3.2 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Section 26 05 53 "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads and incorporating Owner's final room designations. Obtain approval before installing. Use a computer with word processor or spreadsheet program to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

A. Perform inspections.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection stated in NETA Acceptance Testing Specification.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance.

C. Prepare inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION

SECTION 26 24 19
MOTOR-CONTROL CENTERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes MCCs for use with ac circuits rated 600 V and less and having the following factory-installed components:

1. Incoming main lugs and OCPDs.
2. Full-voltage magnetic controllers.
3. Feeder-tap units.
4. Instrumentation.
5. Auxiliary devices.

1.2 DEFINITIONS

A. BAS: Building automation system.

B. CPT: Control power transformer.

C. LED: Light-emitting diode.

D. MCC: Motor-control center.

E. MCCB: Molded-case circuit breaker.

F. MCP: Motor-circuit protector.

G. NC: Normally closed.

H. NO: Normally open.

I. OCPD: Overcurrent protective device.

J. PT: Potential transformer.

K. SCR: Silicon-controlled rectifier.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of controller and each type of MCC.

B. Shop Drawings: For each MCC, manufacturer's approval drawings as defined in UL 845. In addition to requirements specified in UL 845, include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting

arrangements, and details, including required clearances and service space around equipment.

1. Show tabulations of installed devices, equipment features, and ratings.
2. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring for each installed controller.
3. Nameplate legends.
4. Vertical and horizontal bus capacities.
5. Features, characteristics, ratings, and factory settings of each installed unit.

C. Fuse and Overload Sizes: Submit a compiled list of motors, fuse sizes, overload sizes, and types for motors actually installed.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around MCCs where pipe and ducts are prohibited. Show support locations, type of support, and weight on each support.

B. Product certificates.

C. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. Source Limitations: Obtain MCCs and controllers of a single type from single source from single manufacturer.

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. NEMA Compliance: Comply with NEMA Standards Pub/No. ICS-2, pertaining to construction, testing, and installation of MCCs, and with applicable NEMA standards for circuit breakers and fuses.

D. UL Compliance: Comply with applicable requirements of UL Standard 486A, "Wire Connectors and Soldering Lugs for Use with Copper Conductors," and UL Standard 845, "Electric Motor Control Centers." Provide MCCs and ancillary equipment which are UL listed and labeled.

E. IEEE Compliance: Comply with applicable requirements of IEEE Standard 241 pertaining to construction and installation of MCCs.

F. ANSI Compliance: Comply with applicable requirements of ANSI as applicable to MCCs.

G. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Eaton Electrical/Cutler-Hammer.
2. Schneider Electric/Square D Services.
3. Allen-Bradley.
4. Siemens.

B. General Requirements for MCCs: Comply with NEMA ICS 18 and UL 845.

2.2 FUNCTIONAL FEATURES

A. Description: Modular arrangement of main units, controller units, control devices, feeder-tap units, instruments, metering, auxiliary devices, and other items mounted in vertical sections of MCC.

B. Feeder-Tap Units: Through 225-A rating shall have drawout mountings with connectors that automatically line up and connect with vertical-section buses while being racked into their normal, energized positions.

C. Future Units: Compartments fully bused and equipped with guide rails or equivalent, ready for insertion of drawout units.

D. Spare Units: Installed in compartments indicated "spare."

E. Disconnect Operators: Provide external operator handles for switches and circuit breakers. Construct handles which permit locking handle in OFF position with 3 padlocks.

F. Motor Circuit Protector: Adjustable trip magnetic-only instantaneous molded-case circuit breakers for use in starter units. Provide a continuous current rating of at least 125 percent of the motor full load current and an interrupting capacity of 65,000 amps symmetrical. Provide a field adjustable instantaneous trip unit capable of being adjusted from 7 to 13 times motor full load current.

G. Circuit Breakers: Factory assembled, molded-case circuit breakers with permanent instantaneous magnetic and thermal trips in each pole and with fault-current limiting protection; ampere ratings as indicated. Construct breakers for mounting and operating in any physical position and in an ambient temperature of 40 degrees. Provide with AL/CU rated mechanical screw type removable connector lugs.

2.3 INCOMING MAINS

A. Incoming Mains Location: bottom.

B. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. MCCB Features and Accessories:

a. Standard frame sizes, trip ratings, and number of poles.
b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
c. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
d. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

2.4 COMBINATION CONTROLLERS

A. Full-Voltage Controllers:

1. General Requirements for Full-Voltage Enclosed Controllers: Comply with NEMA ICS 2, general purpose, Class A.
2. Magnetic Controllers: Full voltage, across the line, electrically held.

a. Configuration: Nonreversing.

B. Disconnecting Means and OCPDs:

1. MCCB Disconnecting Means:

a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.

b. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
c. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
d. NC alarm contact that operates only when MCCB has tripped.

C. Control Power:

1. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.

a. CPT Spare Capacity: 200 VA.

2.5 FEEDER-TAP UNITS

A. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

2. MCCB Features and Accessories:

a. Standard frame sizes, trip ratings, and number of poles.
b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
c. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
d. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

2.6 ENCLOSURES

A. Enclosures: Freestanding steel cabinets unless otherwise indicated. NEMA 250, Type 2 unless otherwise indicated to comply with environmental conditions at installed location.

B. Enclosure Finish: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

C. Compartments: Modular; individual lift-off doors with concealed hinges and quick-captive screw fasteners. Interlocks on units requiring disconnecting means in off position before door can be opened or closed, except by operating a permissive release device.

D. Interchangeability: Compartments constructed to allow for removal of units without opening adjacent doors, disconnecting adjacent compartments, or disturbing operation of other units in MCC; same size compartments to permit interchangeability and ready rearrangement of units, such as replacing three single units with a unit requiring three spaces, without cutting or welding.

E. Wiring Spaces:

1. Vertical wireways in each vertical section for vertical wiring to each unit compartment; supports to hold wiring in place.
2. Horizontal wireways in bottom and top of each vertical section for horizontal wiring between vertical sections; supports to hold wiring in place.

2.7 AUXILIARY DEVICES

A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.

1. Push Buttons, Pilot Lights, and Selector Switches: Heavy-duty, oiltight type.

a. Push Buttons: Equip Start push button with extended guard and black color insert. Equip Stop push buttons with half guard and red color insert.
b. Pilot Lights: LED types; push to test.
c. Selector Switches: Rotary type.

2. Elapsed Time Meters: Heavy duty with analog readout in hours; nonresettable.
3. Meters: Panel type, 2-1/2-inch minimum size with 90- or 120-degree scale and plus or minus 2 percent accuracy with selector switches having an off position.

B. Reversible NC/NO contactor auxiliary contact(s).

C. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

2.8 CHARACTERISTICS AND RATINGS

A. Wiring: NEMA ICS 18, Class II, Type B, for all starters. Wire labels (identifying circuit) shall be applied to each end of every wire.

B. Control and Load Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

C. Nominal System Voltage: 480Y/277 V, three phase, four wire.

D. Short-Circuit Current Rating of MCC: Fully rated with its main overcurrent device; 65 kA.

E. Environmental Ratings:

1. Ambient Temperature Rating: Not less than 0 deg F and not exceeding 104 deg F, with an average value not exceeding 95 deg F over a 24-hour period.
2. Ambient Storage Temperature Rating: Not less than minus 4 deg F and not exceeding 140 deg F
3. Humidity Rating: Less than 95 percent (noncondensing).
4. Altitude Rating: Not exceeding 6600 feet, or 3300 feet if MCC includes solid-state devices.

F. Main-Bus Continuous Rating: As shown on the drawings.

G. Horizontal and Vertical Bus Bracing (Short-Circuit Current Rating): Match MCC short-circuit current rating.

H. Main Horizontal and Equipment Ground Buses: Uniform capacity for entire length of MCC's main and vertical sections. Provide for future extensions from both ends. Brace bus extensions for busway feeder bus.

I. Vertical Phase and Equipment Ground Buses: Uniform capacity for entire usable height of vertical sections, except for sections incorporating single units.

J. Phase- and Neutral-Bus Material: Tin-plated, high-strength, electrical-grade copper alloy.

K. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.

L. Ground Bus: Minimum size required by UL 845, hard-drawn copper of 98 percent conductivity, equipped with mechanical connectors for feeder and branch-circuit equipment grounding conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

M. Front-Connected, Front-Accessible MCCs:

1. Main Devices: Fixed mounted.
2. Controller Units: fixed mounted.
3. Feeder-Tap Units: fixed mounted.
4. Sections front and rear aligned.

N. Pull Box on Top of MCC:

1. Adequate ventilation to maintain temperature in pull box within same limits as MCC.
2. Set back from front to clear circuit-breaker removal mechanism.
3. Removable covers forming top, front, and sides. Top covers at rear easily removable for drilling and cutting.
4. Insulated bottom of fire-resistive material with separate holes for cable drops into MCC.
5. Cable supports arranged to facilitate cabling and adequate to support cables, including those for future installation.

O. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of unit.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Floor-Mounting Controllers: Install MCCs on 4-inch nominal thickness concrete base. Comply with requirements for concrete base specified in Section 03 30 00 "Cast-in-Place Concrete."

1. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
2. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
3. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

C. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

D. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

E. Comply with NECA 1.

3.2 IDENTIFICATION

A. Comply with requirements in Section 26 05 53 "Identification for Electrical Systems" for identification of MCC, MCC components, and control wiring.

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label MCC and each cubicle with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

3.3 CONTROL WIRING INSTALLATION

A. Install wiring between enclosed controllers and remote devices and facility's central-control system. Comply with requirements in Section 26 05 05 "Conductors."

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control selection devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.
2. Connect selector switches within enclosed controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.4 CONNECTIONS

A. Comply with requirements for installation of conduit in Section 26 05 33 "Raceways and Boxes." Drawings indicate general arrangement of conduit, fittings, and specialties.

B. Comply with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Verify that voltages at controller locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Construction Manager before starting the motor(s).
3. Test each motor for proper phase rotation.
4. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

5. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

C. Enclosed controllers will be considered defective if they do not pass tests and inspections.

D. Prepare inspection reports, including a certified report that identifies enclosed controllers. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

A. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

B. Adjust overload relay heaters or settings if power factor correction capacitors are connected to the load side of the overload relays.

C. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to six times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Construction Manager before increasing settings.

D. Set field-adjustable switches and program microprocessors for required start and stop sequences in reduced-voltage, solid-state controllers.

E. Set field-adjustable circuit-breaker trip ranges as specified in Section 26 05 73.16 "Overcurrent Protective Device Coordination Study."

3.7 DEMONSTRATION

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

3.8 MOTOR DATA

A. Provide typed, self-adhesive label attached inside each motor starter enclosure door displaying the following information:

1. Motor served by tag number and equipment name.
2. Nameplate horsepower.
3. Motor code letter.
4. Full load amperes.

5. Service factor.
6. Installed overload relay heater catalog number.

3.9 MANUFACTURER'S SERVICES

A. Furnish manufacturer's representative in accordance with Section 01 43 33 "Manufacturers' Field Services" for the following services at job site or classroom as designated by Owner, for minimum person-days listed below, travel time excluded:

1. 1/2 person-day for installation assistance, and inspection of installation.
2. 1/2 person-day for functional and performance testing.
3. 1/2 person-day for plant startup.
4. 1/2 person-day for training of Owner's personnel

END OF SECTION

SECTION 26 27 26
WIRING DEVICES

PART 1 – GENERAL

1.01 REFERENCES

A. The following is a list of standards which shall apply by reference to all devices, as appropriate, referenced in this section:

1. ASTM International (ASTM): A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
2. Federal Specifications (FS):
   a. W-C-596, General Specification for Connector, Electrical, Power.
   b. W-S-896F/GEN, Switches, Toggle (Toggle and Lock), Flush Mounted (General Specification).
3. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   b. WD 1, General Requirements for Wiring Devices.
4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
5. Underwriters Laboratories Inc. (UL):
   a. 498, Standard for Attachment Plugs and Receptacles.
   b. 508, Standard for Safety for Industrial Control Equipment.
   c. 943, Standard for Ground-Fault Circuit-Interrupters.
   d. 1449, Standard for Transient Voltage Surge Suppressors.

1.02 SUBMITTALS

A. Action Submittals: Manufacturer's product data for wiring devices.

PART 2 PRODUCTS

2.01 SWITCHES

A. Switch, General Purpose:

1. NEMA WD 1 and FS W-S-896F/GEN.
2. Totally enclosed, ac type, with quiet tumbler switches and screw terminals.
3. Rivetless one-piece brass or copper alloy contact arm with silver alloy contacts.
4. Capable of controlling 100 percent tungsten filament and fluorescent lamp loads.

5. Rating: 20 amps, 120/277 volts.
6. Color: Ivory.
7. Automatic grounding clip and integral grounding terminal on mounting strap.
8. Manufacturers and Products, Industrial Grade:
   a. Bryant; 4801/4901 Series.
   b. Hubbell; 1202/1222Series.
   c. Leviton; 1201/1221 Series.
9. Manufacturers and Products, Commercial Grade:
   a. Bryant; CSB115/CSB120.
   b. Hubbell; CSB I15/CSB I20.
   c. Leviton; CSBI-I5/CSBI-20 Series.

B. Switch, Motor Rated:

1. Type: Two-pole or three-pole, manual motor starting/disconnect switch without overload protection.
2. Enclosure/Mounting and Rating:
   a. General Purpose:
      1) Totally enclosed snap-action switch. Quick-make, slow-break design with silver alloy contacts. UL 508 listed.
      2) General Purpose Rating: 30 amperes, 600V ac.
      3) Minimum Motor Ratings:
         a) 2 hp for 120V ac, single-phase, two-pole.
         b) 3 hp for 240V ac, single-phase, two-pole.
         c) 15 hp for 480V ac, three-phase, three-pole.
      4) Screw-type terminals.
3. Manufacturers:
   a. General Purpose:
      1) Bryant.
      2) Hubbell.

2.02 RECEPTACLES

A. Receptacle, General Purpose:

1. NEMA WD 1 and FS W-C-596.
2. Duplex, two-pole, three-wire grounding type with screw type wire terminals.
3. Impact resistant nylon cover and body.
4. One-piece mounting strap with integral ground contact (rivetless construction).
5. Contact Arrangement: Contact to be made on two sides of each inserted blade without detent.
6. Rating: 125 volts, NEMA WD 1, Configuration 5-20R, 20 amps.
7. Size: For 2-inch by 4-inch outlet boxes.

8. Industrial Grade:
    a. Color: Ivory.
    b. Manufacturers and Products:
        1) Bryant; 5262/5362 Series.
        2) Hubbell; 5262/5362 Series.
        3) Leviton; 5262/5362 Series.
9. Commercial Grade:
    a. Color: Ivory.
    b. Manufacturers and Products:
        1) Bryant; CBRS15/CBRS20 Series.
        2) Leviton; BR15/BR20 Series.

B. Receptacle, Surge Protective

1. Meet requirements of general-purpose receptacles.
2. Color: Ivory.
3. Listed UL 498 receptacles and UL 1449 TVSS.
4. Alarm Light: Red LED with nylon muting screw.
5. Manufacturers and Products:
    a. Bryant; SP52/SP53 Series.
    b. Leviton; 5280/5380 Series.

C. Receptacle, Ground Fault Circuit Interrupter:

1. Meet requirements of general-purpose receptacles.
2. Listed Class A to UL 943, tripping at 5 mA.
3. Color: Ivory.
4. Standard Model: NEMA WD 1, with No. 12 AWG copper USE/RHH/RHW-XLPE insulated pigtails and provisions for testing.
5. Manufacturers:
    a. Bryant.
    b. Hubbell.
    c. Leviton.

D. Receptacle, Corrosion-Resistant.

1. Meet requirements of general-purpose receptacles.
2. Nickel coated metal parts.
3. Color: Yellow.
4. Manufacturer and Product:
    a. Hubbell; 52CM62/53CM62
    b. Leviton; 52CM-62/53CM-62.

E. Receptacle, Special-Purpose:

1. Rating and number of poles as indicated or required for anticipated purpose.
2. One matching plug with cord-grip features for each special-purpose receptacle.

2.03 DEVICE PLATES

A. General: Sectional type plates not permitted.

B. Nylon:

1. Material: Specification grade, 0.10-inch minimum thickness, noncombustible.
2. Color: To match associated wiring device.
3. Mounting Screw: Oval-head metal, color matched to plate.

C. Metal:

1. Material: Specification grade, one-piece, 0.040-inch nominal thickness stainless steel.
2. Finish: ASTM A167, Type 302/304, satin.
3. Mounting Screw: Oval-head, finish matched to plate.

D. Cast Metal:

1. Material: Copper-free aluminum, with gaskets.
2. Screw: Oval-head stainless steel.

E. Sheet Steel:

1. Finish: Zinc electroplate.
2. Screws: Oval-head stainless steel.
3. Manufacturers:
   a. Appleton.
   b. Crouse-Hinds.

F. Engraved:

1. Character Height: 1/8-inch.
2. Filler: Black.

G. Weatherproof:

1. Receptacles, Weatherproof Type 1:
   a. Gasketed, cast-aluminum, with individual cap over each receptacle opening.

b. Mounting Screw and Cap Spring: Stainless steel.
c. Manufacturers and Products:
1) Crouse-Hinds; Type WLRD-1.
2) Appleton; Type FSK-WRD.

2. Receptacles, Weatherproof Type 2:
a. UL listed for WET location while in use.
b. Die cast metal cover.
c. Manufacturers and Products: TayMac; Type Multi-Mac.

3. Switches:
a. Gasketed, cast-metal or cast-aluminum, incorporating external operator for internal switch.
b. Mounting Screw: Stainless steel.
c. Manufacturers and Products:
1) Crouse-Hinds; DS-181 or DS-185.
2) Appleton; FSK-1VTS or FSK-1VS.

H. Raised Sheet Metal: 1/2-inch high zinc- or cadmium-plated steel designed for one-piece drawn type sheet steel boxes.

I. Sheet Steel: Formed sheet steel or Feralloy designed for installation on cast metal boxes.

PART 3 EXECUTION

3.01 SWITCHES

A. Switch, General Purpose:

1. Mounting Height: See Section 26 05 33, Raceways and Boxes.
2. Install with switch operation in vertical position.
3. Install single-pole, two-way switches so toggle is in up position when switch is on.

B. Switch, Motor Rated:
1. Mounting Height: See Section 26 05 33, Raceways and Boxes
2. Install with switch operation in vertical position so toggle is in up position when ON.
3. Install within sight of motor when used as a disconnect switch.

3.02 RECEPTACLES

A. Duplex Receptacles:

1. Install with grounding slot down, except where horizontal mounting is shown, in which case install with neutral slot down.
2. Ground receptacles to boxes with grounding wire only.

3. Weatherproof Receptacles:
   a. Install in cast metal box.
   b. Install such that hinge for protective cover is above receptacle opening.
4. Ground Fault Interrupter: Install feed-through model at locations where ground fault protection is specified for "downstream" conventional receptacles.
5. Special-Purpose Receptacles: Install in accordance with manufacturer's instructions.
6. Commercial grade in office areas, industrial grade in all other areas.

3.03 DEVICE PLATES

A. Securely fasten to wiring device; ensure a tight fit to box.

B. Flush Mounted: Install with all four edges in continuous contact with finished wall surfaces without use of mats or similar materials. Plaster fillings will not be acceptable.

C. Surface Mounted: Plate shall not extend beyond sides of box, unless plates have no sharp corners or edges.

D. Install with alignment tolerance to box of 1/16 inch.

E. Types (Unless Otherwise Shown):

1. Office: Nylon.
2. Exterior:
   a. Switch: Weatherproof.
   b. Receptacle in DAMP location: Weatherproof Type 1.
   c. Receptacle in WET location: Weatherproof Type 2.

F. Interior:

1. Flush Mounted Boxes: Plastic.
2. Surface Mounted, Metal Boxes:
   a. General Purpose Areas: Sheet Steel.
   b. Other Areas: Cast.
3. Surface Mounted, Aluminum Boxes:
   a. General Purpose Areas: Stamped.
   b. Other Areas: Cast.
4. Surface Mounted, Sheet Steel Boxes: Raised sheet steel.
5. Surface Mounted, Nonmetallic Boxes: Manufacturer's standard.
6. Receptacle shown as Weatherproof on Drawings: Weatherproof Type 1.

END OF SECTION

SECTION 26 28 16
ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Safety switches.
2. Enclosures.

1.2 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Current and voltage ratings.
3. Short-circuit current ratings (interrupting and withstand, as appropriate).
4. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
5. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

B. Shop Drawings: For enclosed switches and circuit breakers.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.

2. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

1.5 MAINTENANCE MATERIAL SUBMITTALS

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

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Fuse Pullers: Two for each size and type.

1.6 QUALITY ASSURANCE

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.

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. Comply with NFPA 70.

1.7 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet.

1.8 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 SAFETY SWITCHES

A. Manufacturer:

1. Eaton Electrical Sector.

2. General Electric Company.
3. Siemens Industry, Inc.
4. Square D; By Schneider Electric.

B. Type HD, Heavy-Duty, Single-Throw Fusible Switch: 600-V ac, 60 A; UL 98 and NEMA KS 1; horsepower rated, with clips or bolt pads to accommodate indicated fuses; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

C. Type HD, Heavy-Duty, Single-Throw Nonfusible Switch: 600-V ac, 60 A; UL 98 and NEMA KS 1; horsepower rated, lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

2.2 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Locations: NEMA 250, Type 3R.
3. Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
6. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

B. Comply with mounting and anchoring requirements for local seismic zone.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in fusible devices.

E. Comply with NECA 1.

3.3 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized representative to inspect components, assemblies, and equipment installations, including connections.

B. Tests and Inspections:

1. Perform each visual and mechanical inspections stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

C. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

D. Prepare inspection report that identifies enclosed switches and circuit breakers. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 26 05 73.16 "Overcurrent Protective Device Coordination Study."

END OF SECTION

SECTION 26 28 17
FUSES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Types of fuses specified, including:

1. Class L time-delay.
2. Class RK1 time-delay.

1.02 SUBMITTALS

A. Shop Drawings: Submit in accordance with Section 01 33 00, Shop Drawings covering the items included under this Section. Shop Drawing submittals shall include:

1. Product Data: Submit manufacturer's technical product data on fuses, including specifications, electrical characteristics, installation instructions, furnished specialties, and accessories. In addition, include voltages and current ratings, interrupting ratings, current limitation ratings, time-current trip characteristics curves, and mounting requirements.

1.03 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of equipment, of types and sizes required, and whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. UL Compliance and Labeling: Comply with applicable provisions of UL 198D, "High-Interrupting Capacity Class K Fuses." Provide overcurrent protective devices which are UL listed and labeled.

2. ANSI Compliance: Comply with applicable requirements of ANSI C97.1, "Low-Voltage Cartridge Fuses 600 Volts or Less."

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with specified requirements, manufacturers offering fusable devices which may be incorporated in Work include:

1. Bussmann Division, Cooper Industries.
2. Edison Fuse, Inc
3. Littelfuse, Inc.
4. Shawmut Division, Gould, Inc.

2.02 FUSES

A. Except as otherwise indicated, provide fuses of types, sizes, ratings, and average time-current and peak let-through current characteristics indicated, which comply with manufacturer's standard design, materials, and constructed in accordance with published product information, and with industry standards and configurations.

B. Class L Time-Delay Fuses: UL Class L time-delay fuses rated 600 volts, 60 Hertz, 800 amperes, with 200,000 rms symmetrical interrupting current rating for protecting transformers, motors, circuit breakers.

C. Class RK1 Time-Delay Fuses: UL Class RK1 dual element time-delay fuses rated 600 volts, 60 Hertz, 400 amperes, with 200,000 rms symmetrical interrupting current rating for protecting motors and circuit breakers.

2.03 EXTRA MATERIAL

A. Spare Fuses: For the types and ratings required, furnish additional fuses, amounting to 1 unit for every 10 installed units, but not less than 1 set of 3 of each kind.

PART 3 EXECUTION

3.01 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems" and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block and holder.

END OF SECTION

SECTION 26 29 23
LOW VOLTAGE VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes separately enclosed, preassembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

1.2 DEFINITIONS

A. CE: Conformité Européene (European Compliance).

B. CPT: Control power transformer.

C. DDC: Direct digital control.

D. EMI: Electromagnetic interference.

E. OCPD: Overcurrent protective device.

F. PID: Control action, proportional plus integral plus derivative.

G. RFI: Radio-frequency interference.

H. VFC: Variable-frequency motor controller.

1.3 ACTION SUBMITTALS

A. Product Data: For each type and rating of VFC indicated.

B. Shop Drawings: For each VFC indicated.

1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Seismic Qualification Certificates: For each VFC, accessories, and components, from manufacturer.

1. Certificate of compliance.

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.

C. Product certificates.

D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. ABB Group

B. Eaton Electrical Sector; Eaton Corporation

C. General Electric Co.

D. Rockwell Automation, Inc.

E. Schneider Electric USA, Inc.

F. Siemens Industry, Inc.

G. Toshiba

2.2 SYSTEM DESCRIPTION

A. General Requirements for VFCs:

1. VFCs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508A.

B. Application: Variable torque.

C. VFC Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.

1. Units suitable for operation of NEMA MG 1 motors.

2. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

D. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

E. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.

F. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFC input voltage rating.

2. Input AC Voltage Unbalance: Not exceeding 5 percent.

3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.

4. Minimum Efficiency: 97 percent at 60 Hz, full load.

5. Minimum Displacement Primary-Side Power Factor: 98 percent under any load or speed condition.

6. Minimum Short-Circuit Current (Withstand) Rating: 65 kA.

7. Ambient Temperature Rating: Not less than 32 deg F and not exceeding 104 deg F.

8. Humidity Rating: Less than 95 percent (noncondensing).

9. Altitude Rating: Not exceeding 3300 feet.

10. Vibration Withstand: Comply with NEMA ICS 61800-2.

11. Overload Capability: 1.5 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.

12. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.

13. Speed Regulation: Plus or minus 5 percent.

14. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.

15. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.

G. Inverter Logic: Microprocessor based, 32 bit, isolated from all power circuits.

H. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.

1. Signal: Electrical.

I. Internal Adjustability Capabilities:

1. Minimum Speed: 5 to 25 percent of maximum rpm.

2. Maximum Speed: 80 to 100 percent of maximum rpm.

3. Acceleration: 0.1 to 999.9 seconds.

4. Deceleration: 0.1 to 999.9 seconds.

5. Current Limit: 30 to minimum of 150 percent of maximum rating.

J. Self-Protection and Reliability Features:

1. Surge Suppression: Factory installed as an integral part of the VFC, complying with UL 1449 SPD, Type 1 or Type 2.

2. Surge Suppression: Field-mounted surge suppressors complying with Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits," UL 1449 SPD, Type 2.

3. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.

4. Under- and overvoltage trips.

5. Inverter overcurrent trips.

6. VFC and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor-overload alarm and trip; settings selectable via the keypad.

7. Critical frequency rejection, with three selectable, adjustable deadbands.

8. Instantaneous line-to-line and line-to-ground overcurrent trips.

9. Loss-of-phase protection.

10. Reverse-phase protection.

11. Short-circuit protection.

12. Motor-overtemperature fault.

K. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

L. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.

M. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

N. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

O. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

P. Integral Input Disconnecting Means and OCPD: UL 489, instantaneous-trip circuit breaker with pad-lockable, door-mounted handle mechanism.

1. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.

2. Auxiliary Contacts: NO or NC, arranged to activate before switch blades open.

3. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.

2.3 CONTROLS AND INDICATION

A. Status Lights: Door-mounted LED indicators displaying the following conditions:

1. Power on.

2. Run.

3. Overvoltage.

4. Line fault.

5. Overcurrent.

6. External fault.

B. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.

2. Security Access: Provide electronic security access to controls through identification and password with at least one level of access: View only; view and operate; and view, operate, and service.

a. Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.

C. Historical Logging Information and Displays:

1. Real-time clock with current time and date.

2. Running log of total power versus time.

3. Total run time.

4. Fault log, maintaining last four faults with time and date stamp for each.

D. Indicating Devices: Digital display and additional readout devices as required, mounted flush in VFC door and connected to display VFC parameters including, but not limited to:

1. Output frequency (Hz).

2. Motor speed (rpm).

3. Motor status (running, stop, fault).

4. Motor current (amperes).

5. Motor torque (percent).

6. Fault or alarming status (code).

7. PID feedback signal (percent).

8. DC-link voltage (V dc).

9. Set point frequency (Hz).

10. Motor output voltage (V ac).

E. Control Signal Interfaces:

1. Electric Input Signal Interface:

a. A minimum of two programmable analog inputs: 4- to 20-mA dc.
b. A minimum of six multifunction programmable digital inputs.

2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the DDC system for HVAC or other control systems:

a. 0- to 10-V dc.
b. 4- to 20-mA dc.
c. Potentiometer using up/down digital inputs.
d. Fixed frequencies using digital inputs.

3. Output Signal Interface: A minimum of three programmable analog output signal(s) (4- to 20-mA dc), which can be configured for any of the following:

a. Output frequency (Hz).
b. Output current (load).
c. DC-link voltage (V dc).
d. Motor torque (percent).
e. Motor speed (rpm).
f. Set point frequency (Hz).

2.4 OPTIONAL FEATURES

A. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting to the SCADA Modbus network.

2.5 ENCLOSURES

A. VFC Enclosures: NEMA 250, to comply with environmental conditions at installed location.

1. Dry and Clean Indoor Locations: Type 1.

2. Outdoor Locations: Type 3R.

3. Wash-Down Areas: Type 4X, stainless steel.

4. Other Wet or Damp Indoor Locations: Type 4.

5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFC as "Plenum Rated."

2.6 ACCESSORIES

A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFC enclosure cover unless otherwise indicated.

1. Push Buttons: Unguarded.

2. Pilot Lights: Push to test.

3. Selector Switches: Rotary type.

B. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

C. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.

1. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.

D. Supplemental Digital Meters:

1. Elapsed-time meter.

2. Kilowatt meter.

3. Kilowatt-hour meter.

E. Breather and drain assemblies, to maintain interior pressure and release condensation in NEMA 250, Type 4X enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

F. Space heaters, with NC auxiliary contacts, to mitigate condensation in NEMA 250, Type 3R enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

G. Cooling Fan and Exhaust System: For NEMA 250, Type 12; UL 508 component recognized: Supply fan, with stainless-steel intake and exhaust grills and filters; 120V ac; obtained from integral CPT.

H. Spare parts: provide manufacturers recommended spare parts kit for two years of service.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Wall-Mounting Controllers: Install with tops at uniform height and with disconnect operating handles not higher than 72 inches above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 26 05 29 "Hangers and Supports for Electrical Systems."

B. Roof-Mounting Controllers: Install VFC on roofs with tops at uniform height and with disconnect operating handles not higher than 60 inches above finished roof surface unless otherwise indicated, and by bolting units to curbs or mounting on freestanding, lightweight, structural-steel channels bolted to curbs. Seal roof penetrations after raceways are installed.

C. Install fuses in control circuits if not factory installed.

D. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors are installed.

E. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

3.2 CONTROL WIRING INSTALLATION

A. Install wiring between VFCs and remote devices and facility's central-control system. Comply with requirements in Section 26 05 05 "Conductors."

B. Bundle, train, and support wiring in enclosures.

3.3 IDENTIFICATION

A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.

2. Label each VFC with engraved nameplate.

3. Label each enclosure-mounted control and pilot device.

3.4 FIELD QUALITY CONTROL

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

B. Tests and Inspections:

1. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.

2. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify ENGINEER before starting the motor(s).

3. Test each motor for proper phase rotation.

4. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

5. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

C. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.5 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

C. Adjust the trip settings of instantaneous-only circuit breakers and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to 6 times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed 8 times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify ENGINEER before increasing settings.

D. Set the taps on reduced-voltage autotransformer controllers.

E. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Overcurrent Protective Device Coordination Study."

F. Set field-adjustable pressure switches.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFCs.

END OF SECTION

SECTION 26 29 23.11
MEDIUM VOLTAGE VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - INTRODUCTION

1.1 SUMMARY

A. The purpose of this document is to provide a specification for the design, fabrication, inspection, testing and shipment of 4160 volt AC, three-phase input, 60 Hertz, adjustable speed drives (ASD's) that will result in a long design life with very low maintenance requirements

B. Section includes separately enclosed, preassembled, combination ASDs, rated 2300/4160 volt AC, three-phase, 60 Hertz, squirrel-cage induction motors.

C. The ASD shall consist of the following components:

1. Incoming Disconnect
2. Isolation transformers (if required). Contractor shall markup design drawings indicating location, conduit runs, and wiring for engineers review.
3. Multi-secondary 24 Pulse Isolation Transformer with Rectifier
4. Frequency Converter/Inverter
5. ASD Protective System/Devices
6. Output filter or reactor (when required to limit reflected voltage)
7. Output Disconnect(s) or bypass (when specified on Data Sheet)
8. Diagnostics and Control Circuits

D. The ASD assembly shall be designed and constructed to allow listing by Underwriters Laboratory (UL and/or cUL).

E. This Specification does not include the requirements for the motor. More consideration will be given to a bidder that manufactures and guarantees both the motor and ASD.

1.2 DEFINITIONS

A. ASD: Adjustable Speed Drive – Also called variable speed drive (VSD), variable frequency drive (VFD), or adjustable frequency drive (AFD) is a device that used to vary the speed of a previously fixed speed motor.

B. NPC: Neutral Point Clamp – is an ASD topology that has the advantage of reducing the high line to neutral voltage that can occur in other traditional drive designs that can reach 2.7 to 3.3 times normal levels.

C. PWM: Pulse Width Modulation – is a method of controlling power devices to convert voltage levels. PWM is a popular method of control for converting DC voltage to AC voltage.

D. IGBT: Insulated Gate Bipolar Transistor – is a high speed electrical switching power device. It is very efficient requiring very low power for control circuits.

E. HCT: Hall effect Current Transformer – is used for current detection of DC to high frequency without direct contact or shunts.

F. CPT: Control Power Transformer – is typically used to power control circuits and relays for the ASD.

G. LCD: Liquid Crystal Display – is a device used for display of alpha-numeric or graphical characters. It is used in the operator interface ASD.

H. FLA: Full Load Amps. ASD

1.3 ACTION SUBMITTALS

A. Product Data: For each type and rating of ASD indicated.

B. Shop Drawings: For each ASD indicated.

1. Electrical one-line diagrams.
2. Interconnection diagrams among ASD equipment components and between ASD equipment and plant SCADA system.
3. Electrical floor plans drawn to scale showing conduit and wire sizes.
4. Preliminary harmonic analysis.
5. Record of calculations for ASD efficiencies at 50, 75, and 100 percent speed. The system efficiency shall include power losses from the cooling system, controls, isolation transformers, line reactors, and filters.
6. Maximum continuous current and fault current withstand ratings.
7. Complete outline description of proposed factory test procedure and sketch of test setup.
8. Harmonic analysis and results.
9. Certification that motor insulation shall operate continuously from the ASD output waveform throughout the specified speed range without overheating.
10. Complete system rating, including all nameplate data, continuous operation load capability throughout speed range of 10 percent to 100 percent rated speed.
11. Complete unit lineup dimensional drawings, weight, and information on size and location of space for incoming and outgoing power and control cables or conduit.

12. Maximum heat dissipation from enclosure, exhaust air flow requirements, location and dimensions of exhaust duct interface opening(s). Include assessment of existing HVAC capacity for proposed equipment.
13. Layout of controller section face showing pushbuttons, switches, instruments, indicating lights, HMI display unit, etc.
14. Complete system operating description.
15. Complete system schematic (elementary) wiring diagrams, single and three line diagrams.
16. Description of diagnostic features being provided.
17. Descriptive literature for all control devices such as relays, timers, etc.
18. Itemized bill-of-materials listing all system components.
19. Description of programmable logic controller (PLC) communications with tag and table information, human-machine interface (HMI), vibration monitoring panel, and motor protection device being furnished, including a description of the equipment, installation, setup (indicating configuration settings), and operations manuals.
20. Annotated and cross-referenced PLC and HMI program printout.
21. Field performance acceptance test plans reviewed by Owner prior to testing.
22. Training documentation.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Product certificates.

C. Field quality-control reports. Provide copies of the factory testing. Reports shall be stamped and signed by a professional electrical engineer licensed in the USA.

D. Harmonic performance verification report.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Record documents showing the Work as constructed both in 22-inch by 34-inch sheets and on electronic media.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member Company of NETA or an NRTL.

B. The complete pump system (ASD and Motor) shall provide a power factor greater than 90%. Manufacturer is required to provide power correction capacitors (not shown on the drawings) if power factor for standard system is below 90%.

C. The ASD manufacturer shall provide line and/or load side filters (not shown on drawings) when required to protect the ASD and motor.

D. American National Standards Institute/National Fire Protection Association (ANSI/NFPA): 70, National Electrical Code (NEC).

E. Institute of Electrical and Electronics Engineers (IEEE): 519, Recommended Practice and Requirements for Harmonic Control in Electrical Power Systems.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace ASDs that fail in materials or workmanship within specified warranty period.

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. ABB.
2. General Electric.
3. Rockwell Automation.
4. Toshiba.

2.2 SYSTEM DESCRIPTION

A. General Requirements for ASDs:

1. ASDs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 347.
3. The ASD inverter/chopper shall be of the pulse width modulated (PWM) Neutral Point Clamp (NPC) type. The output devices shall be Insulated Gate Bipolar Transistors (IGBT's) with a voltage rating of 3300V using a nominal 1600V DC bus. Use of lower rated devices is unacceptable due to the quantity of devices required in the design.
4. This specification covers an ASD driving a single motor.
5. This specification does not cover the motor(s) to be driven by the ASD. Motor data is to be specified in part 4 of this Section.
6. When indicated on the Data Sheet, the ASD shall be mounted within a 2300 / 4160-volt motor control center (MCC) or switchgear lineup or as a stand-alone component. The MCC or switchgear requirements will be

covered by a separate specification and the ASD will be listed as a component of the MCC or switchgear.

7. All components and material shall be new and of the latest field-proven design and in current production. Obsolete components or components scheduled for immediate discontinuation shall not be used.
8. The equipment shall be completely factory-built, assembled, wired, and tested. When it is necessary to disassemble the units for ease of transportation, adequate materials and instructions shall be provided for easy field reassembling where all wiring and interconnections are supplied.

B. Application: Variable torque

C. ASD Description: Variable-frequency motor controller, consisting of frequency converter/inverter, factory built and tested in an enclosure, with incoming and output disconnects or bypass (when specified on Data Sheet) and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.

1. Units suitable for operation of NEMA MG 1 motors.
2. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

D. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

E. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.

F. Power Requirements:

1. The ASD shall be capable of providing rated output for continuous voltage deviations of +10%.
2. The ASD shall be able to ride through voltage dips down to 67% of nominal, such as those experienced during motor starting.
3. The ASD shall be able to return to normal operation following an incoming power disturbance that falls within the range determined by Figure 3-2 in IEEE 1100.
4. The ASD shall be capable of 100% rated current in continuous operation, in accordance with the requirements of NEC Table 430-150.
5. The ASD one-minute overload current rating shall be 115% of rated current for variable torque applications..
6. The ASD one-minute overload current rating shall be 150% of rated current for constant torque applications when indicated on the Data Sheet.

7. The ASD output voltage shall not cause insulation stress to the motor or exceed the peak voltage insulation level of the motor. Output filters to meet this specification if required shall be integral to the drive cabinet.
8. The ASD shall comply with the latest revision of IEEE 519 for total harmonic current and voltage distortion measurement and calculation. Voltage distortion shall not exceed 3% and current distortion shall not exceed 5% while operating from the utility line. Individual current harmonics shall not exceed the requirements of IEEE 519.
9. The ASD converter section shall be configured as a 24 pulse or greater to eliminate the need for harmonic filters.

G. Power Bus

1. All power bus bars, when part of the standard design, and other current carrying parts shall be tin-plated copper for corrosion resistance. Power bus bar joints shall be tin plated.
2. Bus bars shall be braced to withstand short circuit currents shown on the Data Sheet with a minimum of 50KAIC.
3. Input and output connections shall be either top or bottom access in the standard design.

H. Inverter Section Design:

1. The ASD inverter section shall consist of three cells where each cell has two series DC power supplies per phase. Each DC supply is derived from a phase shifted secondary of the input transformer that cancels reflected harmonics back to the power line. The DC power supply is filtered by long lasting oil filled capacitors. Electrolytic capacitors are not allowed.
2. Each cell has eight 3300V Insulated Gate Bipolar Transistors (IGBT's) in a single phase bridge connection such that when in combination with the other bridges, a 5 level output voltage is constructed to the motor. A bridge neutral point is jumpered to each of the three cells. This configuration called Neutral Point Clamp (NPC) provides a normal phase to ground level voltages that are superior to other direct PWM or multi-level twelve cell ASD designs that can cause 1.8 to 3.3 times normal line to ground voltage.
3. Each power device communicates to the microprocessor with fiber optic communications. No other isolation method is allowed.
4. A high resistance ground detection circuit at the neutral point is used for alarm or warning in the event the load has a ground fault.
5. Two Hall Effect Current Transformers (HCT) are used for current feedback on the ASD output.
6. An optional output filter consisting of inductors, resistors, and oil filled capacitors may be installed inside the standard enclosure when required for the application. Manufacturer shall review application and installation to determine if output filters are required.

7. PWM firing pulses will result in an output voltage and current waveform that will result in less than 2% torque ripple over a 20 to 1 speed range on the motor.

I. Operational Controls:

1. The ASD shall include the following basic operating adjustments:
   a. Acceleration Time
   b. Deceleration time
   c. Current Limit
   d. Minimum frequency or speed
   e. Maximum frequency or speed
   f. Selectable skip frequencies
   g. Sensor-less Vector parameter settings
   h. Local/Remote selection

2. The ASD shall include necessary components to protect the ASD and motor against motor overload, internal faults in either the motor or ASD and disturbances in the incoming AC line. The following conditions shall cause the ASD to be shut down with the output voltage reduced to zero. The failure shall be annunciated on the operator panel's LCD display.
   a. Instantaneous overcurrent - ASD or motor
   b. Motor overload
   c. Undervoltage or overvoltage on the incoming AC line
   d. Single-phasing of the AC incoming line
   e. Overtemperature of the ASD electronics from a component or ventilation failure
   f. Gate driver power supply or control power supply undervoltage
   g. ASD output open circuit during operation
   h. Overvoltage or ground fault of the ASD output
   i. Cause of individual power cell fault
   j. Motor overspeed
3. The ASD shall return the motor to operating speed upon restoration of power following a voltage interruption on the AC incoming line.
4. A door-mounted drive LCD keypad will be standard for operator interface. Along with this keypad, the Manufacturer will provide a software tool with operational, maintenance and diagnostic features. Using an IBM compatible PC, this software shall permit the programming of parameters, display block diagrams, show bar graphs, report adjustment data, display trends, provide troubleshooting using first fault data/trace back data/trouble record, and contain the Operation and Maintenance Manual.

J. Input Power Transformer and Rectifier:

1. The ASD shall contain an incoming isolation transformer whose primary voltage shall be as specified on the Data Sheet
2. The transformer shall contain 12 three phase secondary windings that provide the proper phase shifting to develop a 24-pulse rectification to reduce harmonic currents and voltages reflected to the primary power system.
3. The transformer shall be copper wound and shall have a 220°C insulation system to operate at 115° C rise at full load conditions.
4. The transformer and rectifier shall be an integral part of the ASD assembly along with primary disconnect switch, input vacuum contactor and secondary fusing eliminating the need for separate components field installation or wiring.
5. Soft charge of the DC bus capacitors is accomplished by use of an input reactor on the primary of the input transformer. A vacuum contactor rated for drive full load amps will short the reactor after charge is accomplished.

K. Control Power Transformers (CPTs):

1. A control power transformer (CPT) shall be provided within the enclosure. The CPT primary shall be taken from the drive main power.
2. The kilovolt-ampere rating of the CPT shall be determined by the Manufacturer and shall have a minimum of 25% spare capacity.
3. The CPT secondary voltage shall be 120 VAC.
4. The CPT primary shall be fused with current limiting fuses with an interrupting rating no less than 100,000 amperes.
5. The CPT secondary shall be fused and have one terminal grounded.

L. Motor Space Heater:

1. Circuits shall be provided and sized to coordinate with motor manufacturer. Drawings indicate 120VAC, ASD manufacturer will be required to redesign heater circuit if motor manufacturer supplies 480VAC heaters.
2. Local heater circuit disconnect shall be provided and installed by electrical Contractor.
3. Heater power will be obtained from the primary 2300 / 4160V power through a tap on an internal transformer.

M. Disconnects:

1. The ASD shall include a main disconnect device with an interlocked and padlockable handle mechanism. The disconnecting device shall be a medium voltage vacuum contactor with a bolted pressure disconnect switch whose blades are externally visible from outside the enclosure. The disconnect device shall have a momentary withstand rating greater than the available fault current indicated on the Data Sheet.

2. When multiple doors are supplied, all doors shall be electrically interlocked with the disconnect device. The interlocks shall include provisions to manually override for test and repair.
3. When specified on the Data Sheet, the ASD shall include an output disconnect.
4. ASD shall include a bypass feature. A "maintenance bypass" shall allow servicing of the ASD components while the motor is operating at fixed speed.

N. Vibration Monitoring:

1. See Section 26 19 00 – "Medium Voltage Induction Motors" for vibration monitoring equipment.

O. ASD Protective/Metering Features and Circuits:

1. The ASD system shall include the following protective features:
   a. Fault information shall be accessible through the Electronic Operator Interface.
   b. The ASD shall have the following minimum line side protective features:
      1) Line current unbalance trip with programmable delay.
      2) Line overcurrent trip with programmable delay.
      3) Line overload warning and trip with programmable delay.
      4) Line overvoltage trip with programmable delay.
      5) Line undervoltage trip with programmable delay.
      6) Line voltage unbalance trip with programmable delay.
      7) Ground fault overvoltage trip with programmable delay.
      8) Ground fault overcurrent trip with programmable delay.
   c. The ASD shall have the following minimum system level protective features:
      1) DC overcurrent trip with programmable delay.
      2) DC overvoltage trip with programmable delay.
      3) Rectifier heatsink temperature warning and trip.
      4) Cabinet temperature warning and trip.
      5) Inverter heatsink temperature warning and trip.
      6) Control power warning and fault.
      7) Adapter (communication port) loss warning and fault.
   d. The ASD shall have the following minimum load side protective features:
      1) Ground fault overvoltage trip with programmable delay.
      2) Ground fault overcurrent trip with programmable delay.
      3) Machine side dc link overvoltage trip with programmable delay.
      4) Motor overcurrent trip with programmable delay.
      5) Motor overload warning and trip with programmable delay.
      6) Motor overvoltage trip with programmable delay.

7) Motor stall delay.
8) Motor overspeed trip with programmable delay.
9) Motor flux unbalance trip with programmable delay.
10) Motor current unbalance trip with programmable delay.
11) Load loss level, speed and programmable delay.

e. The ASD shall be capable of transient operation with a line voltage dip of 15 percent of normal operating voltage on a variable torque load. During line dip, the ASD shall automatically provide a speed droop limiting maximum capable speed for the duration of the input voltage dip.

2. The power circuit design shall be such that the following fault conditions can occur without damage to the power circuit components:
   a. Single phase fault or three phase short circuit on ASD output terminals.
   b. Loss of three-phase input power due to opening of ASD input disconnect device or utility power failure during ASD operation.
   c. Loss of one phase of input power.
3. The ASD shall provide a display for monitoring electrical power consumption parameters for the load including watts, vars, current, voltage, power factor watt-hours, and rpm.
4. Metering shall include GE Multilin's "469 SR Motor Management Relay" or Engineer approved equal.

P. Communications:

1. The ASD shall be equipped to communicate using native protocols consistent with that commonly provided by the ASD manufacturer. Communications for monitoring with Station PLC control system shall be via Modbus. Communications for control with Station PLC control system shall be via hardwired I/O.

Q. Operating Conditions:

1. Total harmonic distortion with filtration shall be not more than five percent for voltage and as listed in Table 1 below for current as measured on the 4,160V switchgear serving the input of the ASD in accordance with IEEE 519. Harmonic distortion shall also be calculated and measured when two ASDs are operating at full load.

Table 1

Individual Harmonic Order (Odd Harmonics)	**Harmonic Current Distortion Percent of Max. Demand Load Current I_L**
h < 11	4.0
11 < h < 17	2.0

Table 1	
Individual Harmonic Order (Odd Harmonics)	**Harmonic Current Distortion Percent of Max. Demand Load Current I_L**
17 < h < 23	1.5
23 < h < 35	0.6
35 < h	0.3
Total demand distortion (TDD)	5.0

a. The point of common coupling for all harmonic calculations and factory and field measurements for both voltage and current distortion shall be defined as switchgear, which is the 5-kV switchgear that feeds each ASD.

b. The short circuit current at point of common coupling under utility operation shall be determined by Contractor. This value shall be used in the harmonic calculations.

c. The Contractor shall provide input and/or output harmonic filters as required to meet the above performance requirements and is responsible for the design and manufacturing of the filters.

d. A preliminary harmonic analysis shall be submitted which includes all voltage and current harmonics up to the 49th calculated with both ASDs operating at full load rating.

e. Compliance will be verified with onsite field measurements of both the voltage and current harmonic distortion at the defined point of common coupling with (to measure the harmonic contribution of the ASDs) and without (to measure the background harmonics) the ASDs operating.

f. The ASD shall not produce harmonics within the operating speed range that will excite the motor resulting in excessive vibration.

2. The ASD shall at no time experience any overcurrent during startup and at any time while operating.

3. The ASD output shall produce no electrically induced pulsating torques to the output shaft of the mechanical system, eliminating the possibility of exciting a resonance caused by ASD-induced torque pulsations. The ASD shall not cause micro-pitting of the motor shaft.

2.3 OPERATOR PANEL, INSTRUMENTS, METERS, DISPLAYS, AND INDICATING LIGHTS

A. Each drive shall have two user interfaces (in addition to the communication ports) as standard:

1. Electronic Operator Interface – A 90 X 280 Graphical Backlit LCD display with the ability to display multiple parameters on one screen. The

EOI provides complete operating, monitoring, and programming functionality. The EOI is capable of operation from external power source and firmware operating system is flash upgradeable and may be customized for special applications. A Real Time Clock shall be provided standard with the EOI that provides complete data logging in the event of a fault.

2. Terminal Board Interface – provides complete operation functionality. Standard terminal board interface provides eight digital inputs, six digital outputs, two analog inputs, and three analog outputs, and one pulse output. Inputs and outputs are independently configurable for both scaling and functionality.
3. The drive shall retain the ability to function with no attached interface.

B. A selector switch shall be installed near the Operator Interface to select the reference speed used by the drive. While in hand; the door mounted speed potentiometer will set the speed, while in remote; the PLC will set the speed.

C. The EOI shall provide a convenient method of programming, operating, and monitoring the drive. Utilizing an expanding tree topology, the parameters shall be grouped in a logical manner allowing rapid access to all parameters. All parameters are displayed in an easily understandable format using plain English for all items.

D. A 90 X 280 graphical display allows groupings of multiple, logically associated parameters to be displayed on a single screen.

E. Back lighting and adjustable contrast shall be provided to allow the EOI to be configured for a wide range of ambient lighting.

F. EOI functionality and access shall be limited and password protected preventing an unauthorized user from accessing parameters, functions, or monitoring.

G. The operator panel shall be used to read and write parameter data, to present operational information, to produce first fault and device indication, to show alarms, and to exhibit metering of parameters.

H. Additional metering and indication shall be supplied in accordance with the Data Sheet.

I. Output speed indication shall be in percent or hertz unless otherwise specified on the Data Sheet.

J. Meters, displays, and keyboards shall be accessible and visible from the front without opening the enclosure.

K. Indicating lights on the EOI shall be LED type.

L. Fault log data storage memory shall be powered from a rechargeable source furnished with the ASD and with at least a 6-day capability or shall be nonvolatile EEPROM memory.

2.4 INPUT AND OUTPUT CONTROLS AND ALARMS:

1. External controls and signals shall be furnished by the Manufacturer.
   a. Start
   b. Stop
   c. Speed Command
   d. Speed Feedback
   e. Two Remote Emergence Stop Pushbuttons
   f. Eight Temperature Elements
   g. Six Vibration Elements
   h. Remote Discharge Pressure Switch
   i. Remote Discharge Valve Open
   j. Remote Discharge Valve Close
   k. Remote Discharge Valve Transition
   l. The Manufacturer shall furnish external alarms and signals.
   m. Running
   n. Fault
   o. In remote
   p. MCR-1 Satisfied
   q. Hand Switch in Inverter
   r. Hand Switch in Bypass
   s. High Motor Temperature
   t. High Pump Temperature
   u. High Vibration
   v. Sequence Fail
   w. Control Valve Open
   x. Control Valve Closed
2. The drive shall include a common alarm contact that will be closed during normal operation and will open on ASD fault conditions. In addition, the drive shall provide one normally open and one normally closed contact to indicate motor run status. Contacts shall be rated 5A at 230 VAC and 24 VDC. When specified on the Data Sheet or on the drawings, additional diagnostic contacts shall be provided. The contacts can alarm the following faults:
   a. Input Contactor Failure
   b. Ventilation Fan Malfunction
   c. Control Power Loss
   d. CPU Failure
   e. DC Bus Overvoltage or Undervoltage
   f. Blown Fuse
   g. Open Cabinet Door
   h. Gate Power Loss

i. Drive Cooling Fan Failure
j. Motor Overtemperature
k. Transformer Overtemperature
l. Motor Overspeed
m. PCB Failure
n. Data Network Failure
o. Individual Cell Fault

3. ASD and motor failure alarms shall normally latch in the trip mode and shall require an operator intervention to reset the alarms. An exception to this requirement are overvoltage, undervoltage or voltage failure alarms. These alarms shall automatically reset and allow the operator to manually restart the pump after an adjustable 0- to 60-minute delay period after the alarm occurs and resets. If the alarm condition still exists, the pump shall not restart.
4. The ASD shall provide two (2) analog input and (6) analog output voltage or current signals programmable for versatile functions.
5. The ASD source voltage for external "Start Stop" circuit logic shall be 120 VAC, derived from either the CPT or another remote source.

2.5 ENCLOSURES

A. ASD Enclosures and Cooling:

1. The ASD enclosure shall be as specified on the Data Sheet, suitable for installation in an indoor, unclassified area.
2. All enclosure openings exceeding 0.25 inch (6 mm) in, width shall be provided with screens to prevent the entrance of snakes, rodents, etc. The maximum screen mesh opening width shall be 0.25 inch (6 mm).
3. A “loss of cooling” fault shutdown shall be furnished with forced-cooled equipment. In the event of clogged filters or fan failure, the drive will shut down safely without electronic component failure. Optional redundant fans when specified on the data sheet will be available in the drive design as backup in the event of fan failure.
4. Air filters shall be of a reusable type that can be easily cleaned. All doors or front panels will be fully gasketed. Air exhaust from cooling fans will be at the top of the enclosure away from personnel in front of the equipment.
5. Fan motors shall be protected by an input circuit breaker. Metal squirrel cage ball bearing 460V three phase fan motors with 10-year design life are to be used in the drive design. Plastic muffin fans are not acceptable. Fan power will be obtained from the primary 2300 / 4160V power through a tap on the drive internal input transformer.
6. Air-conditioned enclosures are acceptable.
7. The maximum noise level of the unit shall not exceed 80 dBA at a distance of 1 meter from the unit and at a height of 1.5 meters from the floor.

B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying ASD as "Plenum Rated." Drive Cabinet Space Heaters:

1. When specified on the Data Sheet, space heaters shall be supplied.
2. The space heater circuit shall turn on when the drive is not operating. Thermostatic control cannot determine the dew point.
3. A fused switch or circuit breaker for space heater circuit shall be provided for overload protection and as a disconnecting means.
4. When specified on the Data Sheet, a meter and a test circuit shall be provided on the enclosure door for indication that space heater power is available.
5. Space heaters elements shall be rated 240 VAC and operated at 120 VAC, single-phase.

C. Painting:

1. Use Manufacturer's standard finish unless otherwise shown on the Data Sheet.

D. Pilot Lights:

1. Push to test.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

B. Install fuses in each fusible-switch ASD.

C. Install fuses in control circuits if not factory installed. Comply with requirements in Section 26 28 13 "Fuses."

D. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

E. Comply with NECA 1.

3.2 WIRING AND TERMINATIONS

A. Bus bar with standard four-hole pattern to be supplied for input and output shall be provided for connection of external wiring and shall be conveniently located, clearly numbered, and identified.

B. Control wire terminal blocks for external wiring terminations shall be compression screw type, designed to accommodate stripped insulation bare wire ends, and shall accept a minimum of two No. 14 AWG wires.

C. Connection points for inputs and outputs of different voltage levels shall be segregated to reduce possibility of electrical noise. If necessary, this may be accomplished through the use of terminal barriers and covers.

D. Where wiring is run through sheet metal or any barrier, bushings, grommets or other mechanical protection around the sheet or barrier opening shall be provided.

E. All internal wiring shall be terminated with no more than two (2) conductors per terminal block point.

F. The ASD shall have an internal mechanical ground connection suitable for terminating a stranded copper ground conductor of the same size as the incoming phase conductors. Ground connections shall be near the incoming and outgoing power cable termination points and control wiring connections.

G. Bus bar with standard 4 bolt NEMA pattern to be provided with the equipment for termination of all power wiring. Enclosures shall be designed to accommodate power cable entry as specified on the Data Sheet.

H. Minimum wire bending space shall meet or exceed the value shown in NEC Table 430-10(b) for termination of the power cable and shall be documented on Manufacturer's drawings. IDENTIFICATION AND NAMEPLATES

I. Identify ASDs, components, and control wiring. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs. All wiring shall have wire number labels at each end of the wire. Drawings shall reference wire numbers and terminal block numbers.
2. Label each ASD with engraved nameplate to identify the load it serves.
3. Label each enclosure-mounted control and pilot device.
4. Nameplates are to be laminated plastic with engraved characters 1/2 inch (12.7 mm) high, or larger.
5. Nameplates shall be mounted on the front of the cubicle with stainless steel pins, screws, or permanent adhesive.
6. Special nameplates and engraving shall be as specified on the Data Sheet.
7. Nameplates shall have black letters on a white background, unless otherwise specified on the Data Sheet.
8. Meters, relays, switches, and other devices within the ASD shall be permanently identified using the same name as those appearing on the schematic diagrams.

3.3 FACTORY TESTING

A. Component Tests: All components (including furnished spares) shall be 100 percent tested. All printed circuit boards shall be burned-in continuously for 24 hours at 60 degrees C. The printed circuit boards shall be tested after burn-in to insure they are functioning within specification. Every gated power device shall have the following critical parameters tested at rated current: gating, turn-on, turn-off, high temperature, forward blocking, reverse blocking and waveform characteristics. All assembled phase cells shall be tested for cell balance at rated voltage, maximum current, maximum dV/dT and maximum dI/dT.

1. Control power shall be applied to microprocessors, printed circuit boards, diagnostic boards, LCD display, and similar devices including software to test for proper operation, sequencing, logic and diagnostics.
2. All wiring shall be checked for continuity and for functional compliance with the wiring diagrams.

B. System Tests: Testing shall proceed in the order given below.

1. Functional Test: Each ASD, and bypass control shall be completely functionally tested at the factory as a unit with simulated field signals matching those signals to be provided in the field. The Contractor shall give the Owner a minimum of 5 weeks' notice prior to the test. Test results shall be submitted to the Owner and no equipment shall be shipped until the test data have been approved in writing by the Owner. Test reports shall include the Contractor's standard tests (including EOI, and SCADA messaging). The test report shall indicate the test procedure and instrumentation used to measure and record data. The test report shall be certified by the test personnel and be submitted to the Engineer.
2. Load Tests: Each ASD and bypass combination shall be factory load tested at 100 percent of its maximum rating for a continuous period of 3 hours without overheating or shutdown. The load shall be applied as a motor (or dynamometer) load or a combination of motor and fixed resistor bank. Resistor bank shall not be greater than 25 percent of the applied load.

C. SCADA Communications

1. ASD manufacturer shall provide testing PLC matching Contractor supplied PLC for project. The PLC shall follow the same connection means and methods (equipment, cable, style) as being installed at the project site.
2. ASD manufacturer shall program PLC (utilizing same software version and revision as being provided) to communicate over Modbus and retrieve all data within the ASD and power equipment. (A list with all possible data should be provided to Owner and Engineer for review and purging)

3. The PLC shall update all data within 1 minute, while the drive is receiving power.
4. The PLC program shall be provided to the System Integrator/Contractor for integration into the main plant logic.

3.4 FIELD QUALITY CONTROL

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

B. Acceptance Testing Preparation:

1. Test insulation resistance for each ASD element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections - Manufacturer's standard tests shall be performed. Minimum testing shall include:

1. Power semiconductors shall be thermally cycled and printed circuit boards shall be burned in prior to final assembly into the ASD.
2. Individual power cells shall undergo a visual inspection, an electrical inspection, and a complete full load test prior to final assembly into the ASD. A test record for each power cell shall be furnished as part of the final data requirements if requested on the data sheets.
3. Mechanical operation tests shall be performed for each ASD to verify satisfactory operation. These tests shall include checking operating mechanisms and interlock devices.
4. Electrical function tests shall be performed to ensure proper operation of all devices and components including operation of the ASD at full load conditions. Instrumentation, software, and monitoring tests shall be included. The final assembly will be tested at full load and voltage by a power back method that returns drive output power to the power line. An unloaded full voltage motor will also be used during testing.

a. Steady-state: 0% to 100% loading
b. Dynamic: 110% or 150% overloading for 1 minute every 10 minutes (drive rating dependent)
c. Performance: includes efficiency, waveforms, vibration, frequency and power factor

5. Harmonic Analysis for All Drives: Onsite harmonic tests shall be performed at the maximum speeds allowed by influent flow at the scheduled time of the test with all ASDs operating. Tests shall be conducted using a harmonic analyzer by Fluke (model 434), Dranetz (Power Xplorer PX5) or Engineer approved equal. Tests shall prove that sufficient filtering has been provided to limit the harmonic distortion to a magnitude as defined previously in this Specification. The output of each

drive shall also be measured to record the harmonics present in the motor circuit.

6. Background harmonics shall be recorded for a minimum of 48 hours at the point of common coupling prior to the first pump field harmonics tests are recorded.
7. Power and heat monitoring of ASDs, and motors to ensure acceptable performance and heat dissipation to the extent allowed by available influent flow.
8. A test record for each ASD shall be furnished as part of the final data requirements.

D. ASDs will be considered defective if they do not pass tests and inspections and shall be replaced by Contractor at Contractor's expense.

E. Prepare test and inspection reports, including a certified report that identifies the ASD and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, reprogram, and maintain ASDs.

B. Provide two 7-hour training sessions, 7:00 a.m. to 2:30 p.m., on consecutive days prior to startup. Days scheduled are limited to Tuesday through Thursday.

C. Training each day shall cover a classroom oriented session for operators and maintenance personnel, followed by a hands-on session for same.

D. A sample outline of topics and a preliminary training manual shall be submitted and approved prior to scheduling training. Assume 10 attendees for each session.

E. Training shall be performed by factory-authorized personnel. Training credentials of proposed trainer shall be submitted prior to scheduling training.

PART 4 - DATA SHEET

4.1 BASIS OF DESIGN

A. Motor Data

1. HP: Two 1000 HP, Four 450 HP, and Two 250 HP
2. Installation: New
3. Voltage: 4,160 VAC
4. FLA: Depends on motor size
5. Speed: Depends on pump
6. Motor Lead Length: 7 ft

7. Service Factor: 1.15
8. Space Heater (Volts/Watts): 120 VAC / 400W
9. RTD (Make/QTY): 100 OHM Platinum / 8
10. Inverter-Duty: YES
11. Encoder: NO
12. Cable Distance from Motor to ASD: 70 ft

B. Load Type

1. Variable Torque: YES
2. Constant Torque: NO
3. Regeneration: NO
4. Fan / Pump: NO
5. Other: NO
6. Speed Range: 30 to 60 HZ
7. Rectification: 24 Pulse

C. Environment

1. Site Location: NEMA 12
2. Control Room Max Ambient: 95 Deg F
3. Control Room Min Ambient: 35 Deg F
4. Elevation: 600 ft
5. Humidity Non-Condensing: 30%
6. Drive Cabinet Space Heater: NO
7. Space Heater Test Circuit: NO
8. Motor Space Heater Circuit: YES
    a. Internally Powered: YES
    b. Externally Powered: NO

D. Design Standards

1. UL: YES
2. cUL: NO
3. IEEE 519: YES
4. Other: NO

E. Supply System Voltage (+/- 10%)

1. 2400 V: NO
2. 3300 V: NO
3. 4160 V: YES
4. 6600 V: NO
5. Other V: NO
6. Line Frequency: 60 HZ

F. Enclosure

1. NEMA 1: NO
2. NEMA 3R: YES
3. Electrical House
   a. Power Cable Entry: TOP
   b. Power Cable Exit: TOP
   c. Control Cable Entry: TOP
   d. Control Cable Exit: TOP
4. Panel Ventilation Method: YES, 100% Redundant, Air Cooled
5. Provisions for ducting air: NO
6. Panel Lighting
   a. A60 – Lighting module with 40 W incandescent lamp: YES
   b. A61 – Lighting module with 9 W fluorescent lamp: NO
   c. A61 – CE Certified lighting module with 11 W fluorescent lamp: NO

G. Operation Form

1. Manual: YES
2. Automatic: NO
3. Local: YES
4. Remote: YES
5. With Bypass: YES

H. Control Signals

1. Start / Stop Pushbuttons: YES
2. Emergency Stop Pushbutton: YES
3. "VFD Ready" Pilot light – Color: NO
4. "VFD Fault" Pilot light – Color: YES
5. "VFD Running" Pilot light – Color: YES
6. 2 Positions Select Switch (Local / Remote): YES
7. 3 Positions Select Switch (Manual / Off / Auto): NO
8. Speed Up / Speed Down Pot: YES
9. Speed Variation – 4…20mA: YES
10. Other: 2 Position Selector Switch (Open / Close) for MCR
11. Other: 3 Positions Select Switch (INV / OFF / BYPASS)
12. Other: Pressure switch input to control discharge valve circuit
13. Other: Three limit switches from discharge valve
14. Other: Fault contact from discharge valve

I. Outputs to Control System

1. Running: YES
2. Fault: YES

3. MCR-1 Satisfied: YES
4. Hand Switch in Inverter Position: YES
5. Hand Switch in Bypass Position: YES
6. Speed Feedback: YES
7. High Vibration: YES
8. High Motor Temperature: YES
9. High Pump Temperature: YES
10. Sequence Fail: YES
11. Ball Valve Open: YES
12. Ball Valve Fault: YES

J. Options

1. Kirk Key Interlocks: NO
2. Relay Outputs 115 V, 2 A, Form-C: YES
3. 24 VDC Power Supply: NO
4. 4 to 20 mA Isolated Analog Outputs
    a. Speed: YES
    b. Current: NO
    c. Voltage: NO
    d. Load Other: NO
5. Control Power From Main Power Feed (Internally generated): YES
6. Control Power Backup 1 KVA,120V,TIC UPS: NO
7. Auxiliary Pilot Lights: YES
8. Auxiliary Pilot Lights Type: LED
9. Auxiliary Push Buttons: YES
10. Auxiliary Push Buttons Type: Flush
11. Redundant Fan (30, 460V): YES
12. Additional Controls: See Drawings

K. Auxiliary Equipment

1. Bypass Starter: YES
    a. Across the Line: YES
    b. Rvat : NO
    c. Solid State Starter: NO
2. Synchronous Transfer
    a. Number Of Motors:
    b. Indoor Rated Sync.Transfer
    c. Outdoor Rated Sync. Transfer
    d. Gear Supplied By Others

L. Communication Options

1. Tosline S20: NO
2. DeviceNet: NO

3. Profibus: NO
4. Ethernet: NO
5. Modbus Rtu/Plus: YES
6. Other

M. Motor Protection

1. RTD-TR6 Relay: NO
2. Multilin 369: NO
3. Multilin 469: YES
4. Rtd Type: 100 OHM Platinum
5. Vibration: YES
   a. Type: Bentley Navada 3500 Series
   b. Quantity: 8

N. Support

1. Startup (Included In Price Of Unit): YES
2. Onsite Factory Training Testing: YES
3. Factory Training Houston: NO

O. Spares

1. Spare Parts Kit: YES (manufacturers recommended spare parts for two years)
2. Spare Power Module: YES

P. Software

1. Pc Interface Software: NO

Q. Testing

1. Witness Test— Qc Runback: YES
2. Witness Test Dynamometer (Up to 1000 Hp): YES
3. Drive/Motor Combined Test At Motor Vendor's Facility: NO

END OF SECTION

SECTION 26 32 13

ENGINE GENERATORS

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 packaged engine-generator sets for emergency power supply with the following features:

1. Natural-gas engine.
2. Remote-mounted cooling system on main generators, skid mounted on admin backup generator.
3. Unit-mounted and remote-mounted control and monitoring.
4. Performance requirements for sensitive loads.
5. Fuel system.
6. Parallel generator sets.
7. Exterior enclosure for admin backup generator.

1.3 DEFINITIONS

A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

B. LP: Liquid petroleum.

C. EPS: Emergency power supply.

D. EPSS: Emergency power supply system.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Include thermal damage curve for generator.
3. Include time-current characteristic curves for generator protective device.

4. Include fuel consumption in cubic feet per hour at 0.8 power factor at 0.5, 0.75 and 1.0 times generator capacity.
5. Include generator efficiency at 0.8 power factor at 0.5, 0.75 and 1.0 times generator capacity.
6. Include air flow requirements for cooling and combustion air in cfm at 0.8 power factor, with air supply temperature of 95, 80, 70, and 50 deg F. Provide drawings showing requirements and limitations for location of air intake and exhausts.
7. Include generator characteristics, including, but not limited to kW rating, efficiency, reactances, and short-circuit current capability.

B. Shop Drawings:

1. Include plans and elevations for engine-generator set and other components specified.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Identify fluid drain ports and clearance requirements for proper fluid drain.
4. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include base weights.
6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for EPS equipment and functional relationship between all electrical components.
7. Included plans and elevations for enclosures.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer manufacturer and testing agency.

B. Source quality-control reports, including, but not limited to the following:

1. Certified summary of prototype-unit test report.
2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
5. Report of sound generation.
6. Report of exhaust emissions showing compliance with applicable regulations.

7. Certified Torsional Vibration Compatibility: Comply with NFPA 110.

C. Field quality-control reports.

D. Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:

a. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
b. Operating instructions laminated and mounted adjacent to generator location.
c. Training plan.

1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1. Fuses: One for every 10 of each type and rating but no fewer than one of each.
2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.
4. Tools: Each tool listed by part number in operations and maintenance manual.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved by manufacturer.

B. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.9 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 2 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Caterpillar.

B. Onan/Cummins Power Generation.

2.2 PERFORMANCE REQUIREMENTS

A. ASME Compliance: Comply with ASME B15.1.

B. NFPA Compliance:

1. Comply with NFPA 37.
2. Comply with NFPA 70.
3. Comply with NFPA 99.
4. Comply with NFPA 110 requirements for Level 2 emergency power supply system.

C. UL Compliance: Comply with UL 2200.

D. Engine Exhaust Emissions: Comply with EPA Tier 2 requirements and applicable state and local government requirements.

E. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

F. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: 5 to 40 deg C.
2. Relative Humidity: Zero to 95 percent.
3. Altitude: Sea level to 1000 feet.

2.3 ASSEMBLY DESCRIPTION

A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.

C. EPSS Class: Engine-generator set shall be classified as a Class 2 in accordance with NFPA 110.

D. Induction Method: Turbocharged.

E. Governor: Adjustable isochronous, with speed sensing.

F. Emissions: Comply with EPA Tier 2 requirements.

G. Mounting Frame: Structural steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.

1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.

H. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated at 0.8 power factor excluding power required for the continued and repeated operation of the unit and auxiliaries.
2. Output Connections: Three-phase, four-wire.
3. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

I. Generator-Set Performance:

1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed

variations outside the steady-state operational band and no hunting or surging of speed.

5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
8. Start Time: Comply with NFPA 110, Type 10, system requirements.

J. Parallel Engine Generators:

1. Automatic reactive output power control and load sharing between generator sets operated in parallel.
2. Automatic regulation, automatic connection to a common bus, and automatic synchronization, with manual controls and instruments to monitor and control paralleling functions.
3. Protective relays required for equipment and personnel safety.
4. Paralleling suppressors to protect excitation systems.
5. Reverse power protection.
6. Loss of field protection.

2.4 ENGINE

A. Fuel: Natural gas.

B. Rated Engine Speed: 1800 rpm.

C. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm.

D. Lubrication System: The following items are mounted on engine or skid:

1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

E. Jacket Coolant Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.

F. Cooling System: Closed loop, liquid cooled, with remote radiator and integral engine-driven coolant pump except for 150 kW admin backup generator, which will be skid mounted. Comply with requirements in Section 23 21 13 "Hydronic Piping" for coolant piping.

1. Configuration: Vertical air discharge.
2. Radiator Core Tubes: Aluminum.
3. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
4. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
5. Fan: Driven by totally enclosed electric motor with sealed bearings.
6. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
7. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.

G. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 25 dB at 500 Hz.
2. Sound level measured at a distance of 25 feet from exhaust discharge after installation is complete shall be 78 dBA or less.

H. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

I. Starting System: 24-V electric, with negative ground.

1. Components: Sized so they are not damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Performance Requirements" Article.
2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3. Cranking Cycle: As required by NFPA 110 for system level specified.
4. Battery: Lead acid, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least three times without recharging.

5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place. Provide ventilation to exhaust battery gases.
7. Battery Stand: Factory-fabricated, two-tier metal with acid-resistant finish designed to hold the quantity of battery cells required and to maintain the arrangement to minimize lengths of battery interconnections.
8. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35 A minimum continuous rating.
9. Battery Charger: Current-limiting, automatic-equalizing and float-charging type designed for lead-acid batteries. Unit shall comply with UL 1236 and include the following features:

a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg F to 140 deg F to prevent overcharging at high temperatures and undercharging at low temperatures.
c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.5 GASEOUS FUEL SYSTEM

A. Natural-Gas Piping: Comply with requirements in Section 23 11 23 "Facility Natural-Gas Piping."

B. Gas Train: Comply with NFPA 37.

C. Engine Fuel System:

1. Natural-Gas, Vapor-Withdrawal System:

   a. Carburetor.
   b. Secondary Gas Regulators: One for each fuel type, with atmospheric vents piped to building exterior.
   c. Fuel-Shutoff Solenoid Valves: NRTL-listed, normally closed, safety shutoff valves; one for each fuel source.
   d. Fuel Filters: One for each fuel type.
   e. Manual Fuel Shutoff Valves: One for each fuel type.
   f. Flexible Fuel Connectors: Minimum one for each fuel connection.
   g. Gas flow adjusting valve.
   h. Fuel change gas pressure switch.

2.6 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms.

B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts generator set. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms.

C. Provide minimum run time control set for 30 minutes with override only by operation of a remote emergency-stop switch.

D. Comply with UL 508A.

E. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration. Panel shall be powered from the engine-generator set battery.

F. Indicating Devices : As required by NFPA 110 for Level 2 system, including the following:

   1. AC voltmeter.
   2. AC ammeter.
   3. AC frequency meter.

4. EPS supplying load indicator.
5. Ammeter and voltmeter phase-selector switches.
6. DC voltmeter (alternator battery charging).
7. Engine-coolant temperature gage.
8. Engine lubricating-oil pressure gage.
9. Running-time meter.
10. Current and Potential Transformers: Instrument accuracy class.

G. Protective Devices and Controls in Local Control Panel: Shutdown devices and common visual alarm indication as required by NFPA 110 for Level 2 system, including the following:

1. Start-stop switch.
2. Overcrank shutdown device.
3. Overspeed shutdown device.
4. Coolant high-temperature shutdown device.
5. Coolant low-level shutdown device.
6. Low lube oil pressure shutdown device.
7. Air shutdown damper shutdown device when used.
8. Overcrank alarm.
9. Overspeed alarm.
10. Coolant high-temperature alarm.
11. Coolant low-temperature alarm.
12. Coolant low-level alarm.
13. Low lube oil pressure alarm.
14. Air shutdown damper alarm when used.
15. Lamp test.
16. Contacts for local and remote common alarm.
17. Coolant high-temperature prealarm.
18. Generator-voltage adjusting rheostat.
19. Run-Off-Auto switch.
20. Control switch not in automatic position alarm.
21. Low-starting hydraulic pressure alarm.
22. Low cranking voltage alarm.
23. Battery-charger malfunction alarm.
24. Battery low-voltage alarm.
25. Battery high-voltage alarm.
26. Generator overcurrent protective device not closed alarm.

H. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.

I. Connection to Datalink: A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication. Provide connections for datalink transmission of indications to remote data terminals via ProfiBus.

J. Common Remote Panel with Common Audible Alarm: Comply with NFPA 110 requirements for Level 2 systems. Include necessary contacts and terminals in control and monitoring panel. Remote panel shall be powered from the engine-generator set battery.

K. Remote Alarm Annunciator: Comply with NFPA 99. An LED labeled with proper alarm conditions shall identify each alarm event, and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.

1. Overcrank alarm.
2. Coolant low-temperature alarm.
3. High engine temperature prealarm.
4. High engine temperature alarm.
5. Low lube oil pressure alarm.
6. Overspeed alarm.
7. Low coolant level alarm.
8. Low cranking voltage alarm.
9. Contacts for local and remote common alarm.
10. Audible-alarm silencing switch.
11. Air shutdown damper when used.
12. Run-Off-Auto switch.
13. Control switch not in automatic position alarm.
14. Fuel supply alarm.
15. Lamp test.
16. Low cranking voltage alarm.
17. Generator overcurrent protective device not closed.

L. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.

M. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

2.7 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.

1. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.

B. Generator Circuit Breaker: Insulated-case, electronic-trip type; 100 percent rated; complying with UL 489.

1. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
2. Trip Settings: Selected to coordinate with generator thermal damage curve.
3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
4. Mounting: Adjacent to or integrated with control and monitoring panel.

C. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other generator-set protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector performs the following functions:

1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms. Contacts shall be available for load shed functions.
2. Under single or three-phase fault conditions, regulates generator to 250 percent of rated full-load current for up to 10 seconds.
3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the generator set.
4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

D. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground fault.

1. Indicate ground fault with other generator-set alarm indications.
2. Trip generator protective device on ground fault.

2.8 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H or Class F.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required. Provide 12 lead alternator.

E. Range: Provide broad range of output voltage by adjusting the excitation level.

F. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.

G. Enclosure: Dripproof.

H. Instrument Transformers: Mounted within generator enclosure.

I. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified and as required by NFPA 110.

1. Adjusting Rheostat on Control and Monitoring Panel: Provide plus or minus 5 percent adjustment of output-voltage operating band.
2. Maintain voltage within 20 percent on one step, full load.
3. Provide anti-hunt provision to stabilize voltage.
4. Maintain frequency within 5 percent and stabilize at rated frequency within 2 seconds.

J. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

K. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

L. Subtransient Reactance: 12 percent, maximum.

2.9 MOTORS

A. Description: NEMA MG 1, Design B, medium induction random-wound, squirrel cage motor.

B. Efficiency: Energy efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

E. 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.

F. Temperature Rise: Match insulation rating.

G. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.

2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

H. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

I. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in electrical Sections.

2.10 VIBRATION ISOLATION DEVICES

A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

1. Material: Standard neoprene separated by steel shims.
2. Shore "A" Scale Durometer Rating: 30.
3. Number of Layers: One.
4. Minimum Deflection: 1 inch.

B. Comply with requirements in Section 232116 Hydronic Piping Specialties" for vibration isolation and flexible connectors materials for steel piping.

C. Comply with requirements in Section 233113 "Metal Ducts" for vibration isolation and flexible connector materials for exhaust shroud and ductwork.

D. Vibration isolation devices shall not be used to accommodate misalignments or to make bends.

2.11 OUTDOOR ENCLOSURE

A. Provide aluminum enclosure for administration 150 kW backup generator.

2.12 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.13 SOURCE QUALITY CONTROL

A. Project-Specific Equipment Tests: Before shipment, factory test engine-generator set and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:

1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
2. Test generator, exciter, and voltage regulator as a unit.
3. Full load run.
4. Maximum power.
5. Voltage regulation.
6. Transient and steady-state governing.
7. Single-step load pickup.
8. Safety shutdown.
9. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.
10. Report factory test results within 10 days of completion of test.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.

B. Examine roughing-in for piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.

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

3.2 PREPARATION

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Owner no fewer than two working days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Owner's written permission.

3.3 INSTALLATION

A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.

B. Equipment Mounting:

1. Install packaged engine generators on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 03 30 00 "Cast-in-Place Concrete.
2. Coordinate size and location of concrete bases for packaged engine generators and remote radiators mounted on grade. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
3. Coordinate size and location of roof curbs, equipment supports, and roof penetrations for remote radiators. These items are specified in Section 07 72 00 "Roof Accessories."

C. Install packaged engine-generator to provide access, without removing connections or accessories, for periodic maintenance.

D. Install packaged engine-generator with elastomeric isolator pads having a minimum deflection of 1 inch on 4-inch-high concrete base. Secure sets to anchor bolts installed in concrete bases.

E. Install remote radiator with elastomeric isolator pads on concrete base on grade.

F. Install Schedule 40, black steel piping with welded joints for cooling water piping between engine-generator set and remote radiator.

1. Install isolating thimbles where exhaust piping penetrates combustible surfaces. Provide a minimum of 9 inches clearance from combustibles.

G. Install Schedule 40, black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet.

1. Install flexible connectors and steel piping materials.
2. Insulate muffler/silencer and exhaust system components.
3. Install isolating thimbles where exhaust piping penetrates combustible surfaces with a minimum of 9 inches clearance from combustibles.

H. Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and Schedule 40, black steel pipe with welded joints.

I. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.

B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine-generator to allow service and maintenance.

C. Connect cooling-system water piping to engine-generator set and remote radiator with flexible connectors.

D. Connect engine exhaust pipe to engine with flexible connector.

E. Connect fuel piping to engines with a gate valve and union and flexible connector.

1. Natural-gas piping, valves, and specialties for gas distribution are specified in Section 23 11 23 "Facility Natural-Gas Piping."
2. Install manual shutoff valve in a remote location to isolate natural-gas supply to the generator room.
3. Vent gas pressure regulators outside building a minimum of 60 inches from building openings.

F. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

G. Connect wiring according to Section 26 05 05 “Conductors.” Provide a minimum of one 90 degree bend in flexible conduit routed to the generator set from a stationary element.

H. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

3.5 IDENTIFICATION

A. Identify system components according to Section 26 05 53 "Identification for Electrical Systems."

B. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections.

D. Tests and Inspections:

1. Perform tests recommended by manufacturer and each visual and mechanical inspection and electrical and mechanical test listed in the first two subparagraphs as specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.

    a. Visual and Mechanical Inspection
        1) Compare equipment nameplate data with drawings and specifications.
        2) Inspect physical and mechanical condition.
        3) Inspect anchorage, alignment, and grounding.
        4) Verify the unit is clean.

    b. Electrical and Mechanical Tests
        1) Perform insulation-resistance tests in accordance with IEEE 43.
            a) Machines larger than 200 horsepower. Test duration shall be 10 minutes. Calculate polarization index.
            b) Machines 200 horsepower or less. Test duration shall be one minute. Calculate the dielectric-absorption ratio.
        2) Test protective relay devices.
        3) Verify phase rotation, phasing, and synchronized operation as required by the application.
        4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
        5) Conduct performance test in accordance with NFPA 110.
        6) Verify correct functioning of the governor and regulator.

2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.

    a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
    b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
    c. Verify acceptance of charge for each element of the battery after discharge.
    d. Verify that measurements are within manufacturer's specifications.

4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.

5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.
6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg. Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
7. Exhaust Emissions Test: Comply with applicable government test criteria.
8. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
9. Harmonic-Content Tests: Measure harmonic content of output voltage at 25 percent and 100 percent of rated linear load. Verify that harmonic content is within specified limits.
10. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations 25 feet on the property line, and compare measured levels with required values.

E. Coordinate tests with tests for transfer switches and run them concurrently.

F. Test instruments shall have been calibrated within the last 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.

G. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.

H. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.

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

J. Remove and replace malfunctioning units and retest as specified above.

K. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

L. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

M. Infrared Scanning: After Substantial Completion, but not more than 60 days after final acceptance, perform an infrared scan of each power wiring termination and each bus connection while running with maximum load. Remove all access panels so terminations and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 11 months after date of Substantial Completion.
2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
3. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.7 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

3.8 DEMONSTRATION

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

END OF SECTION

SECTION 26 41 00
LIGHTNING PROTECTION SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Lightning protection systems for buildings and associated structures and includes requirements for lightning protection systems components including, but not limited to:

1. Air terminals.
2. Bonding plates.
3. Conductors.
4. Connectors.
5. Fasteners.
6. Grounding plates.
7. Grounding rods.
8. Rod clamps.
9. Splicers.

1.02 SUBMITTALS

A. Shop Drawings: Submit in accordance with Section 01 33 00, Shop Drawings covering the items included under this Section. Shop Drawing submittals shall include:

1. Product data for each type of product specified, including roof adhesive where used.
2. Shop Drawings detailing lightning protection system including, but not limited to, air terminal locations, conductor routing, connections, and grounding.
3. Quality Assurance Submittals:

    a. Provide ENGINEER with 1 copy of LPI-177 and retain 1 copy at Site throughout construction for reference.
    b. Provide 1 copy of each completed inspection form to ENGINEER.
    c. Provide UL inspection and delivery of UL Master Label "C" to ENGINEER.
    d. Provide LPI certification of the system, obtaining necessary certifications and signatures and preparing and handling necessary forms.

1.03 QUALITY ASSURANCE

A. Codes and Standards:

1. NFPA and UL Compliance: Comply with requirements of NFPA Standard 78, and UL Standard 96 as applicable to lightning protection systems for building projects.
2. LPI Compliance: Comply with requirements of Lightning Protection Institute (LPI) Standards 175, 176, and 177, pertaining to lightning protection system material, components, installation, and quality assurance procedures.
3. ANSI Compliance: Comply with applicable requirements of ANSI Standard C2.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with specified requirements, manufacturers offering products which may be incorporated in Work include:

1. Lightning Protection Systems:

a. East Coast Lightning Equipment Inc.
b. ERICO International Corporation.
c. Harger.
d. Heary Bros. Lightning Protection Co. Inc.
e. Independent Protection Co.
f. Preferred Lightning Protection.
g. Robbins Lightning, Inc.
h. Thompson Lightning Protection, Inc.

2.02 LIGHTNING PROTECTION SYSTEM COMPONENTS

A. Provide lightning protection system materials and components that comply with manufacturer's standard design, in accordance with published product information. Provide air terminals, bonding plates, conductors, connectors, conductor straps, fasteners, grounding plates, grounding rods, rod clamps, splicers, and other components required for a complete system that meets LPI-175, UL 96A, and NFPA 78 standards.

B. Type of Metal for air terminals and cables:

1. Aluminum with solid air terminals.

C. Main and bonding conductor shall be copper

D. Down Conductors shall be #4/0 bare stranded annealed copper wire.

E. Air Terminals for standing seam roof mounting. Provide units with bases especially designed for standing seam roof. ½" x 24" Copper, Class II

F. Ground Rods: 3/4-inch minimum diameter by 10 feet long, copper clad steel with minimum 27 percent of the rod weight in the copper cladding.

PART 3 - EXECUTION

3.01 INSTALLATION OF LIGHTNING PROTECTION SYSTEMS

A. Install lightning protection systems as indicated, in accordance with equipment manufacturer's written instructions, and in compliance with applicable installation standards specified above.

B. Install conductors with direct paths from air terminals to ground connections avoiding sharp bends and narrow loops. Where indicated, run conductors in non-metallic raceway, Schedule 40, minimum.

C. Concealment of System Wiring:

1. Conceal down conductors within PVC conduit.

D. Splices and Clamps: Approved exothermic welded connections for conductor splices and connections between conductors and other components.

3.02 SLEEVE & SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.03 CORROSION PROTECTION

A. Use no combination of materials that may form an electrolytic couple of such nature that corrosion is accelerated in the presence of moisture, unless moisture is permanently excluded from the junction of such metals. Where unusual conditions exist that would cause deterioration or corrosion of conductors, use conductors with suitable protective coatings.

3.04 GROUNDING AND BONDING

A. Provide equipment grounding and bonding connections sufficiently tight to assure permanent and effective grounds and bonds.

3.05 FIELD QUALITY CONTROL

A. Perform inspections of the lightning protection system installation in accordance with LPI-177, "Inspection Guide for LPI Certified Systems."

1. Document the inspections on LPI forms LPI-C1-02 and LPI Form 1-R88.

B. Provide advance notice of at least 14 days to ENGINEER before concealing lightning protection system Work.

C. UL Inspection: Meet requirements to obtain a UL Master Label for system.

END OF SECTION

SECTION 26 51 00
INTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Interior solid-state luminaires that use LED technology.
2. Emergency lighting units.
3. Exit signs.
4. Lighting fixture supports.

1.2 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. LED: Light-emitting diode.

F. Lumen: Measured output of lamp and luminaire, or both.

G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, and finishes.

B. Shop Drawings: Show details of nonstandard or custom lighting fixtures. Indicate dimensions, weights, methods of field assembly, components, features, and accessories. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, from manufacturer.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale and coordinated with each other, using input from installers of the items involved including radiant heaters.

B. Product Certificates: For each type of luminaire.

C. Sample 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. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide product indicated on Drawings.

2.2 GENERAL REQUIREMENTS FOR LIGHTING FIXTURES AND COMPONENTS

A. LED:

1. 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.

2. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.

3. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

4. Recessed Fixtures: Comply with NEMA LE 4.

5. CRI of 70. CCT of 3000 K or as indicated on the drawings.

6. Rated lamp life of 50,000 hours.

7. Lamps dimmable from 100 percent to 0 percent of maximum light output.

8. Internal driver.

9. Nominal Operating Voltage: 120 V ac, 240 V ac, 277 V ac (multi-volt).

a. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.

10. Housings:

a. Extruded-aluminum housing and heat sink.

B. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.

C. Incandescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5A.

D. Metal Parts: Free of burrs and sharp corners and edges.

E. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.

F. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

G. Diffusers and Globes:

1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

a. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.
b. UV stabilized.

2. Glass: Annealed crystal glass unless otherwise indicated.

2.3 EMERGENCY POWER UNIT

A. Internal Type: Self-contained, modular, battery-inverter unit, factory mounted within lighting fixture body and compatible with ballast. Comply with UL 924.

1. Emergency Connection: Operate continuously at an output of 1100 lumens each. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture power source.

2. Nightlight Connection: Operate lamp continuously.

3. Test Push Button and Indicator Light: Visible and accessible without opening fixture or entering ceiling space.

a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

4. Battery: Sealed, maintenance-free, nickel-cadmium type.

5. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.

6. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.4 EXIT SIGNS

A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:

1. Lamps for AC Operation: LEDs, 50,000 hours minimum rated lamp life.

2. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.

a. Battery: Sealed, maintenance-free, nickel-cadmium type.
b. Charger: Fully automatic, solid-state type with sealed transfer relay.
c. Operation: Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
d. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
e. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

2.5 EMERGENCY LIGHTING UNITS

A. General Requirements for Emergency Lighting Units: Self-contained units complying with UL 924.

1. Battery: Sealed, maintenance-free, lead-acid type.

2. Charger: Fully automatic, solid-state type with sealed transfer relay.

3. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.

4. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.

5. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

6. Wire Guard: Heavy-chrome-plated wire guard protects lamp heads or fixtures.

7. Integral Time-Delay Relay: Holds unit on for fixed interval of 15 minutes when power is restored after an outage.

2.6 LIGHTING FIXTURE SUPPORT COMPONENTS

A. Comply with Section 26 05 29 "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.

C. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.

D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gauge.

E. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gauge.

F. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

G. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Lighting fixtures: Set level, plumb, and square with ceilings and walls. Install lamps in each fixture.

B. Comply with NFPA 70 for minimum fixture supports.

C. Suspended Lighting Fixture Support:

1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.

D. Air-Handling Lighting Fixtures: Install with dampers closed and ready for adjustment.

E. Adjust aimable lighting fixtures to provide required light intensities.

F. Connect wiring according to Section 26 05 05 "Conductors."

3.2 FIELD QUALITY CONTROL

A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.

B. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

END OF SECTION

SECTION 26 56 00
EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Exterior solid-state luminaires that are designed for and exclusively use LED lamp technology.
2. Poles and accessories.

1.2 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color rendering index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.3 STRUCTURAL ANALYSIS CRITERIA FOR POLE SELECTION

A. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied as stated in AASHTO LTS-4-M.

B. Live Load: Single load of 500 lbf, distributed as stated in AASHTO LTS-4-M.

C. Ice Load: Load of 3 lbf/sq. ft., applied as stated in AASHTO LTS-4-M Ice Load Map.

D. Wind Load: Pressure of wind on pole and luminaire and banners and banner arms, calculated and applied as stated in AASHTO LTS-4-M.

1. Basic wind speed for calculating wind load for poles exceeding 49.2 feet in height is 100 mph.
   a. Wind Importance Factor: 1.0.
   b. Minimum Design Life: 50 years.
   c. Velocity Conversion Factors: 1.0.

2. Basic wind speed for calculating wind load for poles 50 feet high or less is 100 mph.

a. Wind Importance Factor: 1.0.
b. Minimum Design Life: 25 years.
c. Velocity Conversion Factors: 1.0.

1.4 ACTION SUBMITTALS

A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, and finishes.

B. Shop Drawings: Anchor-bolt templates keyed to specific poles and certified by manufacturer.

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. Comply with IEEE C2, "National Electrical Safety Code."

C. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide product indicated on Drawings.

2.2 GENERAL REQUIREMENTS FOR LUMINAIRES

A. LED:

1. CRI of 70. CCT of 3000 K or as indicated on the drawings.
2. L70 lamp life of 50,000 hours.
3. Lamps dimmable from 100 percent to 0 percent of maximum light output.
4. Nominal Operating Voltage: 120 V ac, 240 V ac, 277 V ac (multi-volt).
5. In-line Fusing: Separate in-line fuse for each luminaire.
6. Lamp Rating: Lamp marked for outdoor use.
7. Source Limitations: Obtain luminaires from single source from a single manufacturer.
8. Source Limitations: For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.

B. Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.

1. LER Tests Incandescent Fixtures: Where LER is specified, test according to NEMA LE 5A.
2. LER Tests HID Fixtures: Where LER is specified, test according to NEMA LE 5B.

C. Lateral Light Distribution Patterns: Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.

D. Metal Parts: Free of burrs and sharp corners and edges.

E. Sheet Metal Components: Corrosion-resistant aluminum unless otherwise indicated. Form and support to prevent warping and sagging.

F. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.

G. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect ballast when door opens.

H. Exposed Hardware Material: Stainless steel.

I. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

J. Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.

K. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.

L. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

M. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

N. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."
2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
    a. Color: As selected from manufacturer's standard catalog of colors.
    b. Color: Match Architect's sample of manufacturer's standard color.
    c. Color: As selected by Architect from manufacturer's full range.

O. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.
3. Class I, Clear Anodic Finish: AA-M32C22A41 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
4. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.
    a. Color: Dark bronze.

P. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps and ballasts. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp and ballast characteristics:
    a. "USES ONLY" and include specific lamp type.
    b. Lamp tube configuration (twin, quad, triple), base type, and nominal wattage for compact fluorescent luminaires.
    c. Lamp type, wattage, bulb type (ED17, BD56, etc.) and coating (clear or coated) for HID luminaires.
    d. Start type (preheat, rapid start, instant start) compact fluorescent luminaires.
    e. ANSI ballast type (M98, M57, etc.) for HID luminaires.
    f. CCT and CRI for all luminaires.

2.3 GENERAL REQUIREMENTS FOR POLES AND SUPPORT COMPONENTS

A. Structural Characteristics: Comply with AASHTO LTS-4-M.

1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in "Structural Analysis Criteria for Pole Selection" Article.
2. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.

B. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.

C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.

1. Materials: Shall not cause galvanic action at contact points.
2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.
3. Anchor-Bolt Template: Plywood or steel.

D. Handhole: Oval-shaped, with minimum clear opening of 2-1/2 by 5 inches, with cover secured by stainless-steel captive screws. Provide on all, except wood poles.

E. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Section 03 30 00 "Cast-in-Place Concrete."

F. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123M; and with top-plate and mounting bolts to match pole base flange and strength required to support pole, luminaire, and accessories.

G. Breakaway Supports: Frangible breakaway supports, tested by an independent testing agency acceptable to authorities having jurisdiction, according to AASHTO LTS-4-M.

2.4 ALUMINUM POLES

A. Poles: Seamless, extruded structural tube complying with ASTM B 429/B 429M, Alloy 6063-T6 with access handhole in pole wall.

B. Poles: ASTM B 209, 5052-H34 marine sheet alloy with access handhole in pole wall.

1. Shape: Square, tapered.
2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

C. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

D. Grounding and Bonding Lugs: Welded 1/2-inch threaded lug, complying with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

E. Brackets for Luminaires: Detachable, with pole and adapter fittings of cast aluminum. Adapter fitting welded to pole and bracket, then bolted together with stainless-steel bolts.

1. Tapered oval cross section, with straight tubular end section to accommodate luminaire.
2. Finish: Same as luminaire.

F. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.

G. Aluminum Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.
3. Class I, Clear Anodic Finish: AA-M32C22A41 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
4. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.

PART 3 - EXECUTION

3.1 LUMINAIRE INSTALLATION

A. Install lamps in each luminaire.

B. Fasten luminaire to indicated structural supports.

1. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.

3.2 POLE INSTALLATION

A. Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.

B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on Drawings:

1. Fire Hydrants and Storm Drainage Piping: 60 inches.
2. Water, Gas, Electric, Communication, and Sewer Lines: 10 feet.
3. Trees: 15 feet from tree trunk.

C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Section 03 30 00 "Cast-in-Place Concrete."

D. Foundation-Mounted Poles: Mount pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.

1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
2. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
3. Install base covers unless otherwise indicated.
4. Use a short piece of 1/2-inch-diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

E. Embedded Poles with Tamped Earth Backfill: Set poles to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.

1. Dig holes large enough to permit use of tampers in the full depth of hole.
2. Backfill in 6-inch layers and thoroughly tamp each layer so compaction of backfill is equal to or greater than that of undisturbed earth.

F. Embedded Poles with Concrete Backfill: Set poles in augered holes to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.

1. Make holes 6 inches in diameter larger than pole diameter.

2. Fill augered hole around pole with air-entrained concrete having a minimum compressive strength of 3000 psi at 28 days, and finish in a dome above finished grade.
3. Use a short piece of 1/2-inch-diameter pipe to make a drain hole through concrete dome. Arrange to drain condensation from interior of pole.
4. Cure concrete a minimum of 72 hours before performing work on pole.

G. Poles and Pole Foundations Set in Concrete Paved Areas: Install poles with minimum of 6-inch- wide, unpaved gap between the pole or pole foundation and the edge of adjacent concrete slab. Fill unpaved ring with pea gravel to a level 1 inch below top of concrete slab.

H. Raise and set poles using web fabric slings (not chain or cable).

3.3 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.4 GROUNDING

A. Ground metal poles and support structures according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each pole unless otherwise indicated.
2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

B. Ground nonmetallic poles and support structures according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each pole.
2. Install grounding conductor and conductor protector.
3. Ground metallic components of pole accessories and foundations.

END OF SECTION