Section 26 08 10.

3.6 TRAINING

A. The Contractor shall provide training sessions for up to five (5) owner’s representatives. Both training sessions shall be for 2 normal workdays. One shall be held during project close out as required in other sections of these specifications and one shall be held six (6) months after initial training. Both shall be performed at a jobsite location determined by the owner.

B. For both sessions: Upon successful completion of the demonstration of the automated sequences of operation by the manufacturer and acceptance by the customer, the manufacturer shall provide an eight-hour "hands-on" training course for the customer's operating personnel which shall cover the following topics:

1. Overall System Description and Theory of Operation
2. Automatic Operation
3. Manual Operation
4. Safeties and Protective Relaying
5. Recommended System Check Lists and Log Sheets
6. Recommended Preventive Maintenance

C. A manufacturer’s qualified representative shall conduct the training session. The training program shall also include instruction on the operation of the assembly, circuit breakers, and major components within the assembly.

D. All training sessions shall be video taped. Tape to be turned over to owner.

3.7 ADJUSTING

A. Adjust all operating mechanisms for free mechanical movement.

B. Tighten bolted bus connections in accordance with manufacturer’s instructions.

C. Adjust circuit breaker trip and time delay settings to values determined by approved Contractor provided Power Systems Study, and any manufacturer’s recommendation.

3.8 DEMONSTRATION

A. Provide systems demonstration.

B. Describe loads connected to emergency and standby system and restrictions for future load additions.

C. Simulate power outage by interrupting normal source, and demonstrate that system operates to provide emergency and standby power.

END OF SECTION 26 23 00

SECTION 26 24 13 – SWITCHBOARDS-DRAW OUT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Contractual Conditions and Division 01 Specification sections apply to this section.

1.2 SUMMARY

A. This section includes the requirements for provision and installation of switchboards.

B. Normal and emergency switchboards shall comply with these specifications. Emergency switchboards shall also comply with Section 26 07 17 SCADA Monitoring and Control and Section 26 23 25 Medium-Voltage Generator Paralleling Switchgear and Controls.

1.3 DESCRIPTION

A. Factory-assembled, metal-enclosed switchboard for distribution and control of power from incoming line terminals to outgoing feeder terminals, installed and tested in place.

B. Switchboard shall include all protective devices and equipment as listed on drawings or as included in these specifications, with necessary interconnections, instrumentation and control wiring.

C. The terms switchgear and switchboard are used ~~synonymously~~synonymously with each other. Switchgear shall be considered switchboard(s) and visa versa.

D. All breakers in all emergency switchgear shall be controlled by the control logic of the generator switchgear.

~~D.~~E. All main breakers and tie breakers in all emergency switchgear shall be interlocked with the breakers in emergency switchgear so only one source of power is connected to any one bus at any point in time.

1.4 SUBMITTALS

A. Product data shall be submitted on each basic ~~Switchboard~~switchboard construction type, showing manufacturer's standard construction data, including:

1. Cabinet construction/dimensions.
2. Bus construction.
3. UL labeling.
4. Each overcurrent device.
5. Each component.
6. Provide electrical characteristics including voltage, frame size and trip ratings, fault current withstand ratings, and time-current curves of all equipment and components.
7. Provide data on trip units, and all metering/monitoring components, devices, equipment, etc.
8. Installation information.
9. Certified production test reports.

10. Best battery system.

B. Shop drawings shall be submitted for all switchboards. Indicate the following information:

1. Label.
2. Each circuit breaker amperage rating, circuit number and position/location in Switchboard.
3. Electrical characteristics of ~~Switchboard~~switchboard.
4. Mains rating.
5. Main device rating.
6. Mounting.
7. Dimension, width, depth, height.
8. Bus material.
9. Schematic diagram.
10. Wiring diagrams of all devices complete with terminal strips, controls, wire marking/identification, showing interior connections and external connections.
11. Interrupting capacity of minimum rated breaker.
12. Switchboard type.
13. Component list.
14. Locations of all components including breakers, metering, monitoring, terminal strips, etc.
15. Nameplate legend for each overcurrent device.
16. Front and side views of enclosures with overall dimensions shown.
17. Conduit entrance locations and requirements.
18. Frame sizes and Interrupting capacity of each breaker, and total assembly.
19. Horsepower ratings at rated voltage of fused switches and/or breakers.
20. Switchboard instrument details.
21. Type of labels and labeling for every device and what it feeds.
22. Nameplate on main panelboard giving name of project; Architect, Engineer and Contractor.
23. Bus bar size, arrangement and spacing.
24. ~~TVSS~~Surge Protective Device Equipment
25. Metering/Monitoring Equipment.
26. Layouts showing concrete pad dimensions, conduit entrance and available space, bus duct connections, electrical ratings, nameplate nomenclature, and single-line diagrams in accordance with ANSI Y32.2 indicating connections and controls.

27. Submit coordination drawings of all electrical rooms, showing all electrical (and mechanical) equipment. Comply with requirements of Section 26 05 00 Common Work Results for Electrical.

28. Busway connections.

29. Bus duct connections.

30. Composite front view and plan view of close-coupled assemblies.

31. Key interlock scheme drawing and sequence of operations.

32. Mimic bus size and color.

33. Best battery system.

~~33.~~34. Secondary contact configuration for each breaker type and cubicle type.

C. Manufacturer's Instructions indicating application conditions and limitations of use stipulated by product testing agency specified under regulatory requirements. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.

1.5 PROJECT AS-BUILT DOCUMENTS

A. Record actual locations of switchboards on red lined as-built documents indicating actual circuit arrangement.

B. The drawings shall include the same drawings as the construction drawings and shall incorporate all changes made during the manufacturing and installation process.

1.6 OPERATION AND MAINTENANCE DATA

A. Equipment operation and maintenance manuals shall be provided with each assembly shipped, and shall include instruction leaflets and instruction bulletins for the complete assembly and each major component.

B. Submit spare parts data including source and current prices of replacement parts and supplies; and recommended maintenance procedures and intervals.

1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing Products specified in this Section with minimum 10 years experience.

1.8 REFERENCES AND REGULATORY REQUIREMENTS

A. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for purpose specified and shown.

B. Conform to the requirements of the following:

1. ANSI/NFPA 70 - National Electrical Code.
2. ANSI/IEEE C12.1 - Code for Electricity Metering.
3. ANSI C39.1 - Electrical Analog Indicating Instruments.
4. ANSI C56.13 - Instrument Transformers.
5. ANSI C37.20 - Switchgear Assemblies

6. ANSI C37.13 - Low Voltage Power Circuit Breakers
7. ANSI C37.17 - Trip Devices
8. NEMA SG-5 - Switchgear Assemblies
9. NEMA SG-3 - Low Voltage Power Circuit Breaker
10. UL 1558 – Metal Enclosed Low-Voltage Power Circuit Breaker Switchgear

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver in 35 inch maximum width (or dimension required to fit section through doors), individually wrapped for protection and mounted on shipping skids.

B. Accept switchboards on site. Inspect for damage.

C. Store in a clean, dry space as designated by OAR. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

D. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to switchboard internal components, enclosure, and finish.

1.10 ENVIRONMENTAL REQUIREMENTS

A. Conform to NEMA SG-5 service conditions during and after installation of switchboards.

1.11 FIELD MEASUREMENTS

A. Coordinate field measurements with manufacturer’s requirements.

1.12 MAINTENANCE MATERIALS

A. Provide two of each key (if applicable).

B. Provide two fuse pullers (if applicable).

1.13 EXTRA MATERIALS

A. Provide three of each size and type of fuse installed (if applicable).

B. Provide one spare breaker of each combination of trip unit and frame size used in project. A minimum of five spare breakers are required (1600, 2000, 3200 and 4000 amp). Complete with trip units, options, etc., as specified herein.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Emergency Switchboards/switchgear (All switchgear/switchboards connected to any branch of the emergency distribution system). Manufacturer of emergency switchboards/switchgear shall be the same manufacturer as the manufacturer of the emergency generator ~~GENMVI~~GENMV1 switchboard/switchgear.

1. Basis of Design: Russelectric, or approved substitution.

B. Normal Distribution Switchboards/switchgear (All switchgear/switchboards connected only ~~only~~ to normal power distribution system)

1. ~~Eaton~~Eaton, or approved substitutions.

2.2 GENERAL

A. Switchboards with circuit breaker branch protective devices shall comply with NEMA SG-5 as a minimum requirement. Switchboard shall meet Underwriter's Laboratories enclosure requirements for service conditions.

B. Each cubicle shall have UL Label affixed, unless special construction prohibits and no labeling or listing is available.

C. The sides and tops shall be covered with removable screw-on code gauge steel plates.

D. Switchboards shall be completely self supporting structures, 96” high.

E. Minimum integrated short circuit rating: 100,000 amperes rms symmetrical for 480 volt. Bus shall be braced for minimum capacity equal to or greater than the lowest breaker symmetrical interrupting capacity. Minimum short circuit rating shall be increased to meet the following requirements:

1. Individual C.B. AIC Rating shown on panel schedules indicate lowest AIC rating allowed for individual circuit breaker in panel.

2. Circuit breakers shall be based on a fully rated system. Circuit breaker types are not shown or called for. The contractor must provide breakers in panel or feeder breakers in upstream breakers to comply with the required AIC specified.

F. Main section devices, distribution section devices, and all auxiliary devices shall be individually mounted and compartmented, draw-out construction.

G. Provide best battery system in emergency switchboards to provide shunt trip power to all circuit breakers in boards complete with uninterruptible power supply, battery charger and batteries. System is to be monitored by the ~~PowerXpert~~Power Xpert metering and monitoring system for proper operation. Provide all electrical to achieve this.

H. Provide complete interlock system between all applicable breakers in normal and emergency switchboards as required ~~preventing~~to prevent closing of any two sources onto same bus at same time. Submit narrative of interlock.

2.3 SWITCHBOARD

A. Description: NEMA SG-5 with electrical ratings and configurations as indicated.

B. Main Section Devices: Individually mounted and compartmented, draw-out construction.

C. Distribution Section Devices: Individually mounted and compartmented, draw-out construction

D. Auxiliary Section Devices: Individually mounted and compartmented.

E. Bus Material: Copper with tin plating, standard size.

F. Bus connections: Bolted, accessible from rear only for maintenance.

G. Fully insulate bus bars in rear accessible compartments.

H. Ground bus: Extend length of Switchboard, braced for 100,000 amps symmetrical short circuit current.

I. All protective devices shall be low voltage power circuit breakers. Basis of design is ~~Eaton~~Eaton Type Magnum DS. All breakers shall be UL listed for application in their intended enclosures for 100% of their continuous ampere rating.

J. All power circuit breakers shall be constructed and tested in accordance with ANSI C37.13, C37.16, C37.17C37.50, UL 1066 and NEMA SG-3 standard. The breaker shall carry a UL label.

K. Power circuit breakers shall utilize a two-step stored-energy mechanism to charge the closing springs. The closing of the breaker contacts shall automatically charge the opening springs to ensure quick-break operation.

L. Breakers shall be electrically operated (EO) with 120V AC motor operators. The charging time of the motor shall not exceed 6 seconds.

M. Trip Units:

1. Each low voltage power circuit breaker shall be equipped with a solid-state tripping system consisting of three current sensors, microprocessor-based trip device and flux-transfer shunt trip. Current sensors shall provide operation and signal function. The trip unit shall use microprocessor-based technology to provide the basic adjustable time-current protection functions. True rms sensing circuit protection shall be achieved by analyzing the secondary current signals received from the circuit breaker current sensors and initiating trip signals to the circuit breaker trip actuators when predetermined trip levels and time delay settings are reached. Interchangeable current sensors with their associated rating plug shall establish the continuous trip rating of each circuit breaker. The basis of design is ~~EATON~~Eaton type Digitrip 1150 Plus~~ ARMS~~ on mains and Digitrip 1150 on feeders and ties.

2. Complete system selective coordination shall be provided by the addition of the following individually adjustable time/current curve shaping solid-state elements:

   a) All circuit breakers shall have adjustments for long delay pickup and time.

   b) All circuit breakers shall have individual adjustments for short delay pickup and time, and include I^2t settings and adjustable instantaneous pickup.

   c) All circuit breakers shall have individually adjustable ground fault current pickup and time, and include I^2t settings or ground alarm only.

   d) All circuit breakers on emergency designated switchboards shall have individually adjustable ground fault alarm (LSIA).

3. The trip unit shall be equipped to permit communication via twisted pair for remote monitoring and control.

4. An internal relay shall be programmable to provide contacts for remote ground alarm indication.

5. The display for the trip units shall be a 24 character LED display.

6. Metering display accuracy of the complete system, including current sensors, auxiliary CTs, and the trip unit, shall be +/- 1% of full scale for current values. Metering display accuracy of the complete system shall be +/- 2% of full scale for power and energy values.

7. The unit shall be capable of monitoring the following data:

a) Instantaneous value of phase, neutral and ground current.

b) Instantaneous value of line-to-line voltage.

c) Minimum and maximum current values.

d) Watts, vars, VA, watthours, varhours, and VA hours.

8. The trip unit shall display the following power quality values:

a) Crest Factor.

b) Power Factor.

c) Percent total harmonic distortion.

d) Harmonic values of all phases through the 31st harmonic.

9. The main breaker trip unit shall have the following advanced features integral to the trip unit:

a) Adjustable undervoltage release.

b) Adjustable overvoltage release.

c) Reverse load and fault current.

d) Reverse sequence voltage alarm.

e) Underfrequency.

f) Overfrequency.

g) Voltage phase unbalance and phase loss during current detection.

10. Each breaker shall be provided with arc-flash reduction switches with visual indicator

11. All breakers of common frame size shall have trip units wired to secondary contacts in a consistent manner, including spares, so that breakers are fully interchangeable once settings are updated

~~12. Each breaker shall be provided with arc-flash reduction switches with visual indicator.~~

~~13. All breakers of common frame size shall have trip units wired to secondary contacts in a consistent manner, including spares, so that breakers are fully interchangeable once settings are updated.~~

N. Pull section: Size as shown on Drawings, having width, depth and height to match switchboard. Arrange as shown on Drawings.

O. Future Provisions: Fully equip spaces for future devices with bussing and bus connections, suitably insulated and braced for short circuit currents. Provide continuous current rating as indicated.

P. Enclosure: Type 1 -- General Purpose.

1. Align sections at front and rear.

2. Switchboard Height: 96 inches, excluding floor sills, lifting members and pull boxes.

3. Finish: Manufacturer's standard light gray enamel over external surfaces. ~~Coat~~ Coat internal surfaces with minimum one coat corrosion-resisting paint, or plate with cadmium or zinc.

4. Mimic Bus: Show bussing, connections and devices in single line form on the front panels of the switchboard using black color plastic strips, fastened flat against the panel face with screws or rivets.

5. Provide hinged rear doors with provisions for padlocking.

6. Provide IR windows for infrared scanning.

~~7. Provide IR windows for infrared scanning.~~

2.4 RATINGS

A. Voltage rating shall be as indicated on the drawings. The entire assembly shall be suitable for 600 volts maximum AC service.

B. The assembly shall be rated to withstand mechanical forces exerted during short-circuit conditions when connected directly to a power source having available fault current of minimum of 100,000 amperes symmetrical at rated voltage unless higher amperage is shown on the drawings.

C. The bus system shall have a minimum ANSI 4-cycle short-circuit withstand rating of 100,000 amperes symmetrical.

D. All circuit breakers shall have a minimum symmetrical interrupting capacity of 100,000 amperes. To ensure a fully selective system, all circuit breakers shall have 30 cycle short-time withstand ratings equal to their symmetrical interrupting ratings through 85,000 amperes, regardless of whether equipped with instantaneous trip protection or not.

E. All ratings shall be tested to the requirements of ANSI C37.20.1, C37.50 and C37.51 and UL witnessed and approved.

2.5 CONSTRUCTION

A. The switchgear shall consist of the required number of vertical sections bolted together to form a rigid assembly. The sides shall be covered with removable bolt-on covers. All edges of front covers or hinged front panels shall be formed. Provide ventilators located on the top of the switchgear over the breaker and bus compartments to ensure adequate ventilation within the enclosure. The assembly shall be provided with adequate lifting means and shall be capable of being moved into installation position and bolted directly to the floor without the use of floor sills providing the floor is level to 1/8 inch per 3-foot distance in any direction. Provisions shall be made for jacking of shipping groups, for removal of skids or insertion of equipment rollers. Base of assembly shall be suitable for rolling directly on pipes without skids. The base shall be equipped with slots in the base frame members to accommodate the use of pry bars for moving the equipment to its final position.

B. Each vertical steel unit forming part of the switchgear line-up shall be a self-contained housing having one or more individual breaker or instrument compartments, a centralized bus compartment and a rear cable compartment. Each individual circuit breaker compartment, or cell, shall be segregated from adjacent compartments and sections by means of steel barriers to the maximum extent possible. It shall be equipped with drawout rails and primary and secondary disconnecting contacts. Removable hinge pins shall be provided on the breaker compartment door hinges. Current transformers for feeder instrumentation, where shown on the plans, shall be located within the appropriate breaker cells and be front accessible and removable.

C. The stationary part of the primary disconnecting devices for each power circuit breaker shall be breaker mounted and consist of a set of contacts extending to the rear through a glass polyester insulating support barrier; corresponding moving finger contacts, suitably spaced, shall be furnished on the power circuit breaker studs which engage in only the connected position. The assembly shall provide multiple silver-to-silver full floating high pressure point contacts with uniform pressure on each finger maintained by springs. Each circuit shall include the necessary three-phase bus connections between the section bus and the breaker line side studs. Load studs shall be equipped with insulated copper load extension buses terminating in solderless type terminals in the rear cable compartment of each structure. Bus extensions shall be silver-plated where outgoing terminals are attached.

D. The circuit breaker door design shall be such that the following functions may be performed without the need to open the circuit breaker door: lever circuit breaker between positions, operate manual charging system, close and open circuit breaker, examine and adjust trip unit, and read circuit breaker rating nameplate.

E. The secondary disconnecting devices shall consist of floating terminals mounted on the stationary unit and engaging mating contacts at the front of the breaker. The secondary disconnecting devices shall be gold-plated and engagement shall be maintained in the “connected” and “test” positions.

F. The removable power circuit breaker element shall be equipped with disconnecting contacts and interlocks for drawout application. It shall have four positions, “connected,” “test,” “disconnected” and “removed.” The breaker drawout element shall contain a worm gear levering “in” and “out” mechanism with removable lever crank. Levering shall be accomplished via the use of conventional tools. Mechanical interlocking shall be provided so that the breaker is in the tripped position before levering “in” or “out” of the cell. The breaker shall include an optional provision for key locking open to prevent manual or electric closing. Padlocking shall provide for securing the breaker in the connected, test, or disconnected position by preventing levering.

G. An insulating flash shield shall be mounted above each circuit breaker to prevent flashover from the arc chutes to ground.

H. The switchgear shall be Eaton Magnum DS low voltage metal-enclosed switchgear, utilizing Magnum DS power circuit breakers as herein specified.

I. The switchgear shall be suitable for use as service entrance equipment and be labeled in accordance with UL requirements.

J. Provide a rear compartment barrier between the cable compartment and the main bus to protect against inadvertent contact with main or vertical bus bars.

K. Provide in the cell when the circuit breaker is withdrawn, a safety shutter which automatically covers the line and load stabs and protects against incidental contact.

L. Provide a metal barrier full height and depth between adjacent vertical structures in the cable compartment.

M. Provide a glass polyester full height and depth barrier between adjacent vertical structures in the bus compartment with appropriate slots for main bus.

2.6 BUS

A. All bus bars shall be silver-plated copper. Main horizontal bus bars shall be mounted with all three phases arranged in the same vertical plane. Bus sizing shall be based on ANSI standard temperature rise criteria of 65 degrees C over a 40 degrees C ambient (outside the enclosure).

1. In addition to full UL air clearances, the phase bus shall be insulated with a minimum of 5 mil thickness of epoxy resin coating. Removable boots shall be provided to give access to the cross bus joints for inspection and maintenance.

B. Provide a full capacity neutral bus where a neutral bus is indicated on the drawings.

C. A copper ground bus shall be furnished firmly secured to each vertical section structure and shall extend the entire length of the switchgear. The ground bus short-time withstand rating shall meet that of the largest circuit breaker within the assembly.

D. All hardware used on conductors shall be high-tensile strength and zinc-plated. All bus joints shall be provided with Belleville-type washers.

2.7 WIRING/TERMINATIONS

A. Small wiring, necessary fuse blocks and terminal blocks within the switchgear shall be furnished as required. Control components mounted within the assembly shall be suitably marked for identification corresponding to the appropriate designations on manufacturer’s wiring diagrams.

B. Provide a front accessible, isolated vertical wireway for routing of factory and field wiring. Factory provisions shall be made for securing field wiring without the need for adhesive wire anchors.

C. Front access to all circuit breaker secondary connection points shall be provided for ease of troubleshooting and connection to external field connections without the need of removing the circuit breaker for access.

D. All control wire shall be type SIS. Control wiring shall be 14 ga for control circuits and 12 ga for shunt trip and current transformer circuits. Wire bundles shall be secured with nylon ties and anchored to the assembly with the use of pre-punched wire lances or nylon non-adhesive anchors. All current transformer secondary leads shall first be connected to conveniently accessible shorting terminal blocks before connecting to any other device. Shorting screws with provisions for storage shall be provided. All groups of control wires leaving the switchgear shall be provided with terminal blocks with suitable numbering strips and provisions for #10 AWG field connections. Each control wire shall be marked to the origin zone/wire name/destination zone over the entire length of the wire using a UV cured ink process. Provide wire markers at each end of all control wiring. Plug-in terminal blocks shall be provided for all shipping split wires. Terminal connections to remote devices or sources shall be front accessible via doors above each circuit breaker.

E. NEMA 2-hole mechanical type lugs shall be provided for all line and load terminations suitable for copper or aluminum cable rated for 75 degrees C of the size indicated on the drawings.

F. Lugs shall be provided in the incoming line section for connection of the main grounding conductor. Additional lugs for connection of other grounding conductors shall be provided as indicated on the drawings.

G. Reusable insulating boots shall be provided to cover all power cable terminations.

2.8 CIRCUIT BREAKERS

A. All protective devices shall be low voltage power circuit breakers. Basis of design is ~~Eaton~~Eaton Type Magnum DS. All breakers shall be UL listed for application in their intended enclosures for 100% of their continuous ampere rating.

B. All power circuit breakers shall be constructed and tested in accordance with ANSI C37.13, C37.16, C37.17C37.50, UL 1066 and NEMA SG-3 standard. The breaker shall carry a UL label.

C. Breakers shall be provided in drawout configuration. ~~Circuit breaker frame sizes shall be only 1600A and 4000A~~The 1600, 2000 and 3200 ampere frame power circuit breakers shall be provided in the same physical frame size, while 4000 and 5000 ampere frame power circuit breakers shall be provided in a second physical frame size. Both physical frame sizes shall have a common height and depth.

D. Power circuit breakers shall utilize a two-step stored-energy mechanism to charge the closing springs. The closing of the breaker contacts shall automatically charge the opening springs to ensure quick-break operation.

E. All circuit breaker shall be electrically operated and equipped with auxiliary contacts, bell alarm contacts, and microprocessor based trip units.

F. Breakers shall be electrically operated (EO) with 120V AC motor operators. The charging time of the motor shall not exceed 6 seconds.

G. Breakers shall have 24Vdc shunt trip.

H. To facilitate lifting, the power circuit breaker shall have integral handles on the side of the breaker.

I. The power circuit breaker shall have a closing time of not more than 3 cycles.

J. The primary contacts shall have an easily accessible wear indicator to indicate contact erosion.

K. The power circuit breaker shall have three windows in the front cover to clearly indicate any electrical accessories that are mounted in the breaker. The accessory shall have a label that will indicate its function and voltage.

L. Trip Units:

1. Each low voltage power circuit breaker shall be equipped with a solid-state tripping system consisting of three current sensors, microprocessor-based trip device and flux-transfer shunt trip. Current sensors shall provide operation and signal function. The trip unit shall use microprocessor-based technology to provide the basic adjustable time-current protection functions. True rms sensing circuit protection shall be achieved by analyzing the secondary current signals received from the circuit breaker current sensors and initiating trip signals to the circuit breaker trip actuators when predetermined trip levels and time delay settings are reached. Interchangeable current sensors with their associated rating plug shall establish the continuous trip rating of each circuit breaker. The basis of design is ~~EATON~~Eaton type Digitrip 1150.

2. The trip unit shall have an information system that provides LEDs to indicate mode of trip following an automatic trip operation. The indication of the mode of trip shall be

retained after an automatic trip. A reset button shall be provided to turn off the LED indication after an automatic trip.

3. The trip unit shall be provided with a display panel, including a representation of the time/current curve that will indicate the protection functions. The unit shall be continuously self-checking and provide a visual indication that the internal circuitry is being monitored and is fully operational.
4. The trip unit shall be provided with a making-current release circuit. The circuit shall be armed for approximately two cycles after breaker closing and shall operate for all peak fault levels above 25 times the ampere value of the rating plug.
5. Trip unit shall have selectable thermal memory for enhanced circuit protection.
6. Complete system selective coordination shall be provided by the addition of the following individually adjustable time/current curve shaping solid-state elements:
   a) All circuit breaker shall have adjustments for long delay pickup and time.
   b) All circuit breakers shall have individual adjustments for short delay pickup and time, and include I^2t settings and adjustable instantaneous pickup.
   c) All circuit breakers shall have individually adjustable ground fault current pickup and time, and include I^2t settings or ground alarm only.
   d) All circuit NEC 700 (Life Safety) and NEC 701 (Legally Required) breakers on emergency designated switchboards shall have individually adjustable ground fault alarm (LSIA). All NEC 702 Breakers (Security and Equipment) shall have ground fault trip (LSIG).
7. The trip unit shall have provisions for a single test kit to test each of the trip functions.
8. The trip unit shall provide zone interlocking for the short-time delay and ground fault delay trip functions for improved system coordination. The zone interlocking system shall restrain the tripping of an upstream breaker and allow the breaker closest to the fault to trip with no intentional time delay. In the event that the downstream breaker does not trip, the upstream breaker shall trip after the present time delay. Factory shall wire for zone interlocking for the power circuit breakers within the switchgear.
9. The trip unit shall have an information system that utilizes battery backup LEDs to indicate mode of trip following an automatic trip operation. The indication of the mode of trip shall be retained after an automatic trip operation. The indication of the mode of trip shall be retained after an automatic trip. A test pushbutton shall energize a LED to indicate the battery status
10. The trip unit shall have a 4-character LCD display showing phase, neutral, and ground current. The accuracy of these readings shall be +/- 2% of full scale
11. The trip unit shall be equipped to permit communication via twisted pair for remote monitoring and control by existing ~~and new~~ PowerNet ~~system~~System and new Power Xpert System. The trip unit shall include a power/relay module which shall supply control to the readout display. Following an automatic trip operation of the circuit breaker, the trip unit shall maintain the cause of trip history and the mode of trip LED indication as long as its internal power supply is available. An internal relay shall be programmable to provide contacts for remote ground alarm indication.

12. The trip unit shall include a voltage transformer module, suitable for operation up to 600V, 50/60 Hz. The primary of the power relay module shall be connected internally to the line side of the circuit breaker through a dielectric test disconnect plug.
13. An internal relay shall be programmable to provide contacts for remote ground alarm indication.
14. The display for the trip units shall be a 24 character LED display.
15. Metering display accuracy of the complete system, including current sensors, auxiliary CTs, and the trip unit, shall be +/- 1% of full scale for current values. Metering display accuracy of the complete system shall be +/- 2% of full scale for power and energy values.
16. The unit shall be capable of monitoring the following data:
    a) Instantaneous value of phase, neutral and ground current.
    b) Instantaneous value of line-to-line voltage.
    c) Minimum and maximum current values.
    d) Watts, vars, VA, watt-hours, var-hours, and VA hours.
17. The energy-monitoring parameter values (peak demand, present demand, and energy consumption) shall be indicated in the trip unit’s alphanumeric display panel
18. The trip unit shall display the following power quality values:
    a) Crest Factor.
    b) Power Factor.
    c) Percent total harmonic distortion.
    d) Harmonic values of all phases through the 31st harmonic.
19. The main breaker trip unit shall have the following advanced features integral to the trip unit:
    a) Adjustable undervoltage release.
    b) Adjustable overvoltage release.
    c) Reverse load and fault current.
    d) Reverse sequence voltage alarm.
    e) Under frequency.
    f) Over frequency.
    g) Voltage phase unbalance and phase loss during current detection.
20. An adjustable high load alarm shall be provided, adjustable from 50 to 100% of the long delay pickup setting.
21. The trip unit shall contain an integral test pushbutton. A keypad shall be provided to enable the user to select the values of test currents within a range of available settings.

The protection functions shall not be affected during test operations. The breaker may be tested in the TRIP or NO TRIP test mode.

22. Programming may be done via a keypad at the faceplate of the unit or via the existing communication network.

23. System coordination shall be provided by the following microprocessor-based programmable time-current curve shaping adjustments. The short-time pickup adjustment shall be dependant on the long delay setting.

    a) Programmable long-time setting

    b) Programmable long-time delay with selectable I^2T or I^4T curve shaping

    c) Programmable short-time setting

    d) Programmable short-time delay with selectable flat or I^2T curve shaping, and zone selective interlocking

    e) Programmable instantaneous setting

    f) Programmable ground fault setting trip or ground fault setting alarm

    g) Programmable ground fault delay with selectable flat or I^2T curve shaping and zone selective interlocking.

24. The trip unit shall offer a three-event trip log that will store the trip data, and shall time and date stamp the event

M. Pull section: Size as shown on Drawings, having width, depth and height to match switchboard. Arrange as shown on Drawings.

N. Future Provisions: Fully equip spaces for future devices with bussing and bus connections, suitably insulated and braced for short circuit currents. Provide continuous current rating as indicated.

O. Bus Duct connections sections: Provide complete as required for bus duct connection.

P. Enclosure: Nema Type 1

1. Align sections at front and rear.

2. Switchboard Height: 96 inches, excluding floor sills, lifting members and pull boxes.

3. Mimic Bus: Show bussing, connections and devices in single line form on the front panels of the switchboard using black color plastic strips, fastened flat against the panel face with screws or rivets.

4. Provide hinged rear doors with provisions for padlocking.

2.9 ~~TRANSIENT VOLTAGE SURGE SUPPRESSION~~SURGE PROTECTIVE DEVICES

~~A.~~A. Each lineup of switchgear shall include a door mounted surge protector(s). ~~The TVSS~~~~surge protective device~~ ~~unit(s) shall be rated by UL as a lightning arrestor, or a separate lightning arrestor shall be installed.~~ Between the bus and the ~~TVSS~~surge protective device(s) shall be mounted a 30 amp, 3 pole, 480 V circuit breaker type HFD. ~~TVSS~~Surge protective devices shall be mounted in an open section nearest to the main incoming power source section with lead length kept to a minimum. The display unit shall be connected via ribbon cable to the main unit and mounted so as to be visible when the door is closed.

~~B.~~C. See specification ~~section 264300 on TVSS~~Section 26 43 00 Surge Protective Devices for additional information.

~~C.~~D. Provide ~~TVSS~~surge protective devices for each feeder connected between buildings and on each service feeder.

~~D.~~E. Provide disconnect, connections, etc for ~~TVSS~~surge protective devices as recommended by ~~TVSS~~surge protective devices manufacturer.

2.10 POWER QUALITY METER AND ANALYZER METERS

A. Each lineup of switchgear shall include ~~an Eaton PXM6000~~an Eaton PXM6000 wired with a category 5 data cable. Belden 9463 (blue hose) family in a daisy chain and connected to the Digitrip trip units on each circuit breaker to the existing EATON PowerNet System. All communications cabling is to be factory installed and terminated to a terminal block for continuation to the EMMS ~~PowerExpert~~Power Xpert System.

B. Provide meters with appropriate multiplier tags.

2.11 ANALOG ~~ANALOG~~ METERING TRANSFORMERS

A. Current Transformers; ANSI C57.13; 5 ampere secondary, primary/ secondary ratio as required, burden and accuracy consistent with connected metering and relay devices, 60 Hertz.

B. Potential Transformers: ANSI C57.13; 120 volt disconnecting type with integral fuse mountings, primary/secondary ratio as required, burden and accuracy consistent with connected metering and relay devices, 60 Hertz.

C. Analog meters shall be provided ~~current~~ to indicate Phase to Phase ~~P-P~~ voltage and phase to ground voltage for all 3 phases.

~~D. Analog meters shall be provided current to indicate P-P voltage and for all 3 phases.~~

2.12 ACCESSORIES

A. Circuit Breaker Lifting Device: Carriage and track on top of each switchboard with lifting device to serve draw-out circuit breakers in switchboard.

B. Provide integrally mounted transient voltage surge suppression as specified in Section 26 ~~27 13~~43 00 Surge Protective Devices.

~~C. Provide remote racking device, Eaton MRR1000.~~

C. Provide remote racking device, Eaton MRR 1000

2.13 SERVICE ENTRANCE EQUIPMENT

A. Switchboards used as service entrance equipment shall be listed and labeled by UL for use as service equipment.

2.14 NAMEPLATES

A. Engraved nameplates, mounted on the face of the assembly, shall be furnished for all main and feeder circuits as indicated on the drawings. Nameplates shall be laminated plastic, black characters on white background, and secured with screws. Characters shall be 3/16-inch high, minimum.

B. Furnish master nameplate giving switchgear designation, voltage ampere rating, short-circuit rating, and manufacturer's name.

C. Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturer's drawings~~.~~

2.15 FINISH

A. All exterior and interior steel surfaces of the switchgear shall be properly cleaned and provided with a rust-inhibiting phosphatized coating. Color and finish of the switchgear shall be ANSI 61

2.16 CONTROLS (Emergency Transfer Switchboards Only)

A. A Transfer Switchgear Control System shall be provided to facilitate overall system operation including automatic transfer control, monitoring of the available power sources, engine start command, alarm/fault monitoring, breaker control and monitoring and communication to remote Generator Building CEP controls and remote OIP locations.

B. The Emergency Switchgear Control System shall utilize redundant fiber optic communication networks, in ring configuration, to communicate with the redundant PLC controls located in the Generator Building CEP main emergency switchgear controls. I/O drops shall be provided within each 480V Transfer Switchgear to interface with breakers, meters, annunciators, control switches and other devices as required. The CEP Switchgear Control System shall provide all functions and operations as specified in these specifications and as listed or noted on drawings.

C. Coordination of 480V EmergencyTransfer Switchgear Controls with the Generator CEP control system shall be the responsibility of the 480V emergency switchgear supplier. Update of the Generator Building Control and SCADA screens, logic software and communication hardware, that may be required for this Emergency Control Switchgear shall be provided by the Emergency Control Switchgear provider. All documentation updates of the Main Generator Switchgear controls and SCADA system that are necessary for implementation and support of the Emergency Switchgear shall also be provided.

D. A third fiber-optic pair shall be provided for SCADA communications between the Generator Building Main Controls and the emergency switchgear.

E. Controls shall operate from 24VDC as supplied from the station battery system for each Emergency Switchgear. A best battery selector shall be included to enable connection to more than one station batteries should a connection to a battery from another nearby switchgear be possible.

E. Hard Wired Controls: The emergency switchgear controls shall have a complete set of hard wired meters, control switches, indicating lights and other devices to enable complete manual operation of the emergency switchgear without availability of any PLC or OIP or network communications. The minimum instrumentation requirements are listed below. In addition, all necessary hard wired interlocks shall be included to prevent possible operator error while in manual operation. Use of a backup OIP DOES NOT SATISFY THIS REQUIREMENT.

F. Each Main Breaker and Tie Breaker shall have the following discrete hard wired metering:

1. Analog Voltmeter (4”) with phase selector switch
2. Analog Ammeter (4”) with phase selector switch
3. Crompton Integra Multi-function meter (4”) to display selectable values: KW, PF, Freq, THD, etc.
4. Eaton PX-6000 on Main breakers only wired to PX900 Gateway

G. Each Feeder Breaker shall have the following discrete hard wired metering and control devices.

1. Analog Voltmeter (4”) with phase selector switch
2. Crompton Integra Multi-function meter (4”) to display selectable values: KW, Amps, PF, Freq, THD, etc.
3. Breaker control switch.
4. The above shall be grouped together on door of the ”B” cubicle compartment for each feeder breaker vertical section together with the 3-lite breaker annunciator (open-withdrawn-closed) and breaker control switch. A common lamp test push button shall also be included on the door.

H. Human Machine Interface (OIP)

1. A 23-inch *minimum* (diagonal), color TFT industrial display shall be provided for operator interface panel(s) as standard equipment. This display shall support a minimum resolution of 1280 x 1024 pixels. Interface shall be accomplished via a key protected touch screen permanently affixed to the display. The touch screen shall be clear glass, with light transmission of 95% or better, furnished with a Surface Acoustic Wave touch interface. Resistive or Capacitive touch interfaces are not acceptable. Navigation and operation shall be intuitive such that Help Screens are not required. The Operator Interface will access to system operating parameters, set points, graphical displays and other information as defined elsewhere in this specification.
2. OIP screens shall include <u>all</u> of the screens as specified for the OIP’s in the new Generator Control Building. This will include an active one-line for every Emergency Transfer Switchgear installed anywhere on site. The home screen for each Switchgear shall be the active one line for that specific switchgear.
3. Each OIP shall have access as defined by passwords. The level of access shall be limited based on the password entered. Up to 100 different password levels shall be possible.

2.17 SEQUENCE OF OPERATION (Emergency Transfer Switchgear Only)

A. <u>Normal Operation:</u>

1) GENMV1 switchgear
   a. Utility breakers closed
   b. All generator breakers and both General Main breakers are open
   c. Feeder breakers each supplying normal power to the Life Safety loads in downstream LV Transfer Switchgear

2) LV Emergency Transfer switchgear
   a. Utility Main breaker closed
   b. Emergency Main breaker closed
   c. Bus Tie breaker open
   d. Life Safety (Priority 1) loads are being powered via the Utility feeding the associated GENMV1 switchgear bus
   e. Equipment and other loads (Priority 2 & lower) are powered via the Utility substation feeder dedicated to the associated LV Transfer Switchgear

B. Failure of Emergency (Utility via GENMV1) at LV Emergency Transfer switchgear(s)

1) If the Emergency power source (as detected at the LV Transfer switchgear) should fail with the Normal Utility power source (as detected at the LV Transfer switchgear) still available, then the Emergency Main breaker (EM) shall immediately open and the Bus Tie breaker (BT) shall immediately close, placing the Life Safety loads on the Utility feeder coming directly from the utility substation.

2) This state shall remain until such time that the controls have determined that the Utility source feeding the associated Emergency feeder in GENMV1 is connected to that load bus AND the LV Transfer switchgear has detected an acceptable power source at the EM breaker, at which time the system shall initiate a transfer of the Life Safety loads back to its normal source by opening the bus tie (BT) breaker and closing the Emergency Main breaker (EM).

C. Failure of Normal Utility at LV Emergency Transfer switchgear(s)

1) Upon loss of the Normal power source as determined at the LV Transfer switchgear (UM), the controls shall (after a programmable time delay) initiate a start of the emergency generators. This shall occur regardless of whether the Utility source connected to the GENMV1 load bus is still available and connected.

2) Upon the first generator being connected to the generator bus in GENMV1, the controls shall open the Utility Main breaker(s) in GENMV1 feeding the load bus of the associated LV Transfer switchgear, open all non-priority 1 feeder breakers in all LV Transfer Switchgears fed from the same load bus in GENMV1 as the LV Transfer switchgear(s) that is calling for the Emergency start, and then closing the Generator Main breaker(s) (GM) in GENMV1 to place the Priority 1 loads in all of the LV Transfer switchgears (sharing the same load bus in GENMV1) on generator power.

3) Prior to adding any non-priority 1 load to the Emergency system, the controls will open all non-priority 1 breakers in all affected LV Transfer switchgears and then close the Bus Tie breaker in each affected LV Transfer switchgear.

4) As additional generators are paralleled to the generator bus and their generator breakers closed, the system will add load by closing load breakers in all of the affected LV Transfer switchgears in order of their priority, highest to lowest. Priority assignments and anticipated load will be configurable via the system OIP's

.

5) Since there are multiple LV Transfer switchgears with Life Safety loads being normally fed via two (2) separate load buses in the GENMV1 switchgear, it may be possible that only one load bus need be placed on generator power, should none of the LV Transfer switchgears of the other bus have failure of their Normal power source and the Utility feed to that load bus in GENMV1 switchgear be available.

6) Once all available generators have connected to the Emergency bus, the system can then be placed in Load Control Mode, if enabled, so that the controls can automatically remove and add generators to match the overall load requirements with spinning reserve as determined by field settable parameters in the OIP.

7) Upon return of Normal power (as determined at each LV Transfer switchgear) and after an adjustable delay, each LV shall initiate a retransfer sequence back to normal conditions, by first opening its Bus Tie breaker (BT) and then closing its Utility Main breaker, placing all non-life safety loads on Normal Utility power. Life Safety loads at this point remain on generator power.

8) Upon the system determining that the Utility source serving the affected load bus in GENMV1 has returned and after an adjustable time delay, the controls will initiate a closed transition transfer of the load bus from generators to the restored utility by paralleling the load bus to the Utility, closing the Utility Main breaker in GENMV1 and performing a soft loading of the utility until the load across the associated Generator Main breaker (GM) has reached a minimum set point level at which time the Generator Main breaker (GM) will open.

9) If both load buses are on generator power, then the system will first perform a closed transition soft loading transfer to utility 1 on load bus 1 followed by performing the soft load loading transfer to utility 2 on load bus 2.

10) Once all transfers to utility are complete the system will initiate a cool down cycle for all running generators.

D. <u>Load Shedding</u>

1) Load shedding shall be active whenever the system is in automatic mode

2) Whenever the load exceeds the available on-line generator capacity, the system shall shed downstream loads at the LV Emergency Transfer switchgears, based on the assigned priority for each breaker, lowest priority loads shed first.

3) Once enough load has been shed to stabilize the emergency generator bus, the system shall cease further load shedding.

4) Loads shall be automatically re-added if the available generator capacity increases to a level that permits adding the next highest priority anticipated load.

5) The system shall allow the operator to override the load shed to manually re-add selected load breakers or to alter which breakers remain open.

2.18 STATION BATTERY SYSTEM (Required for Each Emergency Transfer Switchgear ONLY)

A. Provide 24 VDC Nicad Station Battery System for Switchgear controls that will be connected to the best battery selector

B. Minimum battery capacity shall be 150 amp-hr @ 8-hour rate.

C. Provide rack, cell connectors and power lugs

D. Furnish wall mount charger, 120 VAC input, 25 amp @24 VDC output with AC input breaker, DC output breaker, DC volt meter, DC amp meter, equalizing timer, alarms lights for AC failure, DC failure, High VDC, Low VDC, positive & negative ground fault and common alarm contact

PART 3 - EXECUTION

3.1 PREPARATION/INSPECTION/EXAMINATION

A. Verify that surface is suitable for switchboard installation.

B. Check that concrete pads are level and free of irregularities

C. Examine area to receive switchboard to assure adequate clearance for switchboard installation.

D. Verify that National Electrical Code clearances will be maintained after installation. Rework equipment locations as required to provide required clearances.

E. Start Work only after unsatisfactory conditions are corrected.

F. All magnum DS breakers shall be internally wired in similar fashion for interchangeability.

~~G. All magnum DS breakers shall be internally wired in similar fashion for interchangeability.~~

3.2 INSTALLATION

A. Install all switchboard enclosures in accordance with the manufacturer's written instructions, NECA's "Standard of Installation", the applicable requirements of the National Electrical Code, and recognized industry practices.

B. Mount switchboard on 3” concrete base extending 3” outside all sides.

C. Provide rubber insulating mats on floor in front of board for entire length of board, minimum 4 feet wide.

D. Install switchboards plumb. Provide supports in accordance with Section ~~26 05 29~~16190.

E. Provide doors for unused spaces in switchboards.

F. Install switchboards so that proper working clearances shall be maintained at every switchboard location, both front and back.

G. Clean the interior of each switchboard before installing conductors. At all times, keep the interior trim and exterior surfaces of the switchboard free of rust and debris. Repaint finishes if necessary.

H. Coordinate all raceways and conductors with their respective switchboards so that all connections and conductors routing present an orderly appearance. Conductors in the switchboards shall be laced and arranged in orderly manner.

I. Provide a separate 120 volt, 20 AMP circuit as required to power any shunt-trip function/device for normal switchboards and 24 Vdc for emergency switchboards. Provide complete 120 Vac to 24 Vdc system in each switchboard, including batteries, UPS and charger system to power shunt trip system.

J. All necessary hardware to secure the assembly in place shall be provided by the Contractor.

K. The equipment shall be installed and checked in accordance with the manufacturer's recommendations. This shall include but not limited to:

1. Checking to ensure that the pad location is level to within 0.125 inches per three foot of distance in any direction.
2. Checking to ensure that all bus bars are torqued to the manufacturer's recommendations.
3. Assembling all shipping sections, removing all shipping braces and connecting all shipping split mechanical and electrical connections.
4. Securing assemblies to foundation or floor channels.
5. Measuring and recording Megger readings phase-to-phase, phase-to-ground, and neutral-to-ground (four wire systems only).
6. Inspecting and installing all circuit breakers in their proper compartments.

L. Conduit or piping systems that contain water or liquid of any kind shall not be installed over the top of any electrical equipment, transformers, racks, cabinets, or enclosures without prior written approval from the Owner.

3.3 FACTORY TESTING

A. The switchgear shall be completely assembled, wired, adjusted and tested at the factory. After assembly, the complete switchgear shall be tested to ensure the accuracy of the wiring and the functioning of all equipment. The main bus system shall be given a dielectric test of 2200 volts for one minute between live parts and ground and between opposite polarities.

B. The wiring and control circuits shall be given a dielectric test of 1500 volts for one minute, or 1800 volts for one second, between live parts and ground, in accordance with ANSI C37.20.1.

C. A certified test report of all standard production tests shall be shipped with each assembly.

3.4 FIELD QUALITY CONTROL

A. Provide the services of a qualified factory-trained manufacturer's representative to assist the Contractor in installation and start-up of the equipment specified under this section for a period of ~~1~~one working day. The manufacturer's representative shall provide technical direction and assistance to the contractor in general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained therein.

B. The Contractor shall provide three (3) copies of the manufacturer's field start-up report.

C. Provide complete testing of all components including but not limited to metering, monitoring, ground fault systems, interlocking systems, best battery systems, remote operation/tripping features of breakers, etc.

D. Testing in the field is to include all interlocking and breaker control functions ~~from~~within the emergency switchboard and Generator Switchgear systems~~ and Generator Switchgear systems~~ (both local and remote computer PC control).

E. Measure steady state load currents at each switchboard feeder; rearrange circuits to balance the phase loads to within 20 percent of each other. Maintain proper phasing for multi-wire branch circuits.

F. Visual and Mechanical Inspection: Inspect for physical damage, proper alignment, anchorage, and grounding. Check proper installation and tightness of connections for circuit breakers, fusible switches, and fuses.

G. All circuits shall be operated to establish a good working order and checked for shorts.

H. All panel directory circuit numbers shall be checked to verify accuracy of the number.

I. Measure insulation resistance of each bus section phase to phase and phase to ground for one minute each, at test voltage of 1000 volts; minimum acceptable value for insulation resistance is 2 megohms. Disconnect all electronic circuitry and ~~TVSS~~Surge Protective Device units prior to test.

J. Check tightness of accessible bolted bus joints using calibrated torque wrench.

K. Physically test key interlock systems to insure proper function.

L. Tests:

1. Test Switchboards and switchboard feeders per requirements of Section 26 08 13 Tests and Performance Verification.

2. Test all operational features of switchboard including interlocking, remote controls, touch screen, remote computer PC control, etc.

3. Feeder conductors shall be checked by approved means to establish the absence of shorts to ground; insulation value, etc. and the result recorded and submitted to the Designer.

4. Submit Conductor Insulation Resistance Test per requirements of Section 26 08 13 Tests and Performance Verification.

5. Submit Tabulation Data Voltage and Amperage Readings per requirements of Section 26 08 13 Tests and Performance Verification.

M. Equipment Checkout:

1. When requested by Designer/OAR provide (during construction):

a) Inspection of equipment by authorized equipment manufacturer technician complete with submittal of statement of findings by technician, and providing any adjustments deemed necessary for a complete and operating system.

2. Submit Equipment Checkout Memo per Section 26 08 13 Tests and Performance Verification.

3.5 MANUFACTURER'S CERTIFICATION

A. A qualified factory-trained manufacturer's representative shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations.

B. The Contractor shall provide three (3) copies of the manufacturer's representative's certification before final payment.

3.6 TRAINING

A. The Contractor shall provide a training session for up to five (5) owner's representatives for 1 normal workday at a jobsite location determined by the owner.

B. The training session shall be conducted by a manufacturer's qualified representative. The training program shall consist of the instruction on the operation of the assembly, circuit breakers, metering, monitoring, and major components within the assembly.

3.7 MONITORING/METERING

A. Provide/install all components, wiring, cable (fiber optic and copper), raceways, hubs, switches, patch panel modules, pc cards, communication network devices, converters, etc., as required to connect monitoring/metering equipment in each panelboard (provided with monitoring/metering) to Owner's ~~PowerXpert~~Power Xpert Computer (PC) located in Electrical Maintenance Shop (Rick Schulz's Office) and to the Central Plant (PC) workstation located in the CEP Control Room.

B. Provide/install all software, programming, etc., to facilitate installation and monitoring of all monitor/meter equipment on GOAA's selected ~~PowerXpert~~Power Xpert PC System.

C. Integrate all new equipment provided under this contract into existing software including programming/changes required to computer screens, program trending, program event logging, etc.

D. Coordinate with GOAA final approval of screens, trending, and event logging requirements and program system accordingly.

E. All revisions to software, programming, etc., ~~are~~is to be by manufacturer of software.

3.8 IDENTIFICATION

A. Refer to Section 26 05 53 Identification for Electrical Systems for products and content.

B. Provide engraved plastic nameplates under the provisions of Section 26 05 53 Identification for Electrical Systems.

3.9 ADJUSTING

A. Adjust all operating mechanisms for free mechanical movement.

B. Tighten bolted bus connections in accordance with manufacturer's instructions.

C. Adjust circuit breaker trip and time delay settings to values as instructed by the Designer to manufacturer's recommendation.

END OF SECTION 26 24 13~~26 24 13~~

SECTION 26 24 16 - PANELBOARDS

PART 1- GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Contractual Conditions and Division 01 Specification sections apply to this section.

1.2 SUMMARY

A. This section includes the requirements for provision and installation of panelboards.

1.3 DESCRIPTION

A. Provide all labor, materials, and equipment necessary to properly and completely install panelboards as scheduled on the drawings and as required by this section.

1.4 SUBMITTALS

A. Submit product data on each basic panelboard construction type, showing manufacturer's standard construction data including:

1. Cabinet construction/dimensions.
2. Bus construction.
3. UL labeling.
4. Each overcurrent device.

B. Shop drawings shall be submitted for each panel and clearly indicate the following information:

1. Label.
2. Each circuit breaker amperage rating, circuit number and position/location in panel.
3. Electrical characteristics of panel.
4. Mains rating.
5. Main device rating.
6. Mounting.
7. Dimension, width, depth, height.
8. Bus material.
9. Interrupting capacity of minimum rated breaker.
10. Panel type.

1.5 PROJECT AS-BUILT DOCUMENTS

A. Record actual locations of Panelboards on red lined as-built documents and indicate actual branch circuit arrangement.

1.6 OPERATION AND MAINTENANCE DATA

A. Provide spare parts data listing; source and current prices of replacement parts and supplies; and recommended maintenance procedures and intervals.

1.7 QUALITY ASSURANCE

A. Manufacturer: Company specializing in manufacturing products specified for minimum ten years.

1.8 REFERENCES AND REGULATORY REQUIREMENTS

A. Furnish products listed and classified by UL as suitable for purpose specified and indicated.

B. Conform to the requirements of the following:

1. ANSI/NFPA 70 - National Electrical Code.
2. NECA (National Electrical Contractors Association) - "Standard of Installation."
3. NEMA AB 1 - Molded Case Circuit Breakers.
4. NEMA PB 1 - Panelboards.
5. NEMA PB 1.1 - Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
6. UL 67 - Panelboards
7. UL 50 - Cabinets and Boxes
8. Fed. Spec. W-P-115C

1.9 FIELD MEASUREMENTS

A. Verify that field measurements are as instructed by manufacturer.

1.10 MAINTENANCE MATERIALS

A. Provide two keys per panelboard.

1.11 DELIVERY, STORAGE AND HANDLING

A. Handle panelboards and enclosures carefully to prevent damage.

B. Store equipment indoors and protect from weather.

C. Deliver tubs and internal assemblies sufficiently in advance of installation period as necessary to prevent delay of work.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Eaton, or approved substitutions.

2.2 GENERAL

A. Lighting and Appliance Branch Circuit Panelboards: NEMA PB1, circuit breaker type, dead front, UL 67.

B. Panelboard Bus: Copper ratings as indicated. Provide copper ground bus in each panelboard. Provide isolated full size neutral bus where neutral is applicable. Provide non-linear load panelboards as specified on drawings. Non-linear panelboards shall have 200 percent rated neutral busbar.

C. Short-Circuit Rating:

1. Minimum short circuit interrupting capacity: 10,000 amperes rms symmetrical for 240 volt panelboards; 14,000 amperes rms symmetrical for 480 volt panelboards. Bus shall be braced for minimum capacity equal to or greater than the lowest breaker symmetrical interrupting capacity. Minimum short circuit rating shall be increased to meet the following requirements:

a) Individual C.B. AIC Rating shown on panel schedules indicate lowest AIC rating allowed for individual circuit breaker in panel.
b) Circuit breakers shall be based on a fully rated system.
c) Circuit breaker types are not specified. Provide breakers to comply with the required AIC specified.

D. Enclosure:

1. Enclosures shall be at least 20 inches wide made from galvanized steel. Provide minimum gutter space in accordance with the National Electrical Code. Where feeder cables supplying the mains of a panel are carried through its box to supply other electrical equipment, the box shall be sized to include the additional required wiring space. At least four interior mounting studs with adjustable nuts shall be provided.

2. Enclosures shall be provided with blank ends.

3. Where indicated on the drawings, branch circuit panelboards shall be column width type.

4. Regulatory Requirements:

a) NEMA PB 1, Type 1, Interior dry locations.
b) NEMA PB 1, Type 3R, Interior damp locations.
c) NEMA PB 1, Type 4X stainless steel watertight, Exterior locations including those noted on drawings to be NEMA 3R.
d) NEMA PB 1, Type 4X stainless steel watertight, interior wet locations, and wash-down areas, regardless of that noted on drawings.
e) UL 50

E. Cabinet box:

1. 6 inches (153 mm) deep; width: 20 inches (508 mm), minimum.
2. Interior dry and damp locations shall be constructed of galvanized code gauge steel, to prevent rust.
3. Exterior, wash-down areas, and Interior wet locations shall be constructed of type 4X stainless steel, watertight.

F. Cabinet Front:

1. Flush or surface with concealed trim clamps, concealed hinge, and flush lock all keyed alike.
2. Shall be door-in-door construction.
3. Finish in manufacturer's standard baked enamel finish for interior dry locations. Interior damp location panels to be painted with rust inhibit primer epoxy paint top coat system.
4. Exterior, wash-down areas, and Interior wet locations shall be constructed of type 4X stainless steel, watertight.

G. Panels and breakers shall be rated for voltage and class of service to which applied.

H. Spaces:

1. Space provisions or spaces for future breakers shall be located at the bottom of the panel and be fully bussed complete with all necessary mounting hardware less the breaker.

2.3 MAINS

A. Provide main lug only (MLO) or main circuit breaker (MCB) as noted on drawings either by riser diagram or by schedule. Where conflict exists, provide MCB.

B. Regardless of what is shown on drawings provide the following minimum requirements.

1. Main circuit breaker on each panel serving building main if required by applicable codes.
2. Main circuit breaker on each panel fed directly from a transformer (unless disconnect with overcurrent devices is installed in feeder between transformer and panel).

C. Provide lugs as required for conductors being connected to panelboard lugs, circuit breakers, etc.

D. Main circuit breaker is not to be mounted as branch breaker or subfeed breaker.

2.4 CIRCUIT BREAKERS

A. General

1. Molded Case Circuit Breakers: NEMA AB 1, plug-on type for 250V or less, bolt-on type for over 250V, thermal magnetic trip circuit breakers, with common trip handle for all poles. Provide circuit breakers UL listed as Type SWD for lighting circuits. Provide UL Class A ground fault interrupter circuit breakers where scheduled. Do not use tandem circuit breakers.
2. Current Limiting Molded Case Circuit Breakers: NEMA AB 1. Provide circuit breakers with integral thermal and instantaneous magnetic trip in each pole, coordinated with automatically resetting current limiting elements in each pole.

B. Main Breakers:

1. Main breakers shall be individually mounted separate from branch breakers.
2. Covered by a metal plate, except for operating handle.
3. Connection from the load's side to the panel bus shall be bus bar. Insulated wire not permitted.

C. Branch Breakers:

1. Thermal-magnetic, molded case, with inverse time-current overload and instantaneous magnetic tripping, unless otherwise shown. Breakers shall be calibrated for 40 degrees C or shall be ambient compensating.
2. Quick-make, quick-break, with tripped indication clearly shown by breaker handle taking a position between ON and OFF.
3. Multi-pole breakers shall have common internal trip. No handle ties between single pole breakers are acceptable for this Project.
4. Single pole 15 and 20 ampere circuit breakers shall be rated for switching duty and shall be labeled as "SWD".
5. Rating shall be as called for under "2.2 GENERAL".
6. Ground Fault Circuit Interrupters (GFI):

a) Provide UL Class (5 milliamp sensitivity) ground fault circuit protection on 120 VAC branch circuits for exterior location receptacles and for interior locations where required by NEC. (These may not be indicated on Panel Schedule.) This protection shall be an integral part of the branch circuit breaker which also provides overload and short circuit protection for branch circuit wiring. Tripping of a branch circuit breaker containing ground fault circuit interruption shall not disturb the feeder circuit to the panelboard. Provide separate neutral for circuits on GFI breakers whether indicated on drawings or otherwise.

7. Breakers feeding heating and air conditioning equipment shall be rated HACR type breaker.

D. Monitoring:

1. Provide Branch Circuit Monitoring on all lighting panels plus all other panels noted as such on Riser Diagram, Refer to 26 27 13 for additional requirements.

2.5 SERVICE ENTRANCE EQUIPMENT

A. Panelboards used as service entrance equipment shall be listed and labeled by UL for use as service equipment.

PART 3 - EXECUTION

3.1 PREPARATION/INSPECTION/EXAMINATION

A. Verify that surface is suitable for panelboard installation. Do not install NEMA 1 equipment until building has reached the “dried-in” stage.

B. Examine area to receive panelboard to assure adequate clearance for panelboard installation.

C. Verify prior to installation that National Electrical Code clearances will be maintained after installation. Rework equipment locations as required to provide electrical code clearances.

D. Start Work only after unsatisfactory conditions are corrected.

E. Submit coordination drawings of all electrical rooms, showing all equipment. Comply with Section 26 05 00.

3.2 INSTALLATION

A. Install panelboards in accordance with NEMA PB 1.1. Install all panelboards and panelboard enclosures in accordance with the manufacturer's written instructions, NECA's "Standard of Installation", the applicable requirements of the National Electrical Code, and recognized industry practices.

B. Install panelboards plumb. Install recessed panelboards flush with wall finishes. Provide supports in accordance with Section 26 05 29 Supporting Devices.

C. Panelboards shall be provided with structural framing located within gypsum board partitions. All enclosures shall be firmly anchored to walls and supporting structures (where used) using appropriate hardware. Provide supporting channels on walls constructed of gypsum board or where otherwise necessary to provide a mechanically secure and permanent installation. Attach channels to framing provided within gypsum board partitions.

D. Enclosures shall be installed so that the top is 6'-6" above finished floor.

   1. Where the size of the enclosure is such that the top cannot be installed at 6'-6", the top of the enclosure shall be kept as low as possible.

E. Panelboard backboxes/trim covers mounted adjacent to each other (i.e. multi-section panels, etc) installed in finished areas be of same size.

F. Provide filler plates for unused spaces in panelboards.

G. Provide typed circuit directory from panelboard manufacturers' original card stock, for each branch circuit panelboard. Mount a typewritten directory showing the actual circuit numbers, type of load and room names on inside of door. Room names shall be actual names or numbers used, not necessarily shown on the drawings. Progress Drawings shall show same arrangements as the Directory. Revise directory to reflect circuiting changes required to balance phase loads.

H. Provide four each 1 inch spare conduits out of each recessed panelboard to an accessible location above ceiling. Identify each as SPARE.

I. Clean the interior of each panelboard before installing conductors. At all times, keep the interior trim and exterior surfaces of the panelboard free of rust and debris. Repaint finishes if necessary.

J. Coordinate all raceways and conductors with their respective panelboards so that all connections and conductors routing present an orderly appearance. Conductors in the panelboards shall be neatly laced and arranged in orderly manner.

K. Collect all keys upon delivery of panelboard. Store keys on one ring to be kept by project superintendent. Forward key ring with keys to OAR at substantial completion.

L. Provide a separate neutral conductor for each GFI breaker. These shall not be combined to serve more than 1 circuit, even where on different phases. Increase plan indications of conductors for neutral wires required, as necessary.

M. Conduit or piping systems that contain water or liquid of any kind shall not be installed over the top of any electrical equipment, transformers, racks, cabinets, or enclosures without prior written approval from the Owner.

3.3 IDENTIFICATION

A. Refer to Section 26 05 53 Electrical Identification for products and content.

B. Provide engraved plastic nameplates under the provisions of 26 05 53.

C. Nameplate shall show panel name, voltage and name of panel that feeds this respective panel, and UL short circuit rating.

3.4 FIELD QUALITY CONTROL

A. Measure steady state load currents at each panelboard feeder; rearrange circuits in the panelboard to balance the phase loads to within 20 percent of each other. Maintain proper phasing for multi-wire branch circuits.

B. Visual and Mechanical Inspection: Inspect for physical damage, proper alignment, anchorage, and grounding. Check proper installation and tightness of connections for circuit breakers, fusible switches, and fuses.

C. All circuits shall be operated to establish a good working order and checked for shorts.

D. All panel directory circuit numbers shall be checked to verify accuracy of the number.

E. Tests:

1. Test Panelboards and panelboard feeders per requirements of Section 26 08 13 Tests and Performance Verification.
2. Feeder conductors shall be checked by approved means to establish the absence of shorts to ground; insulation value, etc. and the result recorded and submitted to the Designer.
3. Submit Conductor Insulation Resistance Test per requirements of Section 26 08 13.
4. Submit Tabulation Data Voltage and Amperage Readings per requirements of Section 26 08 13.

F. Equipment Checkout:

1. Where and when requested by Designer/OAR provide (during construction):

   a) Inspection of equipment by authorized equipment manufacturer technician complete with submittal of statement of findings by technician, and providing any adjustments deemed necessary for a complete and operating system.
   b) Submit Equipment Checkout Memo per Section 26 08 13.

3.5 ADJUSTMENT AND CLEANING

A. Adjust operating mechanisms for free mechanical movement.

B. Tighten bus connections and mechanical fasteners.

C. Touch up scratched and marred surfaces to match original finish.

END OF SECTION 26 24 16

SECTION 26 24 17 DISTRIBUTION PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Contractual Conditions and Division 01 Specifications sections apply to this section.

1.2 SUMMARY

A. This section includes the requirements for provision and installation of distribution panelboards.

1.3 DESCRIPTION

A. Factory-assembled, metal-enclosed panelboard for distribution and control of power from incoming line terminals to outgoing feeder terminals, installed and tested in place.

B. Distribution panelboard shall include all protective devices and equipment as specified, with necessary interconnections, accessories and control wiring.

1.4 SUBMITTALS

A. Product data shall be submitted on each basic Distribution Panelboard construction type, showing manufacturer’s standard construction data, including:

1. Cabinet construction/dimensions.
2. Bus construction.
3. UL labeling.
4. Each overcurrent device.
5. Provide electrical characteristics including voltage, frame size and trip ratings, fault current withstand ratings, and time-current curves of all equipment and components.
6. Provide data on trip units and breaker interface module.

B. Shop drawing shall be submitted for all distribution panelboard for this project clearly indicating the following:

1. Label.
2. Each circuit breaker amperage rating, circuit number and position/location in distribution panelboard.
3. Electrical characteristics of distribution panelboard.
4. Mains rating.
5. Main device rating.
6. Mounting.
7. Dimension, width, depth, height~~,~~.
8. Bus material.
9. Interrupting capacity of minimum rated breaker.
10. Distribution panelboard type.
11. Engraved nameplate for each overcurrent device.
12. Front and side views of enclosures with overall dimensions shown.

13. Conduit entrance locations and requirements.
14. Frame sizes and Interrupting Capacity of each breaker, and total assembly.
15. Horsepower ratings at rated voltage of fused switches and/or breakers.
16. Labels and labeling.
17. Nameplate on main panelboard only giving name of project; Architect, Engineer and Contractor.
18. Bus bar size, arrangement and spacing.
19. Breaker interface module.
20. Surge Protective Device Equipment
21. Metering/Monitoring Equipment

C. Submit Manufacturer's Instructions indicating application conditions and limitations of use stipulated by product testing agency specified under regulatory requirements. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

D. Submit Maintenance Data: Include spare parts data listing; source and current prices of replacement parts and supplies; and recommended maintenance procedures and intervals.

E. Submit Spare Parts Certification Memo signifying that the spare parts required by the drawings and/or specifications have been turned over to the Owner.

1.5 PROJECT AS-BUILT DOCUMENTS

A. Record actual locations of distribution panelboards on red lined as-built documents indicating actual circuit arrangement.

1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum 10 years experience.

1.7 REFERENCES AND REGULATORY REQUIREMENTS

A. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for purpose specified and shown.

B. Conform to the requirements of the following:

1. ANSI/NFPA 70 - National Electrical Code.
2. NEMA AB 1 - Molded Case Circuit Breakers and Molded Case Switches.
3. NEMA KS 1 - Enclosed Switches.
4. NEMA PB 1 - Panelboards.
5. NEMA PB 1.1 - Instructions for safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
6. UL 67 - Panelboards
7. UL 50 - Cabinets and Boxes
8. Fed. Spec. W-P-115C

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver in 35 inch maximum width or depth (or dimension required to fit section through doors), individually wrapped for protection and mounted on shipping skids.

B. Accept distribution panelboards on site. Inspect for damage.

C. Store in a clean, dry space designated by OAR. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

D. Handle in accordance with NEMA PB 1 and manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to distribution panelboard internal components, enclosure, and finish.

1.9 ENVIRONMENTAL REQUIREMENTS

A. Conform to NEMA PB 1 service conditions during and after installation of distribution panelboards.

1.10 FIELD MEASUREMENTS

A. Verify that field measurements are as indicated and comply with instructions by manufacturer.

1.11 MAINTENANCE MATERIALS

A. Provide two of each key (where applicable).

B. Provide two fuse pullers (where applicable).

PART 2 - PRODUCTS

2.1 MANUFACTURERS

~~A. Landside Building, Parking Garages, Hyatt, Airside Buildings 2 and 4.~~

~~1.~~A. Eaton/Cutler Hammer (Basis of Design), or approved substitutions.

2.2 GENERAL

A. Distribution Panelboards shall have circuit breaker branch protective devices complying with NEMA PB1 as a minimum requirement. Panelboards shall be NEMA I and shall meet Underwriter's Laboratories enclosure requirements for service conditions.

B. Distribution panelboards shall have UL label affixed, unless special construction prohibits and no labeling or listing is available.

C. Short-Circuit Rating:

1. Minimum integrated short circuit rating: 22,000 amperes rms symmetrical for 240 volt; 35,000 amperes rms symmetrical for 480 volt. Bus shall be braced for minimum capacity equal to or greater than the lowest breaker symmetrical interrupting capacity. Minimum short circuit rating shall be increased to meet the following requirements:

   a) Individual C.B. AIC Rating shown on panel schedules indicate lowest AIC rating allowed for individual circuit breaker in panel.

   b) Circuit breakers shall be based on a fully rated system.

   c) Circuit breaker types are not shown or called for. The contractor must provide breakers in panel or feeder breakers in upstream breakers to comply with the required AIC specified.

   d) Distribution panelboards to be freestanding type construction unless specifically specified otherwise.

2. Short-Circuit Rating Label:

   a) Panelboards shall be labeled with a UL short-circuit rating.

   b) Series ratings shall not be used to achieve short circuit ratings.

D. Enclosure:

1. Enclosures shall be at least 20 inches wide made from galvanized steel. Provide minimum gutter space in accordance with the National Electrical Code. Where feeder cables supplying the mains of a panel are carried through its box to supply other electrical equipment, the box shall be sized to include the additional required wiring space. At least four interior mounting studs with adjustable nuts shall be provided.
2. Enclosures shall be provided with blank ends.
3. Where indicated on the drawings, branch circuit panelboards shall be column width type.
4. Regulatory Requirements:
    a) NEMA PB 1, Type 1, Interior dry locations.
    b) NEMA BP 1 Type 3R, Interior damp locations
    c) NEMA PB 1, Type 4X stainless steel watertight, Exterior locations including those notes on drawings to be NEMA 3R
    d) NEMA PB 1, Type 4X stainless steel watertight, interior wet locations, and washdown areas, regardless of that noted on drawings.
    e) UL 50

2.3 DISTRIBUTION PANELBOARDS

A. Description: NEMA PB 1 with electrical ratings and configurations as indicated.

B. Overcurrent Devices: Panel mounted.

C. Bus Material: Copper standard size.

D. Bus Connections: Bolted, accessible from front for maintenance.

E. Ground Bus: Extend length of board.

F. Molded Case Circuit Breakers - 1200A and Below:

1. Protective devices shall be molded case circuit breakers with inverse time and instantaneous tripping characteristics.
2. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position.
3. Circuit breakers shall have a minimum symmetrical interrupting capacity as indicated on the drawings and as specified herein.
4. Circuit breakers 225 ampere and below shall have thermal-magnetic trip units and inverse time-current characteristics.
5. Circuit breakers above 225 ampere shall have microprocessor based programmable RMS sensing trip units.
6. Ground fault protection shall be provided where indicated.
7. Where indicated circuit breakers shall be current limiting.
8. Where indicated provide UL listed circuit breakers for applications at 100% of their continuous ampere rating in their intended enclosure.

G. Programmable Trip Units: (Circuit Breakers Above 225 Ampere)

1. Each circuit breaker microprocessor-based tripping system shall consist of three (3) current sensors, a trip unit and a flux-transfer shunt trip. The trip unit shall use microprocessor-based technology to provide the adjustable time-current protection functions. True rms sensing circuit protection shall be achieved by analyzing the

secondary current signals received from the circuit breaker current sensors and initiating trip signals to the circuit breaker trip actuators when predetermined trip levels and time-delay settings are reached Basis of Design is Cutler-Hammer type OPTIM 1050.

2. Interchangeable rating plugs shall establish the continuous trip ratings of each circuit breaker. Rating plugs shall be fixed-type as indicated. Rating plugs shall be interlocked so they are not interchangeable between frames, and interlocked such that a breaker cannot be closed and latched with the rating plug removed.

3. System coordination shall be provided by the following microprocessor-based programmable time/current curve shaping adjustments:

    a) Programmable long-time pickup settings in 1% increments, with +/- 5% band tolerance

    b) Programmable long-time delay with selectable I^2t or I^4t curve shaping.

    c) Programmable short-time settings (dependent on long-time setting) in 1% increments, with +/- 5% band tolerance.

    d) Programmable short-time delay with selectable flat or I^2t curve shaping.

    e) Programmable instantaneous pickup settings in 1% increments.

    f) Programmable ground fault pickup settings trip or alarm in 1% increments.

    g) Programmable ground fault delay with selectable flat or I^2t curve shaping.

4. The microprocessor-based trip unit shall have a powered/unpowered selectable thermal memory to provide protection against cumulative overheating should a number of overload conditions occur in quick succession.

5. When the instantaneous setting has been deselected, a selectable discriminator circuit shall be provided to prevent the breaker being closed and latched on to a faulted circuit.

6. Internal ground fault protection or alarm settings, if specified, shall not exceed 1200 amperes. Provide neutral ground fault sensor for four-wire loads.

7. The trip unit shall have an information system that utilizes battery backed up LEDs to indicate mode of trip following an automatic trip operation. The indication of the mode of trip shall be retained after an automatic trip. The LEDs shall be complemented by trip event information stored in non-volatile memory after a trip event. A trip reset button shall be provided to turn off the LED indication and reset the memory after an automatic trip. A test pushbutton shall energize an LED to indicate battery status.

8. A red LED shall be provided on the face of the trip unit and pre-set to flash on and off when an adjustable high-load level is exceeded. A time-delay shall be provided to avoid nuisance alarms. The microprocessor-based trip units shall be capable of monitoring the following data:

    a) Instantaneous value of phase, neutral and ground current.

    b) Minimum and maximum current values.

    c) Average demand current.

    d) System diagnostic information such as alarms and cause of trip.

    e) Approximate level of fault current that initiated an automatic trip operation.

9. The trip unit shall contain test capability. Testing shall be carried out by using a hand-held programmer, a breaker interface module or a remote computer to select the values of test current within a range of available settings. The basic protection functions shall not be affected during test operations. The breaker may be tested in either the "Trip" or "No Trip" test mode.

10. A hand-held programming unit shall be provided to set/change the network communication breaker address for each device, set the stem baud rate, distribution frequency, display breaker information, and display monitored values. In addition, provide password protection for programming time/current set points and to perform functional testing of phase and ground trip characteristics. The programmer shall be self-powered by an internal battery. Provide two (2) hand-held programming units. Contractor shall submit Spare Parts Certification Memo certifying two hand-held programming units have been turned over to the Owner.

11. The monitored data shall be displayed by a hand-held programmer, a breaker interface module and a remote computer.

12. Circuit breakers, 1200 ampere frame and below, shall be provided with a 24 volt DC power supply mounted within the assembly. In addition, provide a minimum of one (1) auxiliary switch and one (1) bell alarm, each with form C contacts in each breaker. Provide additional auxiliary switches, bell alarms, shunt trips, and undervoltage releases where indicated on the drawings.

13. The trip unit shall be capable of two-way communication via a network twisted pair for remote monitoring and control. The trip unit shall be provided with an address register for identification on the network. All monitored values shall be transmittable over the network.

14. The trip unit shall include zone interlocking capability for the short-time delay and ground fault delay trip functions for improved system coordination. The zone interlocking system shall restrain the tripping of an upstream circuit breaker, and allow the circuit breaker closest to the fault to trip with no intentional time delay. In the event that the downstream breaker does not trip, the upstream breaker shall trip after the pre-set time delay. Factory wire zone interlocking system for breakers within each assembly.

15. Molded case circuit breakers shall be provided with a potential transformer, suitable for operation up to 600 volts. The potential transformer shall be mounted externally to the circuit breakers and provided with a dielectric disconnect fuse.

16. For enhanced system analysis, the following additional parameter values shall be monitored:

    a) Peak demand (kW)

    b) Present demand (kW)

    c) Reverse energy (kWh)

    d) Forward energy (kWh)

    e) Total energy (kWh)

    f) Power factor

    g) Percentage harmonic content

    h) Total Harmonic Distortion (THD).

H. Power Monitoring

1. Panel mounted meter (incoming metering device)

    a) All Distribution Panelboards ~~800 Amperage and larger~~ shall be provided with a ~~Cutler-Hammer IQ IQ220~~Power XPert 2000 (or approved substitution) microprocessor based sub-meter complete with C.T.'s and communication to panel mounted monitor/display unit to provide the following data: Volts, amps, watts, watt-hour, vars, power factor, frequency, demand watts. .

    b) Provide all interface cabling and connections.

~~2. Panel mounted breaker monitor/display unit:~~

~~a) All distribution panelboards 800 Amperage and larger shall be provided with a Breaker Interface Module Unit to monitor/display data from incoming metering device and each branch breaker's trip unit 250 Amperage or larger.~~

~~b) Provide all interface cabling and connections.~~

~~3. All breakers over 225 ampere and all meters are to be connected to main Power Xpert computer (PC) in GOAA's Electrical Maintenance Office and the Central Plant operators station via appropriate device, equipment, cables, hubs, switches, converters, etc.~~

I. Ground Fault Sensor (where called for on drawings): Zero sequence of ground return type.

J. Future Provisions: Fully equip spaces for future devices with bussing and bus connections, suitably insulated and braced for short circuit currents. Provide continuous current rating as indicated.

K. Enclosure: Type 1 - General Purpose for interior locations. Type 2 - Rain tight for damp locations.

1. Align sections at front and rear.

2. Finish:

a) Interior dry locations: Manufacturer's standard light gray enamel over external surfaces. Coat internal surfaces with minimum one coat corrosion-resisting paint, or plate with cadmium or zinc.

b) Interior damp locations: Coat interior and exterior of enclosure with rust inhibiting primer and paint over with epoxy paint.

c) Exterior, wash-down areas, and Interior wet locations: NEMA 4X stainless steel, watertight.

2.4 DISTRIBUTION ENTRANCE EQUIPMENT

A. Panelboards used as service entrance equipment shall be listed and labeled by UL for use as service equipment.

PART 3 - EXECUTION

3.1 PREPARATION, INSPECTION, EXAMINATION

A. Verify that surface is suitable for panelboard installation. Do not install NEMA 1 equipment until building has been “dried-in” stage.

B. Examine area to receive panelboard to assure adequate clearance.

C. Verify National Electrical Code clearances will be maintained after installation. Rework equipment locations as required to provide Electrical code clearances.

D. Start Work only after unsatisfactory conditions have been corrected.

E. Submit coordination drawings of all electrical rooms, showing all electrical (and mechanical) equipment. Comply with requirements of Section 26 05 00 Common work Results for Electrical.

3.2 INSTALLATION

A. Install panelboards in accordance with NEMA PB 1.1. Install all panelboards and distribution panelboard enclosures in accordance with the manufacturer's written instructions, NECA's "Standard of Installation", the applicable requirements of the National Electrical Code, and recognized industry practices.

B. Install panelboards plumb. Install recessed distribution panelboards flush with wall finishes. Provide supports in accordance with Section 26 05 29 Hangers and Supports.

C. Panelboards and terminal cabinets shall be provided with structural framing located within gypsum board partition. All enclosures shall be firmly anchored to walls and supporting structures (where used) using appropriate hardware. Provide supporting (unistrut type) channels on walls constructed of gypsum board or where otherwise necessary to provide a mechanically secure and permanent installation. Attach channels to framing provided within gypsum board partitions

D. Install enclosures so that the top is 6'-6" above finished floor. Where the size of the enclosure is such that the top cannot be installed at 6'-6", the top of the enclosure shall be kept as low as possible.

E. Provide filler plates for unused spaces in distribution panelboards.

F. Provide spare conduits out of each recessed distribution panelboard to an accessible location above ceiling. Minimum spare conduits: 4 empty 1 inch. Identify each as SPARE.

G. Install distribution panelboards so that proper working clearances shall be maintained at every distribution panelboard location.

H. Clean the interior of each distribution panelboard before installing conductors. At all times, keep the interior trim and exterior surfaces of the distribution panelboard free of rust and debris. Repaint finishes if necessary.

I. Coordinate all raceways and conductors with their respective distribution panelboards so that all connections and conductors routing present an orderly appearance. Conductors in the distribution panelboards shall be laced and arranged in orderly manner.

J. Provide a separate neutral conductor for each GFI breaker. These shall not be combined to serve more than 1 circuit, even where on different phases. Increase plan indications of conductors for neutral wires required, as necessary.

K. Provide 3” concrete housekeeping pad.

L. Provide and install separate 120 volt, 20 AMP circuit complete with circuit breaker, transformer, conduit, and wire as required to power any shunt-trip function specified.

A. Conduit or piping systems that contain water or liquid of any kind shall not be installed over the top of any electrical equipment, transformers, racks, cabinets, or enclosures without prior written approval from the Owner.

3.3 MONITORING/METERING

A. Provide/install all components, wiring, cable (fiber optic and copper), raceways, hubs, switches, patch panels modules, pc cards, communication network devices, converters, etc. as required to connect monitoring/metering equipment in each panelboard (provided with monitoring/metering) to GOAA's Power Xpert Computer (PC) located in Electrical Maintenance Shop/Office and in the Central Plant’s operators station.

B. Provide/install all software, programming, etc. to facilitate installation and monitoring of all monitor/meter equipment on GOAA's selected Power Xpert PC System.

C. Integrate all new equipment provided under this contract into existing software including programming/changes required to computer screens, program trending, program event logging, etc.

D. Coordinate with GOAA final approval of screens, trending, and event logging requirements and program system accordingly.

E. All revisions to software, programming, etc is to be by manufacturer of software.

3.4 IDENTIFICATION

A. Refer to Section 26 05 53 Identification for Electrical Systems.

B. Provide engraved plastic nameplates under the provisions of 26 05 53 Identification for Electrical Systems.

3.5 FIELD QUALITY CONTROL

A. Measure steady state load currents at each distribution panelboard feeder; rearrange circuits in the distribution panelboard to balance the phase loads to within 20 percent of each other. Maintain proper phasing for multi-wire branch circuits.

B. Visual and Mechanical Inspection: Inspect for physical damage, proper alignment, anchorage, and grounding. Check proper installation and tightness of connections for circuit breakers, fusible switches, and fuses.

C. All circuits shall be operated to establish a good working order and checked for shorts.

D. All panel directory circuit numbers shall be checked to verify accuracy of the number.

E. Measure insulation resistance of each bus section phase to phase and phase to ground for one minute each, at test voltage of 1000 volts; minimum acceptable value for insulation resistance is 2 megohms.

F. Check tightness of accessible bolted bus joints using calibrated torque wrench.

G. Physically test key interlock systems to insure proper function.

H. Tests:

1. Test Distribution panelboards and distribution panelboard feeders per requirements of Section 26 08 13 Tests and Performance Verification.

2. Feeder conductors shall be checked by approved means to establish the absence of shorts to ground; insulation value, etc. and the result recorded and submitted to the Designer.

3. Submit Conductor Insulation Resistance Test per requirements of Section 26 08 13 Tests and Performance Verification.

4. Submit Tabulation Data Voltage and Amperage Readings per requirements of Section 26 08 13 Tests and Performance Verification.

I. Equipment Checkout:

1. When requested by Designer provide (during construction):

a) Inspection of equipment by authorized equipment manufacturer technician complete with submittal of statement of findings by technician, and providing any adjustments deemed necessary for a complete and operating system.

b) Submit Equipment Checkout Memo per Section 26 08 13 Tests and Performance Verification.

3.6 ADJUSTING

A. Adjust all operating mechanisms for free mechanical movement.

B. Tighten bolted bus connections in accordance with manufacturer’s instructions.

C. Adjust circuit breaker trip and time delay settings to values per manufacturer’s recommendation.

END OF SECTION 26 24 17

SECTION 26 25 00 - BUSWAY – LOW VOLTAGE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SCOPE

A. The Contractor shall furnish and install the busway system including all necessary fittings, hangers and accessories as specified herein and as shown on the contract drawings.

1.3 REFERENCES

A. The low voltage busway and all components shall be designed, manufactured and tested in accordance with the latest applicable following standards of ANSI, CSA, IEC and NEMA:

1. NEMA BU.1 - Busways
2. ANSI/UL 857 – Underwriter's Busway Standards
3. NFPA 70 – National Electrical Code
4. CSA C22.2 No. 27
5. IEC 60439-1 and 2

1.4 SUBMITTALS FOR REVIEW/APPROVAL

A. The following information shall be submitted to the Engineer:

1. Master drawing index.
2. Shop Drawings: Indicate ratings, dimensions and finishes. Include dimensioned layout diagram, installation details and locations of supports and fittings such as firestops and weatherseals. Include details of wall and floor penetrations.
3. Isometric drawing of each busway run
4. Component list
5. Busway ratings including:
   a) Short-circuit rating
   b) Voltage
   c) Continuous current
6. Major component ratings including:
   a) Voltage
   b) Continuous current
   c) Interrupting ratings
7. Cable terminal sizes

8. Product data sheets on all components including, but not limited to:
    a) Bus
    b) Expansion fittings
    c) Fire Stops (with UL Detail)
9. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

1.5 SUBMITTALS FOR CONSTRUCTION

A. The following information shall be submitted for record purposes:
    1. Final as-built drawings and information for items listed in paragraph 1.4 above.
    2. Certified production test reports.
    3. Installation information.

B. The final (as-built) drawings shall include the same drawings as the construction drawings and shall incorporate all changes made during the manufacturing process.

1.6 QUALIFICATIONS

A. All components shall be of the same manufacturer as the busway.

B. For the equipment specified herein, the manufacturer shall be ISO 9001 or 9002 certified.

C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of 10 years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

1.7 REGULATORY REQUIREMENTS

A. The busway shall bear a UL label. (Certified copies of production test reports shall be supplied demonstrating compliance with these standards when requested by the Engineer).

B. Conform to requirements of NFPA 70.

1.8 DELIVERY, STORAGE AND HANDLING

A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One copy of these instructions shall be included with the equipment at time of shipment.

B. Refer to NEMA Publication BU 1.1 which is a guide for proper installation, operation, and maintenance of busway products.

C. Accept busway on site in factory containers. Inspect for damage.

D. Protect from moisture by using appropriate coverings. Store in dry interior locations.

1.9 OPERATION AND MAINTENANCE MANUALS

A. Equipment operation and maintenance manuals shall be provided with each assembly shipped, and shall include instruction leaflets and instruction bulletins for the complete assembly and each major component.

B. Operation and maintenance manuals shall include the following information.

1. Instruction books or leaflets
2. Recommended renewal parts list
3. Drawings and information required by Section 1.5

1.10 FIELD MEASUREMENTS

A. Verify that field measurements are as indicated on shop drawings.

1.11 SEQUENCING

A. Sequence work to avoid interferences with building finishes and installation of other products.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis of Design:

1. Eaton

B. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

2.2 RATINGS

A. The busway shall be Eaton type Pow-R-Way III and shall be copper with:

1. Three-phase, four-wire with 50% integral housing ground and 100% neutral.

B. Voltage and current ratings as indicated on the contract drawings. Provide 100% neutral and 50% capacity integral ground bus.

C. The busway shall, have a minimum of 6-cycle short-circuit rating of 85 kA RMS symmetrical for ratings through 800A, 100 kA RMS symmetrical for ratings through 1350A, 125 kA RMS symmetrical for ratings through 1600A, 150 kA RMS symmetrical ratings through 2500A, and 200 kA RMS symmetrical for ratings through 5000A.

D. The short circuit rating of the busway shall be determined according to UL 857 Standards. This rating must be based upon actual test at the rated short circuit current.

2.3 CONSTRUCTION

A. The busway and associated fittings shall consist of [aluminum] [copper] conductors totally enclosed in a 2-piece extruded aluminum housing. Outdoor feeder, indoor feeder and indoor plug-in busway shall be interchangeable at the same rating without the use of adapters or special splice plates. Where indicated on the contract drawings, provide indoor, sprinkler-proof plug-in busway. Outdoor designs requiring addition of caulking or gasketing in the field are not acceptable. Fittings such as elbows, tees, flanges, etc., shall be identical for use with both the plug-in and feeder types of busway. The busway shall be capable of being mounted flatwise, edgewise, or vertically without derating. The busway shall consist of standard 10 foot sections with special sections and fittings provided to suit the installation. Horizontal runs shall be suitable for hanging on 10 foot maximum centers. Vertical runs shall be suitable for mounting on 16 foot maximum centers. Provide one hanger for every 10 feet of horizontally mounted busway. On vertical runs, provide one spring, adjustable suspension type hanger per floor.

B. Busway shall comply with NEMA BU.1.

2.4 CONDUCTOR BUS BAR

A. Bus bars shall be fabricated from high strength, *[55% conductivity aluminum] [99% conductivity copper] and suitably plated at all electrical contact surfaces.

B. Bus bars shall be insulated over their entire length, except at joints and contact surfaces, with a UL listed insulating material consisting of epoxy applied by fluidized bed process. Tape or heat-shrink sleeve insulation, or any other method of insulation which can allow air-gaps or insulation breakdown, shall not be acceptable.

C. The busway shall be capable of carrying rated current continuously without exceeding a temperature rise of 55 degrees C based on a 40 degrees C ambient.

D. Feeder busway (800 A and above) shall be of sandwich construction, meaning no air gap shall exist between bus bars.

2.5 BUS JOINTS

A. Each busway section shall be furnished complete with joint hardware and covers.

B. The busway joints shall be a single-bolt, non-rotating, removable bridge design.

C. All bridge joints shall be furnished with torque-indicating double head joint bolts and Belleville washers. The bridge joint shall utilize a captive nut retainer on the opposite side of the torque indicating bolt. The bridge joint design shall ensure proper installation without the use of a torque wrench, and provide visual indication that the joint is properly torqued.

D. Each busway joint shall allow for a minimum length adjustment of +/- 0.5 inches.

E. De-energization of busway shall not be required for safe testing of joint tightness.

F. Access shall be required to only one side of the busway for tightening joint bolts.

G. The bridge joint shall be the Eaton Pow-R-Bridge.

2.6 HOUSING

A. The busway housing shall be a two-piece design fabricated from extruded aluminum. The two- piece housing shall be bolted together along the bottom flange using grade 5, 1/4 x 20 zinc plated fasteners on 3 inch centers for maximum mechanical strength.

B. The busway enclosure finish shall be ANSI 61 or 49 gray baked epoxy powder paint applied by an electrostatic process.

C. Outdoor feeder busway housing shall be identical to indoor feeder busway housings, and shall be UL listed for outdoor use. Busway shall be completely weatherized at the factory, and designed such that only protective joint covers are required for outdoor application.

D. The busway housing shall be totally enclosed non-ventilated for protection against mechanical damage and dust accumulation.

E. The totally enclosed housing shall be manufactured by the busway manufacturer. Modifications of busway to make it totally enclosed by other than the busway manufacturer voids the manufacturer’s warranty. Busway so modified is unacceptable without the written consent of the manufacturer.

2.7 TRANSIENT VOLTAGE SURGE SUPPRESSION

A. Provide transient voltage surge suppression as specified in Section 26 43 00 Surge Protective Devices.

2.8 FITTINGS

A. Provide fittings in accordance with manufacturer’s recommendations.

2.9 FINISH

A. Baked gray enamel.

2.10 VOLTAGE DROP

A. the voltage drop (input voltage minus output voltage) shall be based on the busway operating at full ranted current and at stabilized operating temperature in 30 degree C ambient.

B. The three-phase, line-to-line voltage drop shall not exceed 3.1 volts per hundred feet at 40% power factor concentrated load which may exist during motor starting.

C. The line-to-line voltage drop shall not exceed 4.0 volts per hundred feet at the load power factor which produces maximum voltage drop in the busway.

PART 3 - EXECUTION

3.1 FACTORY TESTING

A. Standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of ANSI and NEMA standards.

B. The manufacturer shall provide three certified copies of factory test reports.

C. Factory tests as outlined above shall be witnessed by the Owner’s Representative.

1. The manufacturer shall notify the Owner two weeks prior to the date the tests are performed.

2. The manufacturer shall include the cost of transportation and lodging for up to three Owner’s Representatives. The cost of meals and incidental expenses shall be the Owner’s responsibility.

3.2 INSTALLATION

A. The Contractors shall install all equipment per the manufacturer's recommendations and the contract drawings.

B. The Contractor shall be responsible for routing the busway to coordinate with the other trades. Final field measurements shall be made by the Contractor prior to release of the busway for fabrication by the manufacturer.

C. Do not install busway when installation location is not protected from moisture.

D. Tighten joints using a torque wrench, to manufacturer's specified values.

E. Install busway length with expansion fittings at each location where busway run crosses building expansion joint.

F. Mounting and Support: Mount horizontal busway runs in position as required to facilitate layout as indicated on Drawings. Support busway at maximum intervals as recommended by manufacturer. Support vertical riser at each floor.

G. Hanger spacing shall be noted on layout drawings and shall not exceed manufacturer's recommendations.

H. Install busway with integral fire stops located where busway penetrates fire-rated walls and floors. Seal around opening to maintain fire-rating equal to wall or floor rating.

I. Provide concrete curb around interior floor penetrations.

J. Install busway with integral weather seal located where busway penetrates exterior wall and/or roof. Provide wall and/or roof flange and seal around opening to maintain weathertight installation.

K. Provide engraved plastic nameplates under the provisions of Section 26 05 53 Identification for Electrical Systems.

L. Provide transformer taps in one vault as required by OUC.

M. Locate bus vault penetration and transformer tap boxes as directed by OUC.

N. Coordinate all work in OUC vault with OUC prior to bid. Bid to include all work required by OUC.

END OF SECTION 26 25 00

SECTION 26 27 16 – ELECTRICAL CABINETS AND ENCLOSURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This section includes the requirements for provision and installation of cabinets and enclosures.

1.3 DESCRIPTION

A. Provide and install all equipment, labor, material, accessories, and mounting hardware for a complete and operating system for the following:

1. Hinged cover enclosures.
2. Cabinets.

B. Cabinets and enclosures are to include:

1. Terminal blocks,
2. Mounting panel,
3. Ground bus/bar, and
4. All accessories as required for a complete and operating system.

C. Provide cabinets and enclosures for all systems specified in Divisions 27, 28.

1.4 REFERENCES AND REGULATORY REQUIREMENTS

A. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for purpose specified and shown.

B. Conform to the requirements of the following:

1. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)
2. NEMA ICS 4 - Terminal Blocks
3. ANSI/NFPA 70 - National Electrical Code

1.5 SUBMITTALS

A. Submit Product Data: Provide manufacturer's standard data for enclosures and cabinets.

B. Submit Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency specified under regulatory requirements. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

C. Submit shop drawings on all cabinets and enclosures showing:

1. Covers.
2. Dimensions - inside and out.
3. Gauge of metal.
4. Manufacturer.
5. Terminal mounting plate, construction, etc.

6. Ground bus/bar.

1.6 EXTRA MATERIALS

A. Provide two keys for each type of lock.

PART 2 - PRODUCTS

2.1 GENERAL

A. Unless specifically called for otherwise on contract drawings, provide "CABINETS" as specified herein for terminal cabinets mounted indoor. Similarly, provide "HINGED COVER ENCLOSURES" as specified herein for terminal cabinets mounted outdoors or in locations other then NEMA 1 locations. Also, provide "HINGED COVER ENCLOSURES" for locations where size required is not available in "CABINET" construction, or if specifically specified as "enclosure" on contract documents.

B. Size.

1. Dimensions of cabinets and enclosures shall meet the dimensions shown on drawings, dimensions required by NEC, or dimensions sized as required to facilitate all equipment/connections involved installation, whichever is largest.

2. Coordinate sizes required and assure that equipment cabinets or enclosures will house and facilitate proper installation and access to equipment.

C. Provide metal barriers to separate compartments containing control wiring operating at less than 50 volts from power wiring or where wiring from separate systems of Normal and Emergency Power are required to be in one enclosure.

D. Provide accessory feet or mounting brackets for free-standing equipment.

2.2 HINGED COVER ENCLOSURES

A. Construction:

1. Interior Dry Locations: NEMA Type 1 (unless otherwise noted), steel.

2. Exterior and Interior Wet Locations: NEMA Type 4X: Stainless steel.

B. Covers: Continuous hinge.

C. Enclosure Finish:

1. NEMA 1: Manufacturer's standard metallic gray enamel over phosphatized surfaces.

2. NEMA 4X: Stainless steel.

D. Lock/handle.

1. Provide key lock handle on all enclosures mounted in areas that are not dedicated electrical or mechanical rooms. Enclosures installed in electrical rooms are not required to be lockable.

E. Interior mounting plate.

1. Each enclosure is to have interior mounting plate/panel for mounting terminal blocks and electrical components.

2. Plate/panel is to be metal.

F. Ground bus/bar.

1. Each enclosure housing surge suppression equipment or other equipment shall have "local" ground bar/bus installed. See Article "Local Ground Bus/Bar".

2.3 CABINETS

A. Construction: Specified gauge steel with removable enwalls.

B. Finish:

1. Boxes:

a) Surface mounted: Gray baked enamel.

b) Flush mounted: Galvanized steel.

2. Fronts: Gray baked enamel.

C. Fronts:

1. Electrical or Mechanical Room Locations: screw cover with hinged door and flush handle or as noted below.

2. Other Locations: Mono-flat with concealed trim clamps, concealed hinges, flush lock lockable handle, and custom color finish in interior public areas to match mounting surface.

3. Flush or surface type as shown or called for in Contract Documents.

D. Interior mounting plate.

1. Each enclosure is to have interior mounting plate/panel for mounting terminal blocks and electrical components.

2. Panel/plate shall be metal.

E. Ground bus/bar.

1. Each cabinet housing surge suppression equipment or other equipment shall have "local" ground bar/bus installed. See specification for "Local Ground Bus/Bar" included within this section.

2.4 TERMINAL BLOCKS

A. Terminal Blocks: ANSI/NEMA ICS 4.

B. Power Terminals: Unit construction type with closed back and tubular pressure screw connectors, rated 600 volts.

C. Signal and Control Terminals: Modular construction type, suitable for channel mounting, with tubular pressure screw connectors, rated 300 volts.

D. Provide ground bus terminal block, with each connector bonded to enclosure.

2.5 LOCAL GROUND BUS/BAR

A. Size to handle #6 through #14 AWG copper ground wire.

B. Length as required for circuits.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that surfaces are ready to receive work.

3.2 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Install enclosures and cabinets plumb. Anchor securely to wall and structural supports at each corner.

C. Install cabinet fronts plumb.

D. Install per NEC and as required for proper clearance. Coordinate with panels.

E. Provide and install terminal cabinets as shown on drawings or as required by the NEC.

F. Provide terminal cabinets wherever required for a complete and operating distribution system whether shown on drawings or not.

G. Install local ground bus/bar in each terminal cabinet/enclosure that houses surge suppression equipment or other equipment and bond to cabinet enclosure via mounting screws or #6 AWG copper ground wire.

H. Ground local ground bus to "SYSTEMS" ground bus/bar with minimum #6 AWG copper ground wire. Increase size if so required on drawings.

I. Install enclosures.

END OF SECTION 26 27 16

SECTION 26 28 16 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1- GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Contractual Conditions and Division 01 Specification sections apply to this section.

1.2 SUMMARY

A. This section includes the requirements for provision and installation of enclosed switches and circuit breakers.

1.3 DESCRIPTION

A. Provide all labor, materials, and equipment necessary to properly install switches as shown on the drawings and as required by codes.

B. Coordinate with Division 23 for disconnect switches for mechanical equipment. Provide all other disconnect switches required for a complete operating system.

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver switches in factory wrapped packaging. Handle switches carefully to prevent damage. Store in a clean, dry space protected from dirt, water, and physical damage. Reject damaged switches.

1.5 QUALIFICATIONS

A. Manufacturer: Same manufacturer as that for products specified in Section 26 24 13.

1.6 SUBMITTALS

A. Submit catalog cut sheet on each type of disconnect switch to be used on this project.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Eaton/Cutler Hammer, or approved substitutions.

2.2 CONSTRUCTION

A. Switches shall be heavy-duty type with visible, quick-make, quick-break blades.

B. Units for 2-speed motors shall be 6-pole in a single enclosure. Use of 2, 3-pole units will not be acceptable.

C. Provide ground bus and where required, a solid neutral bus.

D. Switches shall be fusible or non-fusible as noted on the drawings or as required by the equipment served from the switch. Fusible switches shall have rejection type fuse holders.

E. Terminal lugs shall be rated for 75 degrees Centigrade.

F. Enclosures, unless otherwise noted, shall be:

1. Interior dry locations shall be NEMA 1.
2. Wash-down areas, interior wet locations or similar shall be NEMA 4X stainless steel watertight, corrosion resistant.
3. Exterior locations shall be NEMA 4X stainless steel watertight, corrosion resistant, including those noted on drawings to be NEMA 3, minimum.

G. The enclosure shall be interlocked with the switch handle such that the enclosure door or cover cannot be opened with the switch in the "ON" position. The switch handle shall be capable of being padlocked in the "OFF" position but not in the "ON" position.

H. Finish for NEMA I units shall be standard baked gray enamel finish over a rust inhibiting phosphate primer.

2.3 RATING

A. The size, number of poles, and fusing for each switch shall be as noted on the drawings. As a minimum, no less than one pole for each ungrounded conductor shall be provided. Switches shall be rated 250 VAC or 600 VAC as required by the circuit to which it is connected.

B. Switches serving motors with more than one set of windings shall have the number of poles necessary to disconnect all conductors to all windings in a single switch.

C. Switches serving motor loads shall be horsepower rated to match motor and of sufficient size to handle the load regardless if rating noted on drawings is provided in ampere.

2.4 SERVICE ENTRANCE EQUIPMENT

A. Switches used as service entrance equipment shall be listed and labeled by UL for use as service equipment.

2.5 FUSES

A. General:

1. All fuses shall be of the same manufacture to retain selectability as designed. No fuse shall be installed until equipment is ready to be energized and after tightening of all electrical

connections, inspection of all ground and grounding conductors and a megger test of adequate insulation to ground of all circuits.

2. All fuses shall be current limiting with 200,000 amperes interrupting capacity.
3. Fuses rated 601 amperes and larger shall be UL Class L and have a minimum time-delay of 45 seconds at 300% rating and have O-ring gas seals at the end bells.
4. Fuses rated 600 amperes or less, installed ahead of circuit breakers or circuit breaker panels, shall be UL Class K-1.
5. Fuses rated 600 amperes or less for all general power circuits shall be dual-element, UL Class RK-5 time-delay type. They shall be self protecting from extraneous heat.
6. Fuses installed in individual motor circuits shall be dual element time-delay type, UL Class RK-5. Provide fuse reducers when necessary.
7. Fuses called for to be rejection type are to have rejection fuse holders.
8. Fused disconnect switches for elevators and escalators shall have rejection fuse holders.

B. Fuse Requirements:

1. Dimensions and Performance: NEMA FU 1, Class as indicated.
2. Voltage: Rating suitable for circuit phase-to-phase voltage.
3. Power Load Feeder Switches Larger than 600 amperes: Class L (time delay).
4. Power Load Feeder Switches: Class RK1 (time delay) or RK5 (based on load).
5. Motor Load Feeder Switches: Class RK5.
6. Lighting Load Feeder Switches Larger than 600 amperes: Class L time delay.
7. Lighting Load Feeder Switches: Class RK1 (time delay).
8. Other Feeder Switches Larger than 600 amperes: Class L time delay.
9. Other Feeder Switches: Class RK1 (time delay) or RK5 (based on load).
10. Power Branch Circuits: Class RK1 (time delay) or RK5 (based on load).
11. Motor Branch Circuits: Class RK5.
12. Lighting Branch Circuits: Class G.

C. Identification Label:

1. Provide a fuse identification label inside each fused switch, showing type and size of each fuse specified or as recommended by the manufacture of the equipment served.
2. Labeling for rejection type fused switches shall read "Warning-Use Only Current Limiting Fuses Class ___, Type ___, MFR ___".

PART 3- EXECUTION

3.1 INSTALLATION

A. Install all switches in accordance with the manufacturer's written instructions, NECA's "Standard of Installation", the applicable requirements of the National Electrical Code, and recognized industry practice.

B. All switches shall be firmly anchored to walls and supporting structures (where used). Switches shall be installed with the turning axis of their handles approximately 5'-0" above finished floor unless otherwise indicated. Provide rigid steel (galvanized for exterior use) mounting stands, brackets, plates, hardware, and accessories for a complete installation.

C. Switches shall be mounted in accessible locations. Where a switch serves as the disconnecting means for a load, the switch shall be located as close as practical to the load with the switch handle within sight of the load.

D. Provide lugs on disconnect switch as required to accept conductors called for on drawings.

E. Disconnect switches shall not be mounted on equipment, unless specifically noted or required and meet all applicable codes. If switches are noted or required to be mounted on equipment they shall have vibrator clips on fuses and be connected to conduit system with liquid tight flexible conduit.

F. Coordinate all requirements for controls between variable speed drive units and its respective motor with drive specification, manufacturer, provider and installer. Provide auxiliary contacts, relays, etc. as required.

G. Install fuses in accordance with manufacturer's instructions, the NEC, and NEMA Standards.

H. Install fuse with label oriented such that manufacturer, type, and size are easily read.

I. Label each fuse.

J. Conduit or piping systems that contain water or liquid of any kind shall not be installed over the top of any electrical equipment, transformers, racks, cabinets, or enclosures without prior written approval from the Owner.

END OF SECTION 26 28 16

SECTION 26 33 53 – STATIC UNINTERRUPTIBLE POWER SUPPLY

PART 1 - GENERAL

1.1 SUMMARY

A. These specifications describe requirements for a complete bypass cabinet, supplying power to sensitive electronic loads. The specified center shall provide control and monitoring of AC power. It shall include all equipment to properly interface the AC power source to the intended load.

1.2 STANDARDS

A. The specified system shall be designed, manufactured, tested and installed in compliance with:

1. American National Standards Institute (ANSI)
2. Federal Information Processing Standards Publication 94 (FIPS Pub 94)
3. Institute of Electrical and Electronics Engineers (IEEE)
4. ISO 9001
5. National Electrical Code (NEC - NFPA 70)
6. National Electrical Manufacturers Association (NEMA)
7. National Fire Protection Association (NFPA 75)
8. Underwriters Laboratories (UL)

B. The UPS shall be UL and CUL listed as a complete system under UL 60950 Standard for Information Technology Equipment.

C. The specified center shall comply with the latest FCC Part 15 EMI emission limits for Class A computing devices and the emission and immunity limits of EN50081-2/EN550022 Class A and EN50082-2.

D. The UPS BDC shall safely withstand without mis-operation or damage:

1. Transient voltage surges on the AC power input as defined by ANSI/IEEE C62.41 for Category B3 locations (high surge exposure industrial and commercial facilities)
2. Electrostatic discharges (ESD) up to 10kV at any point on the exterior of the unit
3. Electromagnetic fields from portable transmitters within 3 ft. (1m) of the unit

1.3 SYSTEM DESCRIPTION

A. Electrical Requirements:

1. Output capacity

a. 130 kVA for Garage, APM, PDL and ITF
b. 40kVA for Toll Plaza.
c. kVA for Landside
   i. 20 kVA
   ii. 30 kVA
   iii. 40 kVA
   iv. 50 kVA

v. 60 kVA
vi. 80 kVA
vii. 100 kVA
viii. 130 kVA

d. kVA for Airside
i. 40 kVA
ii. 50 kVA
iii. 60 kVA
iv. 80kVA
v. 100kVA
vi. 130kVA

1. Input voltage:

   a. 480 volts AC, 60Hz, three-phase, three-wire plus ground.
   b. 208 volts AC, 60Hz, three-phase, four-wire plus ground.

2. Output voltage:

   a. 480 volts AC, 60Hz, three-phase, three wire plus ground.
   b. 208 volts AC, 60Hz, three-phase, four-wire plus ground.

3. Runtime shall be 30 minutes minimum.
4. Batteries shall be sealed lead acid.
5. Basis of Design: APC MGE Galaxy 5000 (130KVA), MGE Galaxy 4000 (40KVA); Powerware and Liebert NX approved equals.

B. Environmental Requirements:

1. Storage temperature range: -67° to +185°F (-55° to +85°C).
2. Operating temperature range: +32° to 104°F (0° to 40°C).
3. Relative humidity: 0% to 95% without condensing.
4. Operating altitude: Up to 6,600 ft. (2,000m) above Mean Sea Level. Derated for higher altitude applications.
5. Storage/transport: Up to 40,000 ft. (12,200m) above Mean Sea Level.
6. Audible noise: Under normal operation noise level shall not exceed than the ANSI C89 standard for transformers.

1.4 DOCUMENTATION

A. Equipment Manual:

1. The manufacturer shall furnish an installation, operation and maintenance manual with installation, startup, operation and maintenance instructions for the specified system.

B. Drawings:

1. Submittal drawings shall include:

   a. One-line wiring diagrams

b. Outline drawings including weight, dimensions, heat dissipation and recommended service clearances
c. Location and detailed layout of customer power and control connections
d. Outline drawings of options if supplied

C. Spare Parts:

1. A list of recommended spare parts shall be supplied at the customer's request.

D. User's List:

1. An in-service user's list shall be furnished upon request.

1.5 WARRANTY

A. The manufacturer shall provide a one-year warranty against defects in material and workmanship for 12 months after initial startup or 18 months after ship date, whichever occurs first. (Refer to the Warranty Statement for details.)

1.6 QUALITY ASSURANCE

A. The specified center shall be factory-tested before shipment. Testing shall include, but shall not be limited to: Quality Control Checks, "Hi-Pot" Test (two times rated voltage plus 1000 volts, per UL requirements) and Metering Calibration Tests. The system shall be designed and manufactured according to world-class quality standards. The manufacturer shall be ISO 9001 certified.

PART 2 - PRODUCTS

2.1 COMPONENTS

A. Frame Construction and Enclosure:

1. The frame shall be constructed of galvanized steel and pop-riveted to provide a strong substructure. The enclosure shall be mounted on heavy-duty swivel casters for portability and ease of installation and shall be provided with permanent leveling jacks for final installation. The unit shall have easily removable output cable trays on the top and bottom to allow matching the size and number of cable/conduit openings to the site requirements. All service shall be capable of being performed with access to the front and top. Retrofitting additional power distribution cables shall require access to the front of the unit only. A tool shall be required to remove the exterior panels, which access the hazardous voltage area of the unit.
2. The unit shall have lockable, removable, hinged front door(s) that are 16-gauge perforated sheet metal construction to maximize ventilation. A two-point latch with key lock is provided for security. Doors shall provide access to the main input circuit breaker and to all output circuit breakers. Doors and side panels (if supplied) are finished in powder-coat black.
3. The unit shall be cooled via internal fans for forced-air cooling. The cooling method shall allow continuous full-load operation without activation of over-temperature circuits. Heat rejection shall be through a screened protective top, which prohibits entry of foreign material.

4. The unit is designed to attach to the UPS to provide bypass, distribution and monitoring.

B. Input Power Connections:

1. Input power terminal blocks or busbar for 2-hole lugs shall be provided for connection of the input power conductors and a parity-sized insulated ground conductor.

C. Cable Entry:

1. The UPS BDC shall have provisions for top and bottom cable entry and exit.

D. Bypass Input Breaker (BIB):

1. The UPS shall be equipped with a bypass input circuit breaker to provide overcurrent protection and a means for disconnecting all power to the input of the UPS. The bypass input breaker shall be a thermal-magnetic three-pole molded case circuit breaker sized for 125% of the specified full load input current plus recharge current and rated for 600 VAC. The minimum UL-listed interrupting rating for the main input circuit breaker shall be 65,000 RMS symmetrical amperes at 480 volts AC for 480V UPS and 22,000 symmetrical amperes at 208 volts AC for 208V UPS.

E. Maintenance Bypass:

1. The UPS shall be equipped with a make-before-break maintenance bypass with key interlock system. Thermal-magnetic three-pole molded case circuit breakers shall be provided for maintenance bypass (MBB) and for maintenance isolation (MIB). Each circuit breaker shall have an interrupting rating of 65,000 RMS symmetrical amperes at 480 volts AC for 480V UPS and 22,000 RMS symmetrical amperes at 208 volts AC for 208V UPS.

F. Computer Grade Ground:

1. The UPS shall include a single-point ground in accordance with sensitive electronic load manufacturer’s recommendations, IEEE Std. 1100 and the requirements of the NEC. The transformer output neutral shall be solidly grounded in accordance with NEC article 250-26. Grounding conductors shall be sized in accordance with IEC 364-HD-384 and applicable national and local codes.

G. Enhanced Monitoring Panel:

1. The enhanced monitoring panel shall consist of a bright, easy-to-read, 12-digit (three lines of four digits each), 3/4-in. high LED display to monitor voltage, current and power parameters. The display shall be accessible without opening the door. The following metering parameters shall be displayed:

- Voltage line-to-neutral for each phase
- Voltage line-to-line for each phase
- Voltage line-to-neutral average
- Voltage line-to-line average
- Current for each phase
- Neutral current
- Current average
- Current demand, for each phase and average
- Peak current demand, for each phase and average
- Frequency
- Total Power Factor
- Total Kw
- Peak kW
- kWH

2. All voltages and currents shall be measured using true RMS techniques for accurate representation of non-sinusoidal waveforms associated with computers and other sensitive electronic loads. The metering parameters shall have a full-scale accuracy of ±0.5%.
3. For remote monitoring, a RS-485 port that includes Modbus RTU protocol is provided.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Factory startup, preventive maintenance and full service for the specified system shall be available and included upon request. The manufacturer shall directly employ a nationwide service organization of factory-trained field service personnel dedicated to the startup, maintenance and repair of the manufacturer’s power equipment. The manufacturer shall maintain a national dispatch center 24 hours per day, 365 days per year, to minimize service response time and to maximize availability of qualified service personnel.

B. Unit shall be installed in a clean / air-conditioned space.

END OF SECTION 26 33 53

SECTION 26 33 53 - STATIC UNINTERRUPTIBLE POWER SUPPLY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Conditions, Division 01, and other applicable specification sections in the Project Manual apply to the work specified in this Section.

1.2 SUMMARY

A. Scope: Provide design and engineering, labor, material, equipment, related services, and supervision required, including, but not limited to, manufacturing, fabrication, erection, and installation for a solid state uninterruptible power supply (UPS) as required for the complete performance of the work, and as shown on the Drawings and as herein specified.

B. Section Includes: The work specified in this Section includes, but shall not be limited to, a three-phase, on-line, double conversion, solid state UPS. The UPS shall operate in conjunction with the building electrical system to provide high quality power conditioning, back-up power protection, and distribution for electronic equipment loads. The system shall consist of a solid state IGBT rectifier/inverter, power factor corrected rectifier, a 100 percent rated for continuous duty static switch, battery plant, graphical status/control panel, and synchronizing circuitry as described herein.

1.3 REFERENCES

A. General: The publications listed below form a part of this Specification to the extent referenced. The 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.

B. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   1. ANSI/IEEE C62.41, "Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits" (copyrighted by IEEE, ANSI approved).

C. International Organization for Standardization (ISO):
   1. ISO 9001, "Quality Management Systems - Requirements."

D. National Electrical Manufacturers Association (NEMA):
   1. NEMA PE 1, " Uninterruptible Power Systems (UPS) - Specification and Performance Verification."

E. National Fire Protection Association (NFPA):
   1. NFPA 70, "National Electrical Code" (copyrighted by NFPA, ANSI approved) - hereinafter referred to as NEC.

F. Underwriters Laboratories, Inc. (UL):

   1. UL 1778, "Standard for Uninterruptible Power Supply Equipment" (copyrighted by UL, ANSI approved). “
   2. UL 924, “Emergency Lighting and Power Equipment”
   3. The UPS shall be UL and CUL listed as complete system under UL 60950 Standard for Information Technology Equipment.
   4. The Specified center shall comply with the latest FCC Part 15 EMI emission limits for Class A computing devices and emission and immunity limits of EN50081-2/EN550022 Class A and EN50082-2.
   5. The UPS BDC shall safely withstand without mi-operation or damage.

1.4 SYSTEM DESCRIPTION

A. UPS Design Requirements:

1. Output Power Continuous Rating: The continuous output power rating of the UPS at a 0.9 lagging power factor shall be as called for on drawings~~:~~.

~~a. 130kVA for Garage, APM, PDL and ITF~~
~~b. 40kVA for Toll Plaza~~
~~c. kVA for Landside~~
~~1) 20 kVA~~
~~2) 30 kVA~~
~~3) 40 kVA~~
~~4) 50 kVA~~
~~5) 60 kVA~~
~~6) 80 kVA~~
~~7) 100 kVA~~
~~8) 130 kVA~~

~~d. kVA for Airside~~
~~1) 40 kVA~~
~~2) 50 kVA~~
~~3) 60 kVA~~
~~4) 80 kVA~~
~~5) 100 kVA~~
~~6) 130 kVA~~

2. Field-Powered Upgrade: The following power ratings may be upgraded in the field to provide more output power with no increase in footprint:
   a. 100 kVA/90 kW UPS modules shall be capable of an upgrade to 130 kVA/117 kW.

3. Input Current: See chart on drawings.

4. Output Current: See chart on drawings.

5. Battery Autonomy: UPS shall be capable of operating at full load for 30 minutes at 0.9 PF output at a temperature of 77 °F (25 °C) on battery power.
6. Battery Type: Valve regulated sealed lead acid (VRLA).

B. AC Input Characteristics:

1. Voltage: 480 volts AC, -15 percent +10 percent, three-phase, 3 wires, grounded wye, configuration plus ground.
2. Frequency: 60 hertz, ±5 percent.
3. Power Factor: Greater than 0.98 lagging.
4. Total Harmonic Distortion: Less than 5 percent at full load.
5. Inrush Current: Less than nominal input current for less than one cycle.
6. Input Surge Protection: UPS shall be equipped to withstand surges per ANSI/IEEE C62.41.

C. AC Output Characteristics:

1. Voltage: 120/208 volts AC, ±1 percent steady state variation phase-to-phase voltage volts AC, three-phase, 3 wires plus ground. 4 wire output shall be available through provided transformer with breaker(s) provided on output, sized per drawings and built into UPS at factory.
2. Frequency: 60 hertz, ±1.0 percent (or selectable up to 4 percent); 60 hertz, ±0.1 percent when free running.
3. Voltage Regulation: ±1.0 percent for balanced load, ±1.75 percent for 50 percent unbalanced load, ±2.5 percent for 100 percent unbalanced load.
4. Voltage Distortion: Maximum 2 percent total (THD) and 1 percent any single harmonic on 100 percent linear loads.

5. Voltage Transient (Step Load) Response: ±2 percent for load step changes from 100 percent to 0 and from 0 to 100 percent. The system returns to the ±1 percent range in rms value in less than 100 ms.
6. Voltage Recovery Time: Return to within 1 percent of nominal value within 16.67 milliseconds (one cycle).
7. Phase Angle Displacement: 120 degrees, +1 degree for balanced load; 120 degrees, +3 degrees for 100 percent unbalanced load.
8. Non-Linear Load Capability: Output voltage total harmonic distortion shall be less than 3 percent when connected to a 100 percent non-linear load with a crest factor not to exceed 3 percent.
9. Slew Rate: 1.0 hertz/second maximum (or selectable up to 2.0 hertz/second).
10. Power Factor: 0.9 at the rated volt amperes (VA).
11. Inverter Overload Capability: 125 percent of rated load for 10 minutes, 150 percent of rated load for 1 minute.
12. Bypass Overload Capability: Greater than 212 percent for one cycle; greater than 150 percent for 1 minute.

D. Battery:

~~D.~~1. Type: Value regulated lead acid (VRLA)

~~1.~~2. Battery Voltage: 356 volts DC minimum before cutoff; 432 volts DC nominal; 490 volts DC equalization voltage.
~~2.~~3. Maximum DC Current: Maximum DC current at cutoff voltage shall be as recommended by battery manufacturer.
~~3.~~4. The battery charger is equipped with a temperature probe to enable temperature compensated charging.
~~4.~~5. Bypass Input Breaker (BIB)
   a. The UPS shall be equipped with a bypass input circuit breaker to provide overcurrent protection and a means for disconnecting all power to the input of the UPS. The bypass input breaker shall be a thermal-magnetic three-pole molded case circuit breaker sized for 125% of the specified full load input current plus recharge current and rated for 600 VAC. The minimum UL-listed interrupting rating for the main input circuit breaker shall be 65,000 RMS symmetrical amperes at 480 volts AC for 480V UPS and 22,000 symmetrical amperes at 208 volts AC for 208V UPS.
~~5.~~6. Maintenance Bypass:
   a. The UPS shall be equipped with a make-before-break maintenance bypass with key interlock system. Thermal-magnetic three-pole molded case circuit breakers shall be provided for maintenance bypass (MBB) and for maintenance isolation (MIB). Each circuit breaker shall have an interrupting rating of 65,000 RMS symmetrical amperes at 480 volts AC for 480V UPS and 22,000 RMS symmetrical amperes at 208 volts AC for 208V UPS.

1.5 SUBMITTALS

A. General: See General Conditions of these specifications, Div 0 and1
B. Product Data: Submit product data showing material proposed. Submit sufficient information to determine compliance with the Drawings and Specifications. Product data shall include, but shall not be limited to, the following:

1. Catalog sheets and technical data sheets to indicate physical data and electrical performance, electrical characteristics, and connection requirements.
2. Manufacturer’s installation instructions indicating application conditions and limitations of use stipulated by product inspecting and testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of the product. Include equipment installation outline, connection diagram for external cabling, internal wiring diagram, and written instruction for installation.

C. Shop Drawings: Submit shop drawings for each product and accessory required. Include information not fully detailed in manufacturer’s standard product data, including, but not limited to, complete electrical characteristics and connection requirements. Provide detailed equipment outlines with cabinet dimensions and spacing requirements; location of conduit entry/exit paths; location of floor/seismic mounting; available battery types/sizes; cabinet weights; heat rejection and air flow requirements; single-line diagram; and control and external wiring.

D. Wiring Diagrams: Submit wiring diagrams detailing power, signal, and control systems, clearly differentiating between manufacturer-installed wiring and field-installed wiring, and between components provided by the manufacturer and those provided by others.

E. Contract Closeout Submittals:

1. Project Record Documents: Submit a complete set of installation drawings showing all the information specified elsewhere in this Section.
2. Operation and Maintenance Data: Submit operation and maintenance data to include in operation and maintenance manuals specified in Division 01 - GENERAL REQUIREMENTS, including, but not limited to, safe and correct operation of UPS functions.

1.6 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturer Qualifications: Manufacturer shall be a firm engaged in the manufacture of solid state UPS of types and sizes required, and whose products have been in satisfactory use in similar service for a minimum of 20 years.
   a. The manufacturer shall be ISO 9001 certified and shall be designed to internationally accepted standards.
2. Installer Qualifications: Installer shall be a firm that shall have a minimum of five years of successful installation experience with projects utilizing solid state UPS similar in type and scope to that required for this Project.

B. Regulatory Requirements: Comply with applicable requirements of the laws, codes, ordinances, and regulations of Federal, State, and local authorities having jurisdiction. Obtain necessary approvals from such authorities.

1. The UPS shall meet the requirements of the following standards:
   a. UL-listed under UL 1778.
   b. UL Canada (cUL).
   c. FCC rules and regulations of Part 15, Subpart J, Class A.
   d. ANSI/IEEE C62.41.
   e. ISO 9001.

2. The UPS shall be designed in accordance with the applicable sections of the documents published by:
   a. National Fire Protection Association (NFPA); NEC.
   b. National Electrical Manufacturers Association (NEMA); NEMA PE 1.
   c. Occupational Safety and Health Administration (OSHA).

C. Factory Testing: Prior to shipment the manufacturer shall complete a documented test procedure to test functions of the UPS module and batteries (via a discharge test), when supplied by the UPS manufacturer, and warrant compliance with this Section. The factory test shall be performed in the presence of the Owner providing the manufacturer receives adequate prior notice. The manufacturer shall provide a copy of the test report upon request.

D. Pre-Installation Conference: Conduct pre-installation conference in accordance with all the requirements of these specifications, including Div 0 and 1. Prior to commencing the installation, meet at the Project site to review the material selections, installation procedures, and coordination with other trades. Pre-installation conference shall include, but shall not be limited to, the Contractor, the Installer, and any trade that requires coordination with the work. Date and time of the pre-installation conference shall be acceptable to the Owner's Authorized Representative (OAR).

E. Source Responsibility: Materials and parts comprising the UPS shall be new, of current manufacture, and shall not have been in prior service, except as required during factory testing. Active electronic devices shall be solid state and shall not exceed the manufacturer’s recommended tolerances for temperature or current to ensure maximum reliability. Semiconductor devices shall be sealed. Relays shall be provided with dust covers. The manufacturer shall conduct inspections on incoming parts, modular assemblies, and final products.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to the Project site in supplier’s or manufacturer’s original wrappings and containers, labeled with supplier’s or manufacturer’s name, material or product brand name, and lot number, if any.

B. Store materials in their original, undamaged packages and containers, inside a well-ventilated area protected from weather, moisture, soiling, extreme temperatures, and humidity.

C. Products shall be packaged in a manner to prevent penetration by debris and to allow safe delivery by modes of ground transportation and air transportation where specified.

D. Prior to shipping, products shall be inspected at the factory for damage.

E. Equipment shall be protected against extreme temperature and humidity and shall be stored in a conditioned or protected environment.

F. Equipment containing batteries shall not be stored for a period exceeding three months without powering up the equipment for a period of eight hours to recharge the batteries.

1.8 PROJECT CONDITIONS

A. Environmental Requirements: Do not install solid state UPS until space is enclosed and weatherproof, wet work in space is completed and nominally dry, work above ceilings is complete, and ambient temperature and humidity conditions are and will be continuously maintained at values near those indicated for final occupancy.

1. The UPS shall operate under the following environmental conditions:
   a. Temperature:
      1) UPS Module Operating: 32 °F (0 °C) to 104 °F (40 °C).
      2) Non-Operating: -4 °F (-20 °C) to 113 °F (45 °C).
   b. Relative Humidity (Operating and Storage): 0 percent to 95 percent non-condensing.
   c. Barometric Pressure: Up to 3281 feet (1000 meters) above sea level (up to 6562 feet [2000 meters] with ambient temperature less than 82 °F [28 °C]) / up to 39,370 feet (12,000 meters) above sea level non-operating.
   d. Audible Noise: 69 dBA at 3 feet (914 mm).

1.9 WARRANTY

A. General: See General Conditions of these specifications, Div 0 and1.

B. Special Warranty: The Contractor shall warrant the work of this Section to be in accordance with the Contract Documents and free from faults and defects in materials and workmanship for period indicated below. This special warranty shall extend the one year period of limitations contained in the General Conditions. The special warranty shall be countersigned by the Installer and the manufacturer.

1. UPS Module: The UPS shall be covered by a full parts and labor warranty from the manufacturer for a period of 12 months from date of installation or acceptance by the Owner or 18 months from date of shipment from the manufacturer, whichever occurs first.
2. Battery: The battery manufacturer's warranty shall be passed through to the final Owner and shall have a minimum period of one year.

C. Additional Owner Rights: The warranty shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to and run concurrent with other warranties made by the Contractor under requirements of the Contract Documents.

1.10 MAINTENANCE

A. The manufacturer shall, upon request, provide spare parts kits for the UPS module in a timely manner as well as provide access to qualified factory-trained first party service personnel to provide preventative maintenance and service on the UPS module when required.

B. UPS subassemblies, as well as the battery, shall be accessible from the front. UPS design shall provide maximum reliability and minimum MTTR (mean time to repair). To that end, the UPS shall be equipped with a self-test function to verify correct system operation. The self-test function shall identify the subassembly requiring repair in the event of a fault. The electronic UPS control and monitoring assembly shall therefore be fully microprocessor-based, thus doing away with potentiometer settings. This shall allow:

1. Auto-compensation of component drift.
2. Self-adjustment of replaced subassemblies.
3. Extensive acquisition of information vital for computer-aided diagnostics (local or remote).
4. Socket connection to interface with computer-aided diagnostics system.

C. The UPS shall be repairable by replacing standard subassemblies requiring no adjustments. Communication via a modem with a remote maintenance system shall be possible.

D. The manufacturer shall offer additional preventative maintenance and service contracts covering both the UPS and the battery bank. Accredited professional service engineers employed exclusively in the field of critical power systems service shall perform maintenance and service. The manufacturer shall also offer extended warranty contracts.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis of Design: Product specified is "MGE Galaxy 5000" as manufactured by APC by Schneider Electric unless specifically noted otherwise in drawings. Items specified are to establish a standard of quality for design, function, materials, and appearance. Equivalent products by other manufacturers are acceptable. The OAR will be the sole judge of the basis of what is equivalent.

B. Approved Substitutions: Liebert, Powerware

2.2 MODES OF OPERATION

A. UPS module shall be designed to operate as a double conversion, on-line reverse transfer system in the following modes.

1. Normal: The inverter shall continuously supply power to the critical load. The PFC rectifier shall derive power from the utility AC source and supply DC power to the inverter while simultaneously float charging the battery.
2. Emergency: Upon failure of the utility AC power source, the critical load shall be supplied by the inverter, which, without any interruption, shall obtain its power from the battery.
3. Recharge: Upon restoration of the utility AC power source (prior to complete battery discharge), the PFC rectifier shall power the inverter and simultaneously recharge the battery.

4. Bypass Mode: The static bypass transfer switch shall be used to transfer the load to the bypass without interruption to the critical power load. This shall be accomplished by turning the inverter off. Automatic re-transfer or forward transfer of the load shall be accomplished by turning the inverter on.
5. Internal Mechanical Bypass: As a standard feature, the UPS shall be equipped with an internal, make-before-break, bypass switch. This switch shall mechanically bypass the UPS for times where maintenance is required.

2.3 COMPONENT DESCRIPTION

A. PFC Rectifier and Battery Charger: Incoming AC power shall be converted to a regulated DC output voltage by an IGBT (insulated gate bipolar transistor) power factor correction (PFC) rectifier. The PFC rectifier shall provide high quality DC power to charge the batteries and power the inverter and shall have the following characteristics:

1. Input Power Factor Correction (PFC): The PFC rectifier shall be power factor corrected so as to maintain an input power factor of 0.98 lagging to unity at 75 percent or above load levels to ensure generator compatibility and avoid reflected harmonics from disturbing loads sharing the utility power.
2. Input Harmonic Current Suppression: The PFC rectifier shall produce a sinusoidal input AC current on each phase with low harmonic content, limiting THD on the UPS input to below 5 percent.
3. Battery Charger Current Limiting: The UPS shall be equipped with a system designed to limit the battery recharge current (from 0.05 C10 to 0.1 C10).
4. Charging Levels: The battery charging circuitry shall be capable of being set for automatic battery recharge operation, float service, manual battery charge service, and equalizing or commissioning operation.
5. Intermittent Charging: The battery charge level shall be maintained by an intermittent charging technique between two values Vfmin and Vfmax very close to the floating voltage. This technique shall be based on a cycle made up of a short charge period (a few seconds) from Vfmin to Vfmax followed automatically by a slow discharge period (a few minutes) from Vfmax to Vfmin. This cycle shall be repeated continuously to maintain the battery charge level. In this way the battery shall actually be charging only for a small part of the time, which shall considerably increase its service life.
6. Temperature Compensated Charging: The battery charger shall be equipped with a temperature probe to enable temperature compensated charging and shall adjust the battery float voltage to compensate for the ambient temperature using a negative temperature coefficient of 3 mV per cell per degree Celsius at a nominal temperature of 25 °C.
7. Battery Capacity: The battery charger shall have sufficient capacity to support a fully loaded inverter and shall fully recharge the battery to 95 percent of its full capacity within 6 to 8 hours up to four battery cabinets.

B. Inverter: The UPS output shall be derived from a variable frequency Pulse Width Modulated (PWM) IGBT inverter design. The inverter shall be capable of providing the specified precise output power characteristics while operating over the battery voltage range.

C. Static Bypass - 100 Percent Rated, Continuous Duty: The static bypass transfer switch shall be solid state, rated for 100 percent continuous duty without mechanical contactor device in parallel for higher reliability and consistent response time and shall operate under the following conditions:

1. Uninterrupted Transfer: The static bypass transfer switch shall automatically cause the bypass source to assume the critical load without interruption after the logic senses one of the following conditions:

   a. Inverter overload exceeds unit's rating.
   b. Battery protection period expired and bypass current is available.
   c. Inverter failure.

2. Interrupted Transfer: If the bypass source is beyond the conditions stated below, the UPS shall make an interrupted transfer (not less than 100 milliseconds in duration).

   a. Bypass voltage greater than +10 percent, -10 percent from the UPS rated output voltage.
   b. Bypass frequency greater than ±2 hertz from the UPS rated output frequency.

3. Automatic Uninterrupted Forward Transfer: The static bypass transfer switch shall automatically forward transfer power, without interruption, after the UPS inverter is turned on after an instantaneous overload-induced reverse transfer has occurred and the load current returns the UPS's nominal rating or less.

4. Manual Transfer: A manual static transfer shall be initiated from the UPS control panel by turning the UPS inverter off.

5. Overload Ratings: The static bypass transfer switch shall have the following overload characteristics:

   a. 1000 percent of UPS output rating for 0.016 seconds (one cycle).
   b. 150 percent for 1 second.
   c. 125 percent of UPS for 1 minute.

D. Output Static Switch - 100 percent Rated, Continuous Duty: UPS output shall be equipped with a 100 percent rated output static switch without mechanical contactor device in parallel for higher reliability and consistent response time of 16.66 milliseconds.

2.4 SYSTEM CONTROLS AND INDICATORS

A. Microprocessor-Controlled Logic:

1. The full UPS operation shall be provided through the use of microprocessor-controlled logic. Operation and parameters shall be firmware-controlled, thus eliminating the need for manual adjustments or potentiometers. The logic shall include, but shall not be limited to, a self-test and diagnostic circuitry such that a fault shall be isolated down to the printed circuit assembly or plug-in power assembly level. Every printed circuit assembly or plug-in power assembly shall be monitored. Diagnostics shall be performed via a PC through the local diagnostics port on the UPS. UPS shall be microprocessor-controlled.

2. The UPS shall include, but shall not be limited to, a standard easy-to-use control and indicator panel. Included shall be a backlit, color graphic animated LCD display and LED indicators. The UPS panel shall include, but shall not be limited to, UPS on and UPS off pushbuttons that shall permit the Owner to safely command the UPS on or off without risk of load loss.

3. Display shall facilitate operation by offering the functions listed below:

   a. Operating information supplied on the screens.
   b. The graphic display shall assist the Owner by providing step-by-step help in the Owner's language.
   c. LED mimic diagram. The mimic diagram shall enable display of installation parameters, configuration, operating status and alarms and indication of operator instructions for switching operations (i.e., bypass).
   d. It shall be possible to display the following measurements:

      1) Inverter output phase-to-phase voltages.
      2) Inverter output currents.
      3) Inverter output frequency.
      4) Voltage across battery bank.
      5) Battery charge or discharge current.

6) Rectifier/charger input phase-to-phase voltages.
7) Rectifier/charger input currents.
8) Active and apparent power.
9) Power factor of the load.
10) Battery temperature.
11) Display of status conditions and events.

e. It shall be possible to display the following indications:
   1) Load on battery power.
   2) Load on UPS.
   3) Load on automatic bypass.
   4) General alarm.
   5) Battery fault.
   6) Remaining battery backup time.
   7) Low battery warning.
   8) Bypass AC source outside tolerances.

f. Additional information shall be provided in view of accelerating servicing of the system.
g. Log of time-stamped events. This function shall store in memory and make available, for automatic or manually initiated recall, time-stamped logs of important status changes, faults, and malfunctions, complete with an analysis and display of troubleshooting procedures. It shall be possible to time stamp and store at least 2000 events.

B. Front Panel LCD Display: The UPS control panel shall provide a backlit, color graphic display with choice of over 15 operating languages for indication of UPS status, metering, battery status, alarm/event log, and advanced operational features.

1. Access: The display shall provide access to:
   a. Mimic diagram indicating UPS power flow.
   b. Measurements, status indications, and events.
   c. Personalization menu protected by a password, used to make specific settings.
   d. Event log with time stamping.
   e. Access to measurements.

2. System Parameters Monitored: The visual display shall display the following system parameters based on true RMS metering:
   a. Measurements:
      1) Input voltage (Ph-Ph).
      2) Input current per phase.
      3) Bypass voltage.
      4) Bypass input frequency.
      5) UPS output voltage (Ph-Ph and Ph-N).
      6) UPS output current per phase.
      7) UPS output frequency.
      8) UPS output percent load.
      9) UPS output kVA.
      10) UPS output power factor.
      11) Battery voltage.
      12) Crest factor.
      13) Battery current.
      14) Battery backup time and remaining service life.

   b. Status Indications and Events:
      1) Load on battery.
      2) Load on UPS.
      3) Load on automatic bypass.
      4) Low battery warning.
      5) General alarm.
      6) Battery fault.

7) Remaining back-up time during operation on battery power.
8) Bypass source outside tolerances.
9) Additional indications shall provide maintenance assistance.

3. Time-Stamped Historical Events: This function shall time stamp and store important status changes, anomalies, and faults and make this information available for automatic or Owner-requested consultation.

C. LED Status Indicators: The UPS control panel shall provide three LEDs that shall signal the following status conditions:

1. Green LED: Load protected.
2. Yellow LED: Minor fault.
3. Red LED: Major fault, load not protected.

D. On/Off Switch: The UPS shall provide the on and off buttons to start and stop the inverter. The switch shall provide a built-in time delay to eliminate the risk of inadvertent operation (additional confirmation shall be requested). It shall be possible to remotely activate the off function via an isolated dry contact to create an emergency power off function, resulting in:

1. Inverter shutdown.
2. Opening of the automatic bypass.
3. Opening of the input, bypass, output, and battery switches/circuit breakers.
4. Opening of the isolated dry contact on the programmable relay card.

E. Audible Alarm Reset: The UPS shall provide an audible alarm that can be stopped using the user interface. If a new alarm is sensed after the original alarm has been silenced, it shall reactivate the audible alarm.

F. Emergency Power Off (EPO): The UPS shall be equipped with provisions for remote emergency power off and dry contact input that shall be used to command UPS shutdown remotely. Activation of this command shall lead to the following actions:

1. Inverter shutdown.
2. Opening of the static bypass switch and the battery circuit breaker.
3. Opening of an isolated dry contact on the programmable relay board.
4. Provide and locate EPO at door into room.

G. DB-9 Connector: One DB-9 connector with serial output shall be provided for field diagnostics.

H. Dry Contacts: The UPS shall be provided standard with a programmable input/output relay board. This board shall have eight dry contacts (i.e., six for input signals and two for output signals).

1. Contacts shall be programmed as:
   a. UPS on-line.
   b. Load on bypass.
   c. UPS on battery.
   d. UPS battery low.
   e. General alarm.
   f. Battery fault.
   g. Remote UPS on (input).
   h. Remote UPS off (input).

2. The contacts shall be normally open and shall change state to indicate the operating status. The contacts shall be rated at 2.0 amperes (250 volts AC/30 volts DC).

2.5 MECHANICAL DESIGN AND VENTILATION

A. Enclosure: The UPS shall be housed in a freestanding enclosure with dead front construction. The mechanical structure of the UPS shall be sufficiently strong and rigid to withstand handling and installation operations without risk. The sheet metal elements in the structure shall be protected against corrosion by a suitable treatment, such as zinc electroplating, bi-chromating, epoxy paint, or an equivalent.

B. Cable Access: The standard UPS available shall accommodate bottom entry cables (top entry shall be optional).

C. Cabinet Weights and Dimensions: See chart on drawings.

D. Ventilation and Heat Rejection: The UPS shall be designed for forced air cooling. Air inlets shall be provided from the front bottom of the UPS enclosure. Air exhaust shall be from the top portion of the unit.

2.6 BATTERY

A. General: The UPS module shall use a valve-regulated sealed lead acid heavy duty industrial battery, designed for auxiliary power service in an UPS application. The primary battery shall be furnished with impact-resistant plastic cases and housed in a matching cabinet(s) next to the UPS module.

B. Protection against Deep Discharge and Self-Discharge: The UPS shall be equipped with a device designed to protect the battery against deep discharge, depending on discharge conditions, with isolation of the battery by a circuit breaker. In particular, a monitoring device shall adjust the battery shutdown voltage as a function of a discharge coefficient to avoid excessive discharge at less than the rated output. A second device shall avoid self-discharge of the battery into the UPS control circuits during an extended shutdown of the UPS (over two hours).

C. Battery Self-Tests:

1. The battery monitoring system shall be able to perform the following automatic functions:
   a. Battery circuit checks every 12 hours.
   b. Open circuit battery test once a month.
   c. Partial discharge test every three months.
2. This self-test system shall signal faults via LEDs on the front panel ~~or a message to remote supervision systems~~and report to building EMMS system (Power Xpert by Eaton) for alarm.

2.7 ACCESSORIES

A. Remote Alarm Status Panel (RASP): A wall-mounted panel, 17.5 inches (445 mm) high by 12 inches (305 mm) wide by 4 inches (102 mm) deep, with eight indicating LED's shall display UPS status and any active alarms. The alarms shall be a latching type, such that if an alarm is triggered, the LED shall stay on (latch) even if the alarm is corrected. This feature shall provide the operator the chance to verify the occurrence of the alarm.

1. The parameters monitored and controls provided on the RASP shall include, but shall not be limited to, the following:
   a. UPS on-line (green LED).
   b. UPS on battery (yellow LED).
   c. Load on bypass (yellow LED).
   d. UPS summary alarm (red LED).
   e. Low battery shutdown.

2. The RASP shall also be equipped with:
   a. Alarm test/reset pushbutton (white LED) to reset the latching alarm.
   b. Audible alarm for alarm annunciation.
   c. Audible alarm reset pushbutton (white LED) to silence the audible alarm.

3. The RASP door shall be equipped with a key lock. The recommended maximum distance from the UPS module shall be 500 feet (152 m).
4. Locate/mount at location as directed in the field by OAR..

B. Top Entry Cabinet: 16 inch (406 mm) cabinet shall allow cable entry to UPS unit when MBC or transformer cabinets are not selected.

C. Transformer Cabinet: Provide single or dual K20 transformer, 480volts to 120/208 volts, 3 phase. Top entry power cables to the UPS to be achieved via these cabinets.

D. Provide remote monitoring, a RS-485 port that includes Modbus RTU protocol.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions: Examine areas and conditions under which the work is to be installed, and notify the Contractor in writing, with a copy to the Owner and the OAR, of any conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.
1. Beginning of the work shall indicate acceptance of the areas and conditions as satisfactory by the Installer.

3.2 INSTALLATION

A. Preparation and installation shall be in accordance with reviewed product data, final shop drawings, manufacturer’s written recommendations, and as indicated on the Drawings.

3.3 FIELD QUALITY CONTROL

A. General: See Section ~~01 45 23 - INSPECTING AND TESTING SERVICES~~01 78 00 closeout submittals and 01 78 10 warranties.

B. Field Service Engineer Qualifications: The manufacturer shall employ a 7 x 24 nationwide (international where applicable) field service organization with rapid access to all regions of the nation. The responding service professionals shall be factory-trained engineers with an accredited and proven competence to service three-phase UPS.

C. Spare Parts: Field Engineers shall have immediate access to recommended spare parts with additional parts storage located in regional depots. Additional spare parts shall be accessible on a 7 x 24 basis from the national depot and shall be expedited on a next available flight basis or via direct courier (whichever mode is quickest).

3.4 DEMONSTRATION

A. Provide the services of a factory-authorized service representative of the manufacturer to provide start-up service and to demonstrate and train the Owner’s personnel.
1. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
2. Train the Owner’s maintenance personnel on procedures and schedules related to start-up and shutdown, troubleshooting, servicing, and preventive maintenance.
3. Review data in operation and maintenance manuals with the Owner’s personnel.
4. Schedule training with the OAR, with at least seven day’s advanced notice.

~~4.~~B. See 01 79 00 Demonstration and training for additional requirements.

3.5 PROTECTION

A. Provide final protection and maintain conditions in a manner acceptable to the Installer, which shall ensure that the solid state UPS shall be without damage at time of Substantial Completion.

END OF SECTION 26 33 53

SECTION 26 36 16 - MAINTENANCE BYPASS SWITCHES

PART 1- GENERAL

1.1 SCOPE

A. Furnish and install the low voltage manual bypass switches having the ratings, features/accessories and enclosures as specified herein and as shown on the contract drawings.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Contractual Conditions and Division 01 Specifications sections apply to this section.

1.3 REFERENCES

A. The manual bypass switches and all components shall be designed, manufactured and tested in accordance with the latest applicable standards of UL and NEMA as follows:

1. UL 1008 – Transfer Switches
2. UL 991
3. NFPA 70 – National Electrical Code
4. NFPA 110 – Emergency and Standby Power Systems
5. NEMA ICS 10 – AC Transfer Switch Equipment
6. IEEE 446 – Recommended Practice for Emergency and Standby Power Systems
7. IEC 801-2, 3, 4, and 5
8. CISPR 11
9. Compliant with FCC Part 15, Subpart B, Class A.

1.4 DESCRIPTION

A. Manual Bypass switches shall be capable of switching all classes of load, and shall be rated for continuous duty when installed in a non-ventilated enclosure.

B. Bypass switches shall be a true four (4) pole type. Normal and emergency full load current and voltage ratings at 60 cycles shall be as shown on plans.

1.5 SUBMITTALS

A. Product Data: Provide catalog sheets showing voltage, switch size, ratings and size of switching and overcurrent protective devices, operating logic, short circuit ratings, dimensions, and enclosure details.

B. Submit shop drawings and product data clearly indicating:

1. All applicable options and accessories

a. Master drawing index
b. Front view and plan view of the assembly
c. Schematic diagram
d. Nameplate schedule
e. Component list
f. Conduit space locations within the assembly.
g. Assembly ratings including:

1) Short-circuit rating
2) Voltage
3) Continuous current rating.

2. Major component ratings including:

a. Voltage
b. Continuous current rating
c. Interrupting ratings
d. Cable terminal sizes and quantity
e. Product Data Sheets.
f. Delivery, storage and handling instructions.

3. Where applicable, the following additional information shall be submitted to the OAR:

a. Busway connection
b. Connection details between close-coupled assemblies
c. Composite front view and plan view of close-coupled assemblies
d. Key interlock schematic drawing and sequence of operations

4. The following information shall be submitted for record purposes:

a. Final as-built drawings and information for items listed in section 1.4
b. Wiring diagrams
c. Certified production test reports
d. Installation information

5. The final (as-built) drawings shall include the same drawings as the construction drawings and shall incorporate all changes made during the manufacturing process.

6. Submittals and record drawings shall be submitted to the Project Manager.

C. Manufacturer’s Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency specified under regulatory requirements. Include instructions for storage, handling, protection, examination, preparation, installation and starting of product.

1.6 FIELD MEASUREMENTS

A. Verify that field measurements are as indicated on drawings and as instructed by manufacturer.

1.7 OPERATION AND MAINTENANCE DATA

A. Operation Data:

1. Provide detailed instructions for operating equipment.
2. Include instructions for operating equipment under emergency conditions, including when engine generator is running.

B. Maintenance Data:

1. Provide routine preventative maintenance and lubrication schedule.
2. List special tools, maintenance materials, and replacement parts.

1.8 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the Products specified in this section with a minimum of ten years of experience.

B. When requested by the OAR, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

C. Supplier: Authorized distributor of specified manufacturer with a minimum of three years of experience.

1.9 REFERENCES AND REGULATORY REQUIREMENTS

A. Furnish products listed and classified by UL as suitable for purpose specified and indicated.

B. Provide a certificate of compliance with UL 1008 for the manual bypass switches furnished under this section.

C. Conform to the requirements of the following:

1. NFPA 70 - National Electrical Code.
2. NEMA ICS 1 - General Standards for Industrial Control and Systems.
3. NEMA ICS 2 - Standards for Industrial Control Devices, Controllers and Assemblies.
4. NEMA ICS 6 - Enclosures for Industrial Controls and Systems.

1.10 QUALITY ASSURANCE/TESTS

A. When conducting temperature rise tests to paragraph 99 of UL-1008 the manufacturer shall include post-endurance temperature rise tests to verify the ability of the manual switch to carry full rated current after completing the overload and endurance tests.

B. The switch shall meet or exceed the voltage surge withstand capability in accordance with IEEE Standard 472-1974 and the impulse withstand voltage test in accordance with NEMA Standard ICS 1-109.

1.11 DELIVERY, STORAGE AND HANDLING

A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris and traffic.

B. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to internal components, enclosure and finish.

1.12 FIELD MEASUREMENTS

A. Verify that field measurements are as indicated on drawings and as instructed by manufacturer.

1.13 MAINTENANCE SERVICE

A. Furnish service and maintenance of manual switch for one year from Date of Substantial Completion.

1.14 MAINTENANCE MATERIALS

A. Provide two of each special tool required for maintenance.

1.15 OPERATION AND MAINTENANCE MANUALS

A. Equipment operation and maintenance manuals shall be provided with each assembly shipped, and shall include instruction leaflets and instruction bulletins for the complete assembly and each major component. These manuals shall be incorporated into the O & M manuals submitted to the OAR.

1.16 EXTRA PRODUCTS

A. Furnish and install all incidentals and appurtenances required for a complete and fully operational system to the satisfaction of the OAR. Line and load terminals shall be capable of accepting the quantity and size of conductors as specified on the plans.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Russelectric (basis of design).

B. Eaton Cutler-Hammer (Contactor type only)

C. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. The manufacturer listed above is not relieved from meeting these specifications in their entirety. Equivalent products determined by the OAR to be in full compliance with the specification may be acceptable.

2.2 GENERAL

A. The manual maintenance bypass switch shall be double throw, actuated by two electrical operators, momentarily energized and connected to the transfer mechanism by a simple over center linkage with time delay relays to control contact transition time on transfer to either source, adjustable 0-300 seconds. Time delay between the opening of the closed contacts and the closing of the open contacts shall be adjusted to allow for voltage decay before transfer as required to allow re-energization of motor and transformer loads at normal in rush currents.

B. The manual switch shall be capable of transferring successfully in either direction with 70% of the rated voltage applied to the switch terminals. The normal and emergency contacts shall be positively interlocked mechanically and electrically to prevent simultaneous closing. Main contacts shall be mechanically locked in position in both the normal and emergency positions without the use of hooks, latches, magnet, or springs and shall be silver-tungsten alloy protected by arcing contacts, with magnetic blowouts on each pole. Parallel main contacts are not acceptable.

C. The transfer switch shall be equipped with a safe manual operator designed to be operated in the loaded condition and to prevent injury to operating personnel. The manual operator shall provide the same contact-to-contact transfer speed as the electrical operator to prevent a flashover from switching the main contacts slowly. Manual operator shall be usable with the front door of the MTS closed for maximum personnel protection.

D. Elevator pre-transfer contacts shall be provided to signal the elevators that a power source transfer is about to take place. When the door mounted push button is depressed to signal the MTS to transfer to the secondary source, a timer shall be activated that will delay the actual transfer until the timer had expired (based on the adjustable timer setpoint entered) and only then allowing the transfer to complete. Likewise, when the button is depressed to signal the MTS to return to its normal source, a timer shall be activated that will delay the actual transfer until that time has expired (base on the adjustable timer setpoint entered) and only then allowing the transfer to complete. Timers shall be adjustable from 0-30 seconds, air diaphragm type.

E. The manual switch shall be UL listed for withstand and close-in values at least equal to the interrupting rating of the circuit breaker and/or fuse that is specified to protect the circuit, and available short circuit amps from either source, but in no case less than 65,000 amperes symmetrical for 3 cycles.

F. Switch maximum dimensions shall be as shown on drawings.

2.3 CONSTRUCTION

A. The switching panel shall consist of completely enclosed contact assemblies and a separate control logic panel. Control power for all transfer operations shall be derived from the line side of the source to which the load is being transferred.

B. Each manual switch shall be positively interlocked both mechanically and electrically to prevent simultaneous closing of both sources under manual operation. Main contacts shall be mechanically locked in position in both normal and emergency positions. A delayed neutral position shall be possible for switching highly inductive loads. Timers shall be furnished to set the duration of the neutral position delay.

C. Switches shall be capable of being operated manually under full rated load conditions. In addition to the push button initiated electrical operation, Manual operation shall be accomplished by a permanently attached or removable manual operator. The operation of the manual handle shall be possible with the front door of the MTS CLOSED to maximize safety to personnel. Manual operators requiring source or load disconnection prior to manual operation are not acceptable.

2.4 OPERATOR CONTROLS

A. The front of the MTS shall have a pushbutton to initiate transfer to either source.

B. A backlit LED annunciator panel shall be located above the pushbuttons to show:

1. Source 1 available
2. Source 1 connected
3. Source 2 available
4. Source 2 connected

2.5 WIRING/TERMINATIONS

A. Terminal blocks shall conform to NEMA ICS 4. Terminal facilities shall be arranged for entrance of external conductors from the top or bottom of the enclosure. The automatic transfer switch terminals shall be suitable for the termination of conductors shown on the plans.

2.6 RATINGS

A. The Manual Maintenance Bypass switches shall have equal withstand, closing and interrupting ratings as noted below, 3 cycle “any breaker rating.” Series ratings are NOT acceptable. The automatic transfer switches shall be service rated for continuous duty. Unless shown otherwise on the plans and drawings, the minimum withstand rating shall be as follows:

100 – 800 amp	65,000 amps symmetrical
1000 – 1200 amp	85,000 amps symmetrical
1600 – 4000 amp	100,000 amps symmetrical

B. The voltage rating of the switches shall be no less than the system voltage rating. The continuous current rating of the switches shall be no less than the maximum continuous current requirements of the system.

C. The switches shall be fully rated to operate all types of loads, inductive and resistive, from loss of continuity of power, without derating, either open or enclosed.

2.7 ENCLOSURE

A. Enclosure: ICS 6, Type 1.

B. Finish: Manufacturer’s standard gray enamel.

C. NEMA 1 unless shown otherwise on the project drawings.

PART 3 - EXECUTION

3.1 FACTORY TESTING

A. The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of UL and NEMA standards.

B. Insulation check to ensure the integrity of insulation and continuity of the entire system.

C. Visual inspection to ensure that the switch matches the specification requirements and to verify that the fit and finish meet quality standards

D. Mechanical tests to verify that the switch's power sections are free of mechanical hindrances.

E. Electrical tests to verify the complete electrical operation of the switch and to set up time delays and voltage sensing settings of the logic

F. The manufacturer shall provide six (6) certified copies of factory test reports.

3.2 FIELD QUALITY CONTROL

A. Provide the services of a qualified factory-trained manufacturer’s representative to assist the contractor in installation and start-up of the equipment specified under this section for a period of one (1) working day. The manufacturer’s representative shall provide technical direction and assistance to the contractor in general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained therein.

B. The contractor shall provide six (6) copies of the manufacturer’s field start-up report.

3.3 MANUFACTURER’S CERTIFICATION

A. A qualified factory-trained manufacturer’s representative shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer’s recommendations.

B. The Contractor shall provide six (6) copies of the manufacturer’s representative’s certification.

3.4 EXAMINATION

A. Verify that surface is suitable for switch installation.

B. Provide housekeeping pads for all floor mounted switches.

3.5 INSTALLATION

A. The switch shall be installed as shown on the plans, in accordance with the manufacturer's recommendations and all applicable codes.

B. Provide and install maintenance bypass switches with the number of poles and accessories noted on the drawings. Maintain required NEC safe working clearances.

C. All necessary hardware to secure the assembly in place shall be provided by the Contractor.

D. The equipment shall be installed and checked in accordance with the manufacturer's recommendations.

E. Provide engraved plastic nameplates under the provisions of Section 26 05 53.

F. Conduit or piping systems that contain water or liquid of any kind shall not be installed over the top of any electrical equipment, transformers, racks, cabinets, or enclosures without prior written approval from the Owner.

3.6 DEMONSTRATION

A. Demonstrate operation of manual switch in normal and emergency modes.

B. Instruct owner's personnel in the proper operation of the manual switch

3.7 FIELD SERVICE ORGANIZATION

A. The manufacturer of the MTS shall also have a national service organization that is available throughout the contiguous United States and is available on call 24 hours a day, 365 days a year.

3.11 WARRANTY

A. The Maintenance Bypass switch shall be warranty for a period of five (5) years from date of shipment. 100% of all parts and labor shall be covered to repair/replace faulty components or failures that occur during the five (5) year period.

END OF SECTION 26 36 16

SECTION 26 36 23 - AUTOMATIC TRANSFER SWITCHES

PART 1- GENERAL

1.1 SCOPE

A. Furnish and install the low voltage automatic transfer switches having the ratings, features/accessories and enclosures as specified herein and as shown on the contract drawings.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Contractual Conditions and Division 01 Specifications sections apply to this section.

1.3 RELATED SECTIONS

A. Section 26 ~~24 16, Panelboards~~23 25, Medium- Voltage Generator Paralleling Switchgear & Controls

B. Section 26 32 ~~13, Standby~~18, Medium Voltage Diesel Engine ~~Generators~~Drive Generator

1.4 REFERENCES

A. The automatic transfer switches and all components shall be designed, manufactured and tested in accordance with the latest applicable standards of UL and NEMA as follows:

1. UL 1008 – Transfer Switches
2. UL 991
3. NFPA 70 – National Electrical Code
4. NFPA 110 – Emergency and Standby Power Systems
5. NEMA ICS 10 – AC Transfer Switch Equipment
6. IEEE 446 – Recommended Practice for Emergency and Standby Power Systems
7. IEC 801-2, 3, 4, and 5
8. CISPR 11
9. Compliant with FCC Part 15, Subpart B, Class A.

1.5 DESCRIPTION

A. Automatic transfer switches shall be capable of switching all classes of load, and shall be rated for continuous duty when installed in a non-ventilated enclosure.

B. Transfer switches shall be a true four (4) pole type. Normal and emergency full load current and voltage ratings at 60 cycles shall be as shown on plans.

1.6 SUBMITTALS

A. Product Data: Provide catalog sheets showing voltage, switch size, ratings and size of switching and overcurrent protective devices, operating logic, short circuit ratings, dimensions, and enclosure details.

B. Submit shop drawings and product data clearly indicating:

1. All applicable options and accessories

   a. Master drawing index
   b. Front view and plan view of the assembly
   c. Schematic diagram
   d. Nameplate schedule
   e. Component list
   f. Conduit space locations within the assembly.
   g. Assembly ratings including:

      1) Short-circuit rating
      2) Voltage
      3) Continuous current rating.

2. Major component ratings including:

   a. Voltage
   b. Continuous current rating
   c. Interrupting ratings
   d. Cable terminal sizes and quantity
   e. Product Data Sheets.
   f. Delivery, storage and handling instructions.

3. Where applicable, the following additional information shall be submitted to the OAR:

   a. Busway connection
   b. Connection details between close-coupled assemblies
   c. Composite front view and plan view of close-coupled assemblies
   d. Key interlock schematic drawing and sequence of operations
   ~~a. Mimic bus.~~

4. The following information shall be submitted for record purposes:

   a. Final as-built drawings and information for items listed in section 1.4
   b. Wiring diagrams
   c. Certified production test reports
   d. Installation information

5. The final (as-built) drawings shall include the same drawings as the construction drawings and shall incorporate all changes made during the manufacturing process.

6. Submittals and record drawings shall be submitted to the Project Manager.

C. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency specified under regulatory requirements. Include instructions for storage, handling, protection, examination, preparation, installation and starting of product.

1.7 FIELD MEASUREMENTS

A. Verify that field measurements are as indicated on drawings and as instructed by manufacturer.

1.8 OPERATION AND MAINTENANCE DATA

A. Operation Data:

1. Provide detailed instructions for operating equipment.
2. Include instructions for operating equipment under emergency conditions, including when engine generator is running.

B. Maintenance Data:

1. Provide routine preventative maintenance and lubrication schedule.
2. List special tools, maintenance materials, and replacement parts.

1.9 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the Products specified in this section with a minimum of ten years of experience.

B. When requested by the OAR, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

C. Supplier: Authorized distributor of specified manufacturer with a minimum of three years of experience.

1.10 REFERENCES AND REGULATORY REQUIREMENTS

A. Furnish products listed and classified by UL as suitable for purpose specified and indicated.

B. Provide a certificate of compliance with UL 1008 for the automatic transfer switches furnished under this section.

C. Conform to the requirements of the following:

1. NFPA 70 - National Electrical Code.
2. NEMA ICS 1 - General Standards for Industrial Control and Systems.
3. NEMA ICS 2 - Standards for Industrial Control Devices, Controllers and Assemblies.
4. NEMA ICS 6 - Enclosures for Industrial Controls and Systems.

1.11 QUALITY ASSURANCE/TESTS

A. When conducting temperature rise tests to paragraph 99 of UL-1008 the manufacturer shall include post-endurance temperature rise tests to verify the ability of the transfer switch to carry full rated current after completing the overload and endurance tests.

B. The switch shall meet or exceed the voltage surge withstand capability in accordance with IEEE Standard 472-1974 and the impulse withstand voltage test in accordance with NEMA Standard ICS 1-109.

1.12 DELIVERY, STORAGE AND HANDLING

A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris and traffic.

B. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to internal components, enclosure and finish.

1.13 FIELD MEASUREMENTS

A. Verify that field measurements are as indicated on drawings and as instructed by manufacturer.

1.14 MAINTENANCE SERVICE

A. Furnish service and maintenance of transfer switch for one year from Date of Substantial Completion.

1.15 MAINTENANCE MATERIALS

A. Provide two of each special tool required for maintenance.

1.16 OPERATION AND MAINTENANCE MANUALS

A. Equipment operation and maintenance manuals shall be provided with each assembly shipped, and shall include instruction leaflets and instruction bulletins for the complete assembly and each major component. These manuals shall be incorporated into the O & M manuals submitted to the OAR.

1.17 EXTRA PRODUCTS

A. Furnish and install all incidentals and appurtenances required for a complete and fully operational system to the satisfaction of the OAR. Line and load terminals shall be capable of accepting the quantity and size of conductors as specified on the plans.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Russelectric (basis of design).

B. Eaton Cutler-Hammer (Contactor type only)

~~C. Acceptable substitution.~~

C. No substitutions.

D. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. The manufacturer listed above is not relieved from meeting these specifications in their entirety. Equivalent products determined by the OAR to be in full compliance with the specification may be acceptable.

E. All power and control equipment as specified in the contract documents shall be considered an integral part of the Standby Power System and shall be supplied by the Standby Power System Supplier. The Standby Power System Supplier shall be responsible for coordination of the entire Standby Power System to provide for unit responsibility.

2.2 GENERAL

A. The transfer switch shall be double throw, actuated by two electrical operators, momentarily energized and connected to the transfer mechanism by a simple over center linkage with time delay relays to control contact transition time on transfer to either source, adjustable 0-300 seconds. Time delay between the opening of the closed contacts and the closing of the open contacts shall be adjusted to allow for voltage decay before transfer as required to allow re-energization of motor and transformer loads at normal in rush currents. Single throw, actuated by single electric operator shall be allowed in lieu of double throw operator if in phase monitor is used which allows for re-energization as noted above.

B. The transfer switch shall be capable of transferring successfully in either direction with 70% of the rated voltage applied to the switch terminals. The normal and emergency contacts shall be positively interlocked mechanically and electrically to prevent simultaneous closing. Main contacts shall be mechanically locked in position in both the normal and emergency positions without the use of hooks, latches, magnet, or springs and shall be silver-tungsten alloy protected by arcing contacts, with magnetic blowouts on each pole. Parallel main contacts are not acceptable.

C. The transfer switch shall be equipped with a safe manual operator designed to be operated in the loaded condition and to prevent injury to operating personnel. The manual operator shall provide the same contact-to-contact transfer speed as the electrical operator to prevent a flashover from switching the main contacts slowly. Manual operator shall be usable with the front door of the ATS closed for maximum personnel protection.

D. Engine starting contacts shall be provided in transfer switch to start the generating plant if any phase of the normal source drops below 80% of rated voltage, after an adjustable time delay period of 0.5-3 seconds, to allow for momentary dips. The transfer switch shall not transfer to emergency until the generator source voltage and frequency have reached 90% of rated. After restoration of normal power on all phases to 90% of rated voltage, adjustable time delay period of 0-25 minutes shall delay transfer to normal power until it has had time to stabilize. If the emergency power source should fail during the time delay period, the time delay shall be by-passed, and the switch shall return immediately to the normal source. Whenever the switch has retransferred to normal, the engine-generator shall be allowed to operate at no load for a fixed period of time (5 minutes) to allow it to cool before shut-down. The transfer switch shall include a test switch to simulate normal power failure with actual load transfer. Pilot lights shall be included on the cabinet door to indicate the main switch closed on normal or emergency, and two auxiliary contacts on the main shaft; one closed on normal, the other closed on emergency. In addition, two sets of relay contacts shall be provided to open and close upon loss of the normal power supply. All relays, timers, control wiring and accessories to be front accessible and be rated for the load and voltage as required for auxiliary control functions.

E. The transfer switch shall be UL listed for withstand and close-in values at least equal to the interrupting rating of the circuit breaker and/or fuse that is specified to protect the circuit, and available short circuit amps from the generator set.

~~F.~~ F. The transfer switch shall automatically exercise the generating plant a no load or loaded condition. Exerciser shall be adjustable in 15 minute increments. Refer to Contract Documents for specific programming.

~~G.~~ G. Transfer switches shall transfer normal supply to emergency within the time limits as required by the National Electrical Code for emergency loads (10 seconds for life safety, 60 seconds for critical).

~~H.~~ H. When more than one emergency branch is shown, time delay relays shall be provided on the transfer to emergency operation for critical and equipment branch transfer switches. Time delay shall be adjustable 1-300 seconds and shall be adjusted in stages with the limits of the N.E.C. and as follows:

1. Life Safety Branch - no time delay on transfer to emergency.
2. Legally Required (Critical) Branch - shall transfer to emergency after the life safety branch has transferred to emergency and generator has recovered to 90% of rated voltage and frequency.
3. Security Branch - shall transfer to emergency after the legally required branch has transferred to EMG and GEN has recovered to 90% of rated voltage and frequency.
4. Equipment Branch - shall transfer to emergency after the legally required and security branches have transferred to emergency and generator has recovered to 90% of rated voltage and frequency.
5. These time delays shall not effect or be a function of contact transition time as required in A above.

~~I.~~ I. Transfer switch maximum dimensions shall be as shown on drawings.

2.3 CONSTRUCTION

A. The switching panel shall consist of completely enclosed contact assemblies and a separate control logic panel. Control power for all transfer operations shall be derived from the line side of the source to which the load is being transferred.

B. Each automatic transfer switch shall be positively interlocked both mechanically and electrically to prevent simultaneous closing of both sources under either automatic or manual operation. Main contacts shall be mechanically locked in position in both normal and emergency positions. A neutral position shall not be possible under normal electrical operation unless a delayed transition accessory is required for switching highly inductive loads.

C. Automatic transfer switches shall be capable of being operated manually under full rated load conditions. Manual operation shall be accomplished by a permanently attached or removable manual operator, or by integrally mounted pushbuttons. The operation of the manual handle shall be possible with the front door of the ATS CLOSED to maximize safety to personnel. Removable manual operating handles, and handles that may move in the event of an electrical operation during the manual operation, are not acceptable. Manual operators requiring source or load disconnection prior to manual operation are not acceptable.

D. The automatic transfer switches shall have a multi-tap voltage selection plug for ease of voltage adjustment in the field.

E. Automatic transfer switches ~~shall be~~that are applied as service entrance switches ~~and~~shall provided with a service entrance label. ~~An external key-operated selector switch shall be provided to disconnect the power supplies.~~ Indicators shall be provided to show the availability of each source as well as ~~breakers~~the service entrance breaker in a tripped or disconnected position. Provide a switched neutral contact of identical construction and rating as the power poles mounted on the power contact shaft integral to the completed assembly, and a neutral-to-ground main bonding jumper for all switches to meet UL service entrance requirements. Service Entrance breaker shall include GF trip for units 1000 amps and higher.

~~2.4 MICROPROCESSOR LOGIC~~

~~F. The automatic transfer switches shall be controlled by an ASCO microprocessor-based controller or approved equivalent. The controller shall be hardened against potential problems from transients and surges. Operation of the automatic transfer switches and monitoring of both sources shall be managed by the controller.~~

~~G. Automatic transfer switches shall also have provisions for bell alarm and auxiliary switch wired out to terminals for Owner's use.~~

~~2.5~~2.4 MICROPROCESSOR-BASED CONTROLLER

A. The microprocessor-based logic controller shall be door mounted and shall provide the operator with an overview of the automatic transfer switch status, parameters, and diagnostic data. The controller shall have a voltage range of 0-790 volts (50/60 Hz) and an accuracy of +/- 2% of nominal input voltage. The controller shall have a frequency range of 40-70 Hz and an accuracy of +/- .1 Hz. Control power input range shall be from 65V AC – 145V AC RMS 50/60 Hz. The controller shall be listed under UL Standard 1008.

B. The microprocessor-based controller shall include an LCD display, and shall display the following:

1. Line-to-line voltages for each source and the load
2. Line frequency for each source
3. Timer countdown for each timer while functioning
4. Real-time clock
5. Set points.

C. The microprocessor-based controller shall include mimic bus and individual LEDs for indicating the following:

1. Source 1 available
2. Source 1 connected
3. Source 2 available
4. Source 2 connected

D. The microprocessor-based controller shall contain the following features:

1. Password programming protection.

2. Set points shall be stored in Non-Volatile memory, and use of an external battery source to maintain operation during "dead" periods shall not be required.
3. Program/run switch.

E. The microprocessor-based controller shall contain the following voltage and frequency features:

1. The voltage of each phase of the normal source and the alternate source shall be monitored, with undervoltage dropout adjustable from 50% to 90% of nominal and pickup adjustable from dropout setting +/-2% to 99% of nominal.
2. The voltage of each phase of the normal source and the alternate source shall be monitored, with overvoltage dropout adjustable from 105% to 120% of nominal and pickup adjustable from dropout setting +2% to 103% of nominal.
3. The frequency of the normal source and the alternate source shall be monitored, with underfrequency dropout adjustable from 90% to 100% of nominal and pickup adjustable from dropout setting +1 Hz to 99% of nominal.
4. The frequency of the normal source and the alternate source shall be monitored, with overfrequency dropout adjustable from 100% to 120% of nominal and pickup adjustable from dropout setting +1 Hz to 101% of nominal.

F. The microprocessor-based controller shall contain the following time delay features:

1. A time delay shall be provided to override a momentary power outage or voltage fluctuation, adjustable from 0 to 120 seconds.
2. A time delay shall be provided on transfer to alternate source, adjustable from 0 to 1800 seconds.
3. A time delay shall be provided on retransfer from alternate source to normal source, adjustable from 0 to 1800 seconds. This time delay shall be bypassed if emergency source fails and normal source is available.
4. A time delay shall be provided after retransfer that allows the generator to run unloaded prior to shutdown, adjustable from 0 to 1800 seconds.
5. A time delay shall be provided for the neutral position, adjustable from 0 to 120 seconds.
6. A time delay shall be provided for engine failure to start, adjustable from 0 to 6 seconds.
7. All delays shall be field adjustable from the microprocessor-based controller without the use of special tools.

G. The microprocessor-based controller shall contain the following features:

1. Pre-transfer signal, range 0-120 seconds, programmable in either direction
2. Plant exerciser, selectable – disabled or 7 day interval, 0-600 minutes load or no load
3. Retransfer mode – manual or automatic
4. Test pushbutton mode – disabled, load or no load.

H. The microprocessor-based controller shall contain the following input/output contacts:

1. Two (2) SPST contacts for generator start, rated 5A, 250V AC
2. Four (4) SPST contacts for position indication control functions, rated 10A, 250V AC
3. Three (3) SPDT contacts for source availability control functions, rated 10A, 250V AC

~~2.6~~2.5 WIRING/TERMINATIONS

A. Terminal blocks shall conform to NEMA ICS 4. Terminal facilities shall be arranged for entrance of external conductors from the top or bottom of the enclosure. The automatic transfer switch terminals shall be suitable for the termination of conductors shown on the plans.

~~2.7 POWER SWITCHING DEVICE~~

~~B. Protective switching devices shall be fixed mount molded case switch, Square D type LHL or accepted equivalent. Frame ratings shall be as noted. All switches shall be UL listed for application in their intended enclosures for 100% of their continuous ampere rating. Switches shall be electrically operated.~~

~~C. All switches shall be provided with a true, two-step stored energy mechanism providing a maximum of five-cycle closing. All the energy required for closing the switches shall be completely stored and held in readiness pending a release to close action. The molded case switches shall have high-endurance characteristics being capable of no-load and full-load interruptions at rated current equal to or exceeding the UL endurance ratings for molded case switches without maintenance.~~

~~2.8~~2.6 RATINGS

~~D.~~A. The automatic transfer switches shall have equal withstand, closing and interrupting ratings as noted below, 3 cycle "any breaker rating." Series ratings are NOT acceptable. The automatic transfer switches shall be service rated~~. The automatic transfer switches~~ for continuous duty. Unless shown otherwise on the plans and drawings, the minimum withstand rating shall be ~~rated~~ as ~~noted below~~follows:

~~1. 60 kW GEN SET; 200 amperes, 120/240V, single phase, two pole with fully rated switched neutral, 22k AIC~~

~~The automatic transfer switches shall be service rated for continuous duty.~~

100 - 400 amp	42,000 amps symmetrical
600 – 800 amp	65,000 amps symmetrical
1000 – 1200 amp	85,000 amps symmetrical
1600 – 4000 amp	100,000 amps symmetrical

~~E.~~

~~F.~~B. The voltage rating of the automatic transfer switches shall be no less than the system voltage rating. The continuous current rating of the automatic transfer switches shall be no less than the maximum continuous current requirements of the system.

~~G.~~C. The automatic transfer switches shall be ~~service~~ rated for continuous duty as shown on the drawings and shall conform to the applicable requirements of UL 1008 for emergency system total load.

~~H.~~D. The automatic transfer switches shall be fully rated to operate all types of loads, inductive and resistive, from loss of continuity of power, without derating, either open or enclosed.

~~2.9~~2.7 ENCLOSURE

A. Enclosure: ICS 6, Type 1.

B. Finish: Manufacturer's standard gray enamel.

~~C. NEMA 4X stainless steel.~~

C. NEMA 1 unless shown otherwise on the project drawings.

PART 3 - EXECUTION

3.1 FACTORY TESTING

A. The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of UL and NEMA standards.

B. Insulation check to ensure the integrity of insulation and continuity of the entire system.

C. Visual inspection to ensure that the switch matches the specification requirements and to verify that the fit and finish meet quality standards

D. Mechanical tests to verify that the switch's power sections are free of mechanical hindrances.

E. Electrical tests to verify the complete electrical operation of the switch and to set up time delays and voltage sensing settings of the logic

F. The manufacturer shall provide six (6) certified copies of factory test reports.

3.2 FIELD QUALITY CONTROL

A. Provide the services of a qualified factory-trained manufacturer’s representative to assist the contractor in installation and start-up of the equipment specified under this section for a period of five (5) working days. The manufacturer’s representative shall provide technical direction and assistance to the contractor in general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained therein.

B. The contractor shall provide six (6) copies of the manufacturer’s field start-up report.

3.3 MANUFACTURER’S CERTIFICATION

A. A qualified factory-trained manufacturer’s representative shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer’s recommendations.

B. The Contractor shall provide six (6) copies of the manufacturer’s representative’s certification.

3.4 EXAMINATION

A. Verify that surface is suitable for transfer switch installation.

B. Provide housekeeping pads for all floor mounted switches.

3.5 INSTALLATION

A. The transfer switch shall be installed as shown on the plans, in accordance with the manufacturer's recommendations and all applicable codes.

B. Provide and install automatic transfer switches with the number of poles and accessories noted on the drawings. Maintain required NEC safe working clearances.

C. All necessary hardware to secure the assembly in place shall be provided by the Contractor.

D. The equipment shall be installed and checked in accordance with the manufacturer’s recommendations.

E. Provide engraved plastic nameplates under the provisions of Section 26 05 53.

F. Provide all associated control wiring to generator as required.

G. Provide and install all interface control wiring and conduit as required to provide required emergency operation of equipment on project as applicable.

H. Conduit or piping systems that contain water or liquid of any kind shall not be installed over the top of any electrical equipment, transformers, racks, cabinets, or enclosures without prior written approval from the Owner.

3.6 SITE TEST

A. An installation check and building load test shall be performed by the manufacturer's local representative. The OAR, designer, regular operators and the maintenance staff shall be notified of the time and date of the site test. The tests shall include automatic start-up by means of simulated power outage to test remote-automatic starting, transfer of the load and automatic shutdown. Prior to this test, all transfer switch timers shall be adjusted and all necessary programming completed for proper system coordination.

3.7 DEMONSTRATION

A. Demonstrate operation of transfer switch in normal and emergency modes.

3.8 TRAINING

A. The contractor shall provide a training session for up to five (5) owner’s representatives for two (2) normal workdays at a jobsite location determined by the owner.

B. The training session shall be conducted by a manufacturer’s qualified representative. The training program shall consist of the instruction on the operation of the assembly, circuit breakers and major components within the assembly with "hands on" type training with a previously owner approved outline for the specific equipment.

3.9 FIELD SERVICE ORGANIZATION

A. The manufacturer of the ATS shall also have a national service organization that is available throughout the contiguous United States and is available on call 24 hours a day, 365 days a year.

3.10 SITE TEST

A. An installation check and building load test shall be performed by the manufacturer's local representative. The OAR, engineer, regular operators and the maintenance staff shall be notified of the time and date of the site test. The tests shall include automatic start-up by means of simulated power outage to test remote-automatic starting, transfer of the load and automatic shutdown. Prior to this test, all automatic transfer switch timers shall be adjusted for proper system coordination.

B. Test all equipment.

3.11 WARRANTY

A. The Automatic Transfer switch shall be warranty for a period of five (5) years from date of shipment. 100% of all parts and labor shall be covered to repair/replace faulty components or failures that occur during the five (5) year period.

END OF SECTION 26 36 23

SECTION 26 41 13 - LIGHTNING PROTECTION SYSTEM

PART 1- GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Contractual Conditions and Division 01 Specification Sections, apply to this section.

1.2 SUMMARY

A. This section includes the requirements for provision and installation of a complete lightning protection system.

1.3 DESCRIPTION

A. A Lightning Protection System (LPS) shall be provided and installed on the structure as noted, and shall be complete even though all items may not be completely shown on drawings. The LPS shall be installed by an experienced Lightning Protection Institute (LPI) - Certified Installer, and in compliance with the provisions of the prevailing and enforced code(s) for LPS as adopted by the National Fire Protection Association (NFPA) and the Underwriters Laboratories (UL). Confirm the prevailing LPS code(s) prior to preparation of the bid and again prior to commencement of the construction. The LPS drawings are provided as a minimum standard, but where a higher standard exists and will be enforced by the Authority Having Jurisdiction (AHJ), the contractor will use the higher standard if unable to confirm acceptance of the lesser standard prior by the Authority Having Jurisdiction to the bid. All of the LPS equipment required for a completely operable and certified LPS, whether shown or not, shall be included.

B. Materials shall comply in weight, size and composition with the requirements of UL and the NFPA Code relating to this type of installation, and shall be UL Listed.

C. Where the LPS products and materials being used are available from a single (1) manufacturer, the LPS contractor shall use those materials in lieu of products and materials from multiple manufacturers.

D. System shall comply with the following:

1. The Lightning Protection Institute (LPI-175) – confirm edition and amendments with AHJ.
2. ANSI/NFPA 780; Class I or Class II as noted on the respective drawing set. The LPS contractor shall confirm the edition and amendments being enforced with AHJ prior to release of the bid.
3. UL 96A; Master Label for:
    a) A new, single structure installation

1.4 REFERENCES

A. ANSI/NFPA 780 – Standard for the Installation of Lightning Protection System.

B. ANSI/UL 96 – Standard for Lightning Protection Components.

C. LPI-175 and LPI-177 – Lightning Protection Institute.

D. UL 96A - Installation Requirements for Lightning Protection Systems.

E. IEEE 81 – Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.

1.5 SUBMITTALS

A. The LPS design shown on these documents shall be used for the shop drawings and alternate means and methods will not be considered. The LPS contractor shall submit shop drawings showing the complete layout of all the LPS air terminals, all the LPS grounding electrodes, the respective in-ground box, the LPS bonding connections to the building metal structure(s) and the LPS connection to other metal objects located in the building and on the roof as shown. Provide a Symbol Legend to define the air terminals, the LPS grounding electrode, and the counterpoise ground loop size(s), the LPS down lead conductor size(s), and the LPS roof grid conductor size(s). Provide details, equal to those shown on these documents, which show the respective connection and termination types. Drawings shall include full layout of cabling and points, and connections.

B. Submit product data showing dimensions and materials of each component being provided for the LPS. Provide documentation showing compliance with the specific requirements of ANSI/UL 96 and a listing label. Provide documentation showing that coordination between the LPS contractor and the General/Roof/Paint/Finish contractors exists. The LPS contractor shall confirm all LPS connection types and materials with the respective contractor to be sure that adhesives or welds will not compromise the integrity of the material on which it is being installed. The LPS contractor will not void the warranty of any other contractor by using dissimilar metals or adhesives which are not approved by the other contractor/manufacturer.

C. Submit the LPS manufacturer's installation instructions for review and approval. Include submittal data for the adhesives to be used and welding types to be made.

D. Submittal shall include manufacturer’s installation instructions for the in-ground boxes as defined and shown on the LPS drawings.

1.6 PROJECT AS-BUILT DOCUMENTS

A. Record actual locations of air terminals, grounding electrodes, bonding connections, and routing of system conductors on red lined as-built documents. Maintain the red lined as-built documents and upon completion of the building prepare a REVIT model and drawings showing any changes to the bid documents.

B. Photograph and maintain digital pictures of all welding and bonding which will not be visible after completion of the construction. The photos shall use the column line Alpha-Numerical system established by the architect and as shown on the architectural drawings. Provide copies of the digital photographs to the Engineer of Record (EOR) within two (2) days of taking the photos. Use the correct Alpha-Numerical indicator and a typed list of the photos being submitted and a brief explanation of each photo.

1.7 QUALIFICATIONS

A. Manufacturer: A company which specializes in the manufacture of LPS equipment with a minimum of five (5) years documented experience. The company and their products shall be a certified member of the Lightning Protection Institute and the products shall bear the UL label as required.

B. Installer: An LPS company licensed in the State of Florida and the City of Orlando to provide and install the LPS shown on the drawings. The contractor shall be certified and authorized to install the LPS of each manufacturer being used, they shall have a minimum of five (5) years documented experience, and they shall be a certified member of the Lightning Protection Institute.

1.8 PRE-INSTALLATION CONFERENCE

A. Schedule and convene a pre-installation conference at least one (1) week prior to commencing any LPS work or excavation. Provide all attendees with at least a two (2) week notice prior to the meeting.

1.9 SEQUENCING AND SCHEDULING

A. The LPS contractor shall coordinate the work for this section with the roofing, structural steel, exterior and interior finish, HVAC, plumbing, fire protection and electrical contractors prior to any installations. Maintain concurrence with these disciplines throughout the project to avoid any conflict between the materials, and to avoid conflict during installation by means and methods.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Thompson Lightning Protection, Inc.: Premium Line.

B. Independent Protection Company, Inc.: Premium Line.

C. Heary Bros. Lightning Protection: Premium Lines.

2.2 MATERIALS

A. Components: In accordance with ANSI/UL 96 and LPI.

B. Air Terminals:

1. Air Terminals shall be solid (aluminum), one-half inch (1/2”) diameter for Class I installations, five-eighths inch (5/8”) for Class II installations, as required to match roof conductors, and shall have proper base support for surface on which they are attached. Mount and securely anchored to the surface on which they are to be attached. Provide a blunt tip type air terminal.

2. Terminal length: Twenty-four inches (24”) or as otherwise noted on the drawings. Comply with the requirements of NFPA 780 for complete installation.

C. Conductors:

1. LPS Roof Conductor(s)- the LPS roof conductors shall consist of aluminum complying with the weight and construction requirements of the applicable NFPA 780 Code section or the LPI requirements, whichever is more stringent. The LPS roof conductor material shall match, and be compatible with, the roof and flashing materials. The LPS contractor shall use only gradual bends of eight inches (8”) or more in radius when installing the conductor(s).

2. LPS Down Conductor(s) - the LPS down conductors shall be copper, and shall be provided where shown and installed in a minimum one-inch (1”) PVC, schedule 40 conduit as noted in the drawing details. Conceal the conduit within the structure and take a digital photograph of any welds or bonds connected to the LPS. Identify each photo with the location of the weld or bond. The LPS contractor shall use only gradual bends of eight inches (8”) or more in radius when installing the conductor(s) and the conduit. The down conductor shall be sized in accordance with NFPA 780, Table 4.1.1.1.1 for Class I Installations, and in accordance with NFPA 780, Table 4.1.1.1.2 for Class II Installations.
3. LPS Counterpoise – the LPS counterpoise (ground loop) conductor shall be a single (1) cable with thirty-two (32) strands of #17 AWG copper for Class I Installations, and a single (1) cable with twenty-eight (28) strands of #14 AWG copper for Class II Installations. The counterpoise shall be buried in a trench at a depth of two feet (2’-0”) minimum. The LPS contractor shall maintain the integrity of the counterpoise conductor by keeping it out of contact with the piping, conduits or underground utility cables of other trades. Where the pipe, conduit or another utility cable is within six inches (6”) of the counterpoise conductor (above or below), the counterpoise conductor will be routed below the pipe, conduit or utility cable, and the LPS contractor shall maintain a minimum of twelve inches (12”) of separation between the counterpoise conductor and any other utility pipe(s), cable(s) or conduit(s). Provide marking tape at six inches above the counterpoise conductor. Coordinate with all site trades to confirm their routing and depth prior to installation and connection of the counterpoise conductor. Do not connect the counterpoise conductor to the LPS ground rods until each rod has been tested and certified to be 5 Ohms or less in resistance. The LPS contractor shall only use gradual bends of eight inches (8”) or more in radius when installing the counterpoise conductor. Plan and use “Sweep Type” radius when going under all other utility pipes, cables or conduits.

D. Fastener: Exposed LPS conductor fasteners shall be of the same material as the conductor, and shall have ample strength to support conductor. Exposed fasteners shall be installed using only an approved method and only with approved adhesives.

E. Couplings, Connectors and Splicers: The LPS ground rod couplings shall be threaded and self-tightening, DeMark type only. Provide Bronze or aluminum connectors as required to be compatible with conductor being connected.

F. Ground Rods: The LPS grounding rods shall consist of multiple sections of copper clad driven rods, three-quarter inch (3/4”) diameter, a minimum of ten feet (10’-0”) long for each section. The installation shall comply with the instructions listed in the LPS construction documents and any additional requirements of Section 26 05 26 Grounding and Bonding, but this section shall prevail if there is a conflict. The tests shall comply with the instructions listed in the LPS construction documents and any additional requirements of Section 26 08 13 Tests and Performance Verification, but this section shall prevail if there is a conflict. Each LPS ground rod shall have a unique and distinct identification, and all reports provided to the EOR will use the same identification when reporting tests. The LPS ground rods shall be driven to a minimum depth of forty feet (40’-0”) and tested. If required, additional rod section(s) will be added and the assembly will be driven further down until a maximum of 5 Ohms resistance is achieved when measured using a clamp on, digital recorder.

The 5 Ohm requirement will be achieved at the rod before connection of the copper counterpoise ground loop conductor.

PART 3 - EXECUTION

3.1 EXAMINATION

A. The LPS contractor shall verify that all surfaces are cleaned, prepared and ready to receive the work of this discipline.

B. The LPS contractor shall verify that the actual field measurements are the same as those shown on the LPS shop drawings.

C. The LPS contractor indicates acceptance of the existing conditions by beginning the work of the LPS construction.

3.2 PROTECTION OF SURROUNDING ELEMENTS

A. The LPS contractor shall provide protection of all LPS equipment and installations during the project. Coordinate with the general contractor if temporary shoring, barriers or enclosures are required to protect the work of this section from damage or disfiguration.

3.3 INSTALLATION

A. Install all LPS materials in accordance with manufacturer's written and published instructions.

B. Install all LPS materials in accordance with requirements of UL 96A, ANSI/NFPA 780, and LPI. The LPS contractor shall verify with the AHJ prior to shop drawing submission.

C. Install LPS ground rods as noted in the LPS Details and in accordance with Section 26 05 26 Grounding and Bonding. Where conflict exists between the requirements of Section 26 05 26 Grounding and Bonding and this section, the most stringent shall govern.

D. The LPS materials shall be installed in an inconspicuous manner where possible. The LPS conductors shall be routed concealed where possible. Down conductors shall be concealed within structure, and shall be run in a one-inch (1") PVC, Schedule 40 conduit.

E. Where the LPS fasteners are to be mounted in a masonry element, or in a structural element, the LPS contractor shall furnish the required fastener(s) to the Masonry or Structural contractor so they may be installed during construction of the project.

F. Provide the proper connections to the LPS from all the grounded media in and around the protected structure. All connections shall be in accordance with the requirements of NFPA 780 for Surge Protection and Potential Equalization. The LPS contractor shall coordinate with the specific low-voltage contractor to determine the appropriate connection type(s) required and the specific locations.

G. Provide the proper connections to the LPS from all grounding media in, on and around the structure to provide a common ground potential per NFPA 780 for Common Bonding of Grounded Systems, including the electrical service, the data, telephone and antenna system grounds, as well as underground metallic piping systems, underground metal conduits, etc.

H. Counterpoise Ground Loop: The LPS contractor shall bond the counterpoise ground loop to the Electrical Ground System. Refer to Section 26 05 26 Grounding and Bonding for additional information. Items required to be bonded/connected as noted in 'F' and 'G' above shall be bonded/connected via Electrical Ground System where available and applicable.

I. All exposed LPS conductors which are located within six feet (6'-0") or less above finished floor, or the finished grade, shall be protected and shielded properly as well as other exposed locations where a conductor is subject to mechanical damage.

J. The LPS contractor shall coordinate with, and receive approval of, all penetrations of the roofing system and mounting to roofing system with LPS Designer and Roofing Contractor prior to submittal of shop drawings.

K. The LPS contractor shall coordinate with, and receive approval from, the Structural Engineer of Record for all connections to structural steel, rebar, and other structural elements prior to submittal of shop drawings.

L. Ground Terminals:

1. The LPS ground connections shall be made in accordance with requirements of all applicable codes and Section 26 05 26 Grounding and Bonding (including but not limited to requirements for testing, ground rods, materials, wells, etc.).

2. The LPS counterpoise ground rods shall be placed outside of the building at a minimum of two feet (2'-0") away from the building foundation. Refer to the specific LPS Details for additional information.

3. The LPS counterpoise ground rod location shall consist of:

a) One (1) copper-clad steel (Copper-weld) driven ground rod which is three-quarter inch (3/4") in diameter and driven vertically to a minimum depth of forty feet (40'-0") into the ground. The rod will be tested, and if required, the contractor shall provide additional sections of rod to achieve a maximum of Five Ohms (5Ω) or less. The test of the ground rod shall only be performed a minimum of two (2) days after any substantial rain storm to avoid false readings.

b) Provide an in-ground box (ground well) enclosure at each ground rod location in accordance with LPS Details located on the LPS drawings.

3.4 FIELD QUALITY CONTROL

A. The LPS contractor shall test all ground rods, using a digital Ground Testing and Recording Meter and provide a Grounding Matrix in the form of an Excel spread sheet for review. Refer to IEEE Standard 81 for test methods and refer to the specific requirements of Section 26 08 13 Tests and Performance Verification for additional information. Each ground rod shall test positively for a maximum of Five Ohms (5Ω) resistance. The test on all ground rods shall only be performed a minimum of two (2) days after any rain to avoid false readings.

B. The LPS contractor shall obtain the service of Underwriters Laboratories, Inc. to provide inspection and certification of the lightning protection system under provisions of UL 96A. Submit certification and submit in O & M Manual.

C. The LPS contractor shall obtain, from the Underwriters Laboratories, Inc., a UL Master Label and attach it to the building at a location as directed by OAR. Submit copy of paperwork to EOR, OAR and submit in O & M Manual.

D. The LPS contractor shall include the required test results for each counterpoise ground rod location including final length of each ground rod at each ground rod location.

END OF SECTION