

3. Philflex

2.2 FLEXIBLE CORDS

- A. Flexible cords shall be furnished for pendent connections to lighting fixtures and connections to portable equipment.

2.3 CONTROL CABLE

- A. Multiple conductor control cables shall be rated 600 Volts, shall have outer jacket as specified, and be suitable for installation in open, air, ducts, conduit, or direct burial.
- B. Conductors: Stranded soft copper or number shown.
- C. Insulation: As specified below with stranded IPCEA Color Coding.

PART 3 - EXECUTION

3.1 CONDUCTOR INSTALLATION

- A. Interiors of conduit shall be clean and dry before pulling wire. If dirt or moisture has entered conduits contractor shall swab them clean.
- B. Care shall be exercised while installing wire in conduits so as not to injure conductor insulation. Use UL listed wire pulling lubricants for pulling-in conductors.
- C. Free ends and loops of wire at boxes and enclosures shall be pushed back in box and protected by blank covers or other means until the interior painting or decorating work is completed.

3.2 CONDUCTOR IDENTIFICATION

- A. The conductors of branch circuits for power and lighting shall be color coded for identification purposes in accordance with Article 5.3 of the Philippine Electrical Code. Refer to Section 16195 of these specifications.
- B. Power feeders for 600 volts and below shall be color coded by using permanent-colored, non aging insulating tape.
- C. Branch circuits shall be connected as numbered on drawings. Test and permanently tag by circuit number each circuit wire, except neutrals, in panel gutter before connecting to panels, using numbered tapes. For single phase, 3-wire systems, 2 line conductors may be served by a common neutral. In no case may a common neutral be used when two circuits are connected to the same phase of a panelboard.
- D. Terminal strips shall be lettered or numbered, and numbered or lettered tapes shall be attached to conductors connected through terminal strips.

3.3 SPLICES, TAPS AND TERMINATIONS

- A. Splices and taps of conductors 5.5 mm² and smaller shall be made using electrical spring connectors with vinyl insulating caps.
- B. Splices and taps of conductors larger than 5.5 mm² shall all be made by split-bolt type connectors. Finished splice or tap shall be insulated with one layer of vinyl backed mastic followed by two half-lapped layers of electrical tape or premolded caps or heat shrinkable tubing.
- C. Feeder conductors shall be terminated with pressure bolt type lugs.
- D. Conductors for other than feeders shall be terminated using pressure bolt type terminals. Where connections are to be made under screw heads only, install insulated crimp type spade lugs on stranded wire ends before connections are made.
- E. Connectors shall contain only one wire unless listed for multiple conductors.
- F. Feeder cables shall be continuous without splices.

3.4 TESTING

- A. Continuity shall be checked by means of a DC test device using a bell or buzzer. Circuit and phase identification tags shall comply with 3.2 above.
- B. Lighting circuit shall be identified and shall pass operational tests to see that the circuits perform functions for which they are designed.
- C. Cable connections must pass a visual inspection for workmanship and conformance with standard practice.
- D. Conductors and leads shall be tested for continuity. Feeder and branch circuits shall be given a megger test using 1000 volt motor driven megger.
 - 1. Megger tests shall be made between one conductor and ground with the other conductors grounded. Each conductor shall be tested in the same manner. Megger readings for cables connected at both ends shall be recorded.
 - 2. Each feeder conductor shall be meggered with the cable connected to the open breaker at the equipment. Connections at the other end of each of these cables shall be as follows:
 - a. Conductors to motor control centers shall be connected to the motor control center bus with switches in the starters open.

- b. Conductors to motors and other equipment shall be connected to the motors and equipment with feeder switches open.

**** END OF SECTION ****

SECTION 16130 RACEWAYS AND FITTINGS

PART 1 – GENERAL

1.1 SCOPE OF WORK

The Contractor shall furnish and install complete raceway systems as shown on the Drawings and as hereinafter specified.

PART 2 – PRODUCTS

2.1 INTERMEDIATE METALLIC CONDUIT

- A. All wiring shall be in intermediate metallic conduit unless specified in the Drawings.
- B. Metal conduits shall be hot-dipped galvanized with zinc coated threads and shall conform to ANSI C.80.1
- C. All conduits shall be the manufactured by McGill or approved equal but must be products of only one manufacturer.
- D. The metric sizes of conduits quoted on the Drawings are the minimum sizes acceptable and shall conform to the following trade sizes as listed in the latest edition of the PEC.

Metric Size, mm	Trade Size, inches
15	½
20	¾
25	1
32	1 ¼
40	1 ½
50	2
65	2 ½
80	3
90	3 ½
100	4

2.2 FLEXIBLE CONDUIT, COUPLINGS AND FITTINGS

- A. Flexible conduits shall be of metallic flexible core with a copper-bonding conductor between the spiral segments. The flexible core shall be galvanized steel. For wet locations and for all motor connections, the core shall be covered with abrasion resistant liquid-tight polyvinyl chloride jacket.
- B. Couplings and fittings shall be of a design approved for the above type of flexible conduit.

2.3 BOXES AND FITTINGS

- A. Boxes for metallic raceways shall be of the cast-metal hub type when located in normally wet locations, when surface mounted on exterior

surfaces and in hazardous areas. They shall be hot-dipped galvanized after fabrication and shall be provided with cast galvanized covers and corrosion proof screws.

- B. Boxes in other locations shall be constructed of code gage galvanized sheet steel and shall be furnished with screw-fastened covers.
- C. All fittings shall be hot-dipped galvanized.
- D. Exposed expansion fittings shall be designed to compensate for expansion, contraction and deflection in a line of conduit. They shall be of weathertight corrosion resistant construction and shall have flexible copper bonding jumpers.
- E. All boxes and fittings shall be the manufactured by Steel City or approved equal but must be products of only one manufacturer.

2.4 CONDUIT MOUNTING EQUIPMENT

Hangers, rods, backplates, beam clamps, and other hardware shall be hot-dipped galvanized steel.

PART 3 - EXECUTION

3.1 INSTALLATION, RIGID CONDUITS

- A. Unless indicated otherwise, conduits shall be concealed within finished walls, ceiling and floors.
- B. All conduits shall be kept at least 100 mm away from parallel runs of flues and steam or hot water pipes.
- C. Conduits shall have no more than three 90-degree bends in any one run.
- D. Conduits installed in concrete floor slabs shall be located so as not adversely affect the structural strength of the slabs. They shall be installed within the middle one-third of the concrete slab and shall be spaced horizontally not closer than three diameters except at cabinet locations. Curved portion of bend shall not be visible above the finished slab. Slab thickness shall be increased as necessary to provide a minimum 25-mm cover over the conduit. Conduit larger than 25 mm shall be parallel with or at right angles to the main reinforcements.
- E. All conduits on exposed works shall be run at right angles to and parallel with the surrounding walls and shall conform to the form of the ceiling. No diagonal runs will be allowed. Changes in direction of runs shall be made with symmetrical bends or cast metal fittings. Bends in parallel conduit runs shall be concentric. Field made bends (or offsets) shall be made with a hickey or conduit-bending machine.
- F. In suspended ceiling construction, conduits shall be run above the ceiling and shall be supported independently from the ceiling and mechanical equipment.
- G. Conduit supports shall be spaced at no more than 2.5 m or as required to obtain rigid construction.

- H. Single conduit shall be supported by means of one-hole pipe strap in combination with one screw backplate to raise the conduit from the surface.
- I. Multiple runs of conduits shall be supported on trapeze type hangers with steel horizontal members and threaded hanger rods. The rods shall not be less than 10 mm in diameter.
- J. Conduit hangers shall be attached to structural steel by means of beam or channel clamps.
- K. Fastening of conduit supports shall be by wood screws or screw type nails to wood; by toggle bolts on masonry units, by concrete inserts or expansion bolts on concrete or brick; and by machine screws, welded threaded studs, or spring tension clamps on steel work. Threaded studs driven in by a powder charge and provided with lock washers and nuts may be used in lieu of expansion bolts or machine or wood screws. The load applied to fasteners shall not exceed one fourth of the proof test load.
- L. Conduit terminating in sheet metal boxes and cabinets shall have double locknuts and insulating bushings. Locknuts shall be the types with sharp edges for digging into the wall of metal enclosures. Bushings shall be installed on the ends of all conduit and shall be of the insulating type where required by the PEC.
- M. Conduit terminating in gasket enclosures shall be terminated with conduit hub.
- N. Conduit wall seals shall be used for all conduits penetrating walls below grade or at other locations shown on the Drawings.
- O. Expansion and deflection fittings with bonding jumpers shall be used where conduits cross structural expansion joints.
- P. Flexible metal conduits shall be used for all motor terminations and for other equipment subject to vibration or noise transmission.
- Q. No wire shall be pulled into the conduit system until it is complete in all details, in the case of concealed work, until all rough plastering or masonry has been completed, and in the case of exposed work, until the conduit system has been completed in every detail.
- R. The ends of all conduits shall be tightly plugged to exclude dust and moisture during construction. Clogged conduits shall be freed of all obstructions. All conduits shall be swabbed clean before pulling in wires.
- S. Empty conduits which wire is to be provided by others shall have pull wires installed. The pull wire shall be No. 12 AWG, zinc coated steel or of plastic having not less than 90 kgs (200 pounds) tensile strength. Not less than 30 mm of slack should be left at each end of the pull wires.

3.2 INSTALLATION, BOXES

- A. Boxes shall be provided in the wiring or raceway system whenever required for pulling of wires, making connections and mounting of devices or lighting fixtures.

- B. Each box shall have the volume required by the PEC for the number of conduits terminating in the box and the number of conductors enclosed in the box.
- C. Boxes shall be at least 35 mm deep. The smallest utility box shall be 50 mm by 100 mm. Lighting fixture and telephone outlet boxes shall be at least 100 mm by 100 mm.
- D. Boxes installed for concealed wiring shall be provided with suitable extension rings or plaster covers.
- E. All boxes shall be properly supported to obtain a rigid raceway system.

**** END OF SECTION ****

SECTION 16134

WIRING DEVICES

PART 1 – REFERENCE

Requirements of Section 16050 Electrical General Provision apply to all work under this Section.

PART 2 - GENERAL

Furnish and install wiring devices as shown in the electrical plans.

PART 3 - DEVICES AND PLATES

- A. Wall Switches: Quiet type, spring operated. The type of switch shall be of tumbler operation. Rating as shown in the plan.
- B. General Purpose Receptacles: Hospital grade, flush mounting, type and rating as shown in the plan.
- C. General Purpose Wall Plates: Type, color, plating and appearance of device plates shall be as selected by the CONSULTANT. Appropriate samples shall be submitted prior to the purchase of the faceplates.

PART 4 - INSTALLATION

Connect wiring devices ground terminal to circuit ground wire.

PART 5 - LOCATIONS

Indicated locations are approximate. Determine exact locations at site by reference to building drawings and in coordination with work of other trades. Receptacles for appliances shall be as located as to be accessible, but not prominently displayed and upon coordination with the CONSULTANT.

PART 6 - WARRANTY

A warranty for a period of one (1) year shall be provided against failure of components resulting from normal use and/or factory defects.

**** END OF SECTION ****

SECTION 16211 ELECTRICITY METERING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes equipment for electricity metering by Owner.

1.2 DEFINITIONS

- A. KY Pulse: Term used by the metering industry to describe a method of measuring consumption of electricity that is based on a relay opening and closing in response to the rotation of the disk in the meter.
- B. PC: Personal computer.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For electricity-metering equipment.
 - 1. Dimensioned plans and sections or elevation layouts.
 - 2. Wiring Diagrams: For power, signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features.
- C. Field quality-control reports.
- D. Operation and Maintenance Data. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:
 - 1. Application and operating software documentation.
 - 2. Software licenses.
 - 3. Software service agreement.
 - 4. Hard copies of manufacturer's operating specifications, design user's guides for software and hardware, and PDF files on CD-ROM of the hard-copy Submittal.

1.4 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.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Receive, store, and handle modular meter center according to NECA 400.

1.6 COORDINATION

- A. Electrical Service Connections: Coordinate with utility companies and components they furnish as follows:
 - 1. Comply with requirements of utilities providing electrical power services.
 - 2. Coordinate installation and connection of utilities and services, including provision for electricity-metering components.

1.7 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning with Substantial Completion, provide software support for two years.
- B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
 - 1. Provide 30 days' notice to EMPLOYER'S REPRESENTATIVE to allow scheduling and access to system and to allow EMPLOYER'S REPRESENTATIVE to upgrade his computer equipment if necessary.

PART 2 - PRODUCTS

2.1 EQUIPMENT FOR ELECTRICITY METERING

- A. Acceptable Manufacturers: See Section 16007 "Alternative Equipment and Suppliers".
- B. General Requirements for EMPLOYER'S Meters:
 - 1. Comply with UL 1244.
 - 2. Meters used for billing shall have an accuracy of at least 0.5 percent of reading, complying with requirements in ANSI C12.20.
 - 3. Meters shall comply, be tested and certified by Energy Regulatory

- Commission.
4. Enclosure: NEMA 250, Type 1 minimum, with hasp for padlocking or sealing.
 5. Identification: Comply with requirements in Division 16 Section 16075 "Electrical Identification."
 6. Memory Backup: Self-contained to maintain memory throughout power outages of 72 hours, minimum.
 7. Sensors: Current-sensing type, with current or voltage output, selected for optimum range and accuracy for meters indicated for this application.
 - a. Type: Split and solid core as identified on plan.
 8. Current-Transformer Cabinet: Listed or recommended by metering equipment manufacturer for use with sensors indicated.
 9. Building Management System (BMS) Interface: One digital KY pulse to a user-definable increment of energy measurement. Match signal to BMS input and arrange to convey the instantaneous, integrated, demand level measured by meter to provide data for processing and possible programmed demand control action by destination system.
- C. Kilowatt-hour/Demand Meter: Electronic single-and three-phase meters, measuring electricity use and demand. Demand shall be integrated over a 15-minute interval.
1. Voltage and Phase Configuration: Meter shall be designed for use on circuits with voltage rating and phase configuration indicated for its application.
 2. Display: LCD with characters not less than 0.25 inch (6 mm) high, indicating accumulative kilowatt-hours, current time and date, current demand, and historic peak demand and time and date of historic peak demand. Retain accumulated kilowatt-hour and historic peak demand in a nonvolatile memory, until reset.
- D. Data Transmission Cable: Transmit KY pulse data over Class 1 control-circuit conductors in raceway. Comply with Division 16 Section 16123 "Control Communication Cables"
- E. Software: PC based, a product of meter manufacturer, suitable for calculation of utility cost allocation and billing.
1. Tenant or Activity Billing Software: Automatically import energy-usage records to automatically compute and prepare tenant bills, activity demand and energy-use statements based on metering of energy use and peak demand. Maintain separate directory for each tenant's historical billing information. Prepare summary reports in user-defined formats and time intervals.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with equipment installation requirements in NECA 1.
- B. Install meters furnished by utility company. Install raceways and equipment according to utility company's written requirements. Provide empty conduits for metering leads and extend grounding connections as required by utility company.
- C. Install modular meter center according to NECA 400 switchboard installation requirements.

3.2 IDENTIFICATION

- A. Comply with requirements for identification specified in Division 16 Section "Electrical Identification."
 - 1. Series Combination Warning Label: Self-adhesive type, with text as required by NFPA 70.
 - 2. Equipment Identification Labels: Adhesive film labels with clear protective overlay.

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Tests and Inspections:
 - 1. Connect a load of known kilowatt rating, 1.5 kW minimum, to a circuit supplied by metered feeder.
 - 2. Turn off circuits supplied by metered feeder and secure them in off condition.
 - 3. Run test load continuously for eight hours minimum, or longer, to obtain a measurable meter indication. Use test-load placement and setting that ensures continuous, safe operation.
 - 4. Check and record meter reading at end of test period and compare with actual electricity used, based on test-load rating, duration of test, and sample measurements of supply voltage at test-load connection. Record test results.
- C. Electricity metering will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.4 COMMISSIONING

3.5 DEMONSTRATION

- A. Engage a factory authorized service representative to train Owners' maintenance personnel to adjust, operate, and maintain the electrical metering.

*******END OF SECTION*******

SECTION 16230

ENGINE GENERATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions apply to this Section.

1.2 SUMMARY

- A. This Section includes packaged engine-generator sets for emergency standby power supply with the following features:
 - 1. Diesel engine.
 - 2. Unit-mounted cooling system.
 - 3. Unit-mounted control panel.
 - 4. Performance requirements for sensitive loads.
- B. Related Sections include the following:
 - 1. Section 16415 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.

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.

1.4 ACTION SUBMITTALS

- A. Product Data: For the engine generator indicated, include rated capacities, operating characteristics, and furnished specialties and accessories. In addition, include the following:
 - 1. Thermal damage curve for generator.

2. Time-current characteristic curves for generator protective device.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 1. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.
 2. Vibration Isolation Base Details: Include detail fabrication, anchorages and attachments to structure and to supported equipment. Include base weights.
 3. Wiring Diagrams: Power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Manufacturer Seismic Qualification Certification: Submit certification that day tank, engine-generator set, batteries, battery charger, battery racks accessories, and components will withstand seismic forces. Include the following:
 1. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 2. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Qualification Data: For installer, manufacturer and testing agency.
- C. Source certified quality-control test reports such as the following:
 1. Summary of prototype-unit test report.
 2. Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
 3. Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.

4. Report of factory test on units, showing evidence of compliance with specified requirements.
5. Report of sound generation.
6. Report of exhaust emissions showing compliance with applicable regulations.
7. Torsional Vibration Compatibility: Comply with NFPA 110 (Standard for Emergency and Standby Power Systems).

D. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals. In addition to items specified in in Section 01700 under "Execution Requirements" "Operation and Maintenance Data", include the following:
 1. List of tools and replacement items recommended for storage in the project for ready access. Include part and drawing numbers, current unit prices, and source of supply.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. 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.

1.8 QUALITY ASSURANCE

- A. **Installer Qualifications:** Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
 - 1. **Maintenance Proximity:** Not more than four hours' normal travel time from Installer's place of business to Project site.
 - 2. **Engineering Responsibility:** Preparation of data for vibration isolators and seismic restraints of engine skid mounts, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.
- B. **Manufacturer Qualifications:** A qualified manufacturer. With branch office or fabrication shop within 321 km from Project site, a service center capable of providing training, parts, and emergency maintenance repairs.
- C. Retain first paragraph below if Contractor selects testing agency or Contractor is required to provide services of an independent testing agency in Part 3 "Field Quality Control" Article. Qualification requirements supplement those specified in Section 014000 "Quality Requirements," which also includes the definition for "NRTL" (nationally recognized testing laboratory).
- D. **Testing Agency Qualifications:** An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL), and that is acceptable to authorities having jurisdiction.
 - 1. **Testing Agency's Field Supervisor:** Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- E. **Source Limitations:** Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.

- F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- G. Comply with ASME B15.1 (Safety Standard For Mechanical Power Transmission Apparatus).
- H. Comply with NFPA 37 (Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines).
- I. Comply with NFPA 70 (National Electrical Code) and Philippine Electrical Code (PEC).
- J. Retain paragraph below for healthcare facilities
- K. Retain first paragraph below if generator is automatically started. See Editing Instruction No. 4 in the Evaluations.
- L. Comply with NFPA 110 requirements for Level 1 emergency power supply system.
- M. Comply with UL 2200 (Standard for Stationary Engine Generator Assemblies).
- N. Engine Exhaust Emissions: Comply with applicable state and local government requirements.
- O. Noise Emission: Comply with applicable 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.

1.9 PROJECT CONDITIONS

- 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 Construction Manager/Owner no fewer than two days in advance of proposed interruption of electrical service.
 2. Do not proceed with interruption of electrical service without Construction Manager/Owner's written permission.
- B. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
1. Ambient Temperature: 20 to 40 deg C.
 2. Relative Humidity: 0 to 95 percent.
 3. Altitude: Not more than 3000 m above sea level.

1.10 COORDINATION

- A. Coordinate size and location of concrete bases for package engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.11 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged engine generator and associated auxiliary components that fail in materials or workmanship within specified warranty period.
1. Warranty Period: one year from date of Substantial Completion.

1.12 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.

PART 2 - PRODUCTS

2.1 ENGINE-GENERATOR SET

- A. Factory-assembled and -tested, silent type engine-generator set.
- B. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.
 - 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.
- C. Capacity and Characteristics:
 - 1. Power Output Rating: Nominal ratings as indicated in plans.
 - 2. Output Connections: Three-phase, four wire.
 - 3. Nameplate: For each major system component to identify manufacturer's name and address, and model and serial number of component.
- D. 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 (Motors and Generators), shall not exceed 50 percent.
 7. **Sustained Short-Circuit Current:** For a 3-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 (Standard for Emergency and Standby Power Systems), Type 10, system requirements.
- E. **Generator-Set Performance for Sensitive Loads:**
1. Over sizing generator compared with the rated power output of the engine is permissible to meet specified performance.
 - a. **Nameplate Data for Oversized Generator:** Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.
 2. **Steady-State Voltage Operational Bandwidth:** 1 percent of rated output voltage from no load to full load.
 3. **Transient Voltage Performance:** Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage

shall recover and remain within the steady-state operating band within 0.5 second.

4. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.
5. 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.
6. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.
7. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
8. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.
9. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.
 - a. Provide permanent magnet excitation for power source to voltage regulator.
10. Start Time: Comply with NFPA 110, Type 10, system requirements.

2.2 ENGINE

- A. Fuel: Fuel oil, Grade DF-2.

- B. Rated Engine Speed: 1800 rpm.
- C. Maximum Piston Speed for Four-Cycle Engines: 11.4 m/s.
- 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. Engine Fuel System:
 - 1. Main Fuel Pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
 - 2. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.
- F. Governor: Adjustable isochronous, with speed sensing.
- G. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.
 - 1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
 - 2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
 - 3. 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.

4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.
 - a. Rating: 345-kPa maximum working pressure with coolant at 82 deg C, and noncollapsible under vacuum.
 - b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.
- H. Muffler/Silencer: Critical type silencer, 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 3 m from exhaust discharge after installation is complete shall be 75 dBA or less.
- I. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.
- J. Starting System: 24-V electric, with negative ground.
 1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in Part 1 "Project Conditions" 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: Adequate capacity within ambient temperature range specified in Part 1 "Project Conditions"

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 Part 1 "Project Conditions" Article. Include accessories required to support and fasten batteries in place.
7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
8. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. 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 C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
 - c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
 - d. 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 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 generator control panel.
- f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.3 FUEL OIL STORAGE

- A. Comply with NFPA 30 (Flammable and Combustible Liquids Code).
- B. Day Tank: Comply with UL 142 (Standard for Steel Aboveground Tanks for Flammable and Combustible Liquids), freestanding, factory-fabricated fuel tank assembly, with integral, float-controlled transfer pump and the following features:
 - 1. Containment: Integral rupture basin with a capacity of 150 percent of nominal capacity of day tank.
 - a. Leak Detector: Locate in rupture basin and connect to provide audible and visual alarm in the event of day-tank leak.
 - 2. Tank Capacity: As indicated on plans (providing 8 hours at full load capacity).
 - 3. Pump Capacity: Exceeds maximum flow of fuel drawn by engine-mounted fuel supply pump at 110 percent of rated capacity, including fuel returned from engine.
 - 4. Low-Level Alarm Sensor: Liquid-level device operates alarm contacts at 25 percent of normal fuel level.
 - 5. High-Level Alarm Sensor: Liquid-level device operates alarm and redundant fuel shutoff contacts at midpoint between overflow level and 100 percent of normal fuel level.

6. Piping Connections: Factory-installed fuel supply and return lines from tank to engine; local fuel fill, vent line, overflow line; and tank drain line with shutoff valve.
7. Redundant High-Level Fuel Shutoff: Actuated by high-level alarm sensor in day tank to operate a separate motor device that disconnects day-tank pump motor. Sensor shall signal solenoid valve, located in fuel suction line between fuel storage tank and day tank, to close. Both actions shall remain in shutoff state until manually reset. Shutoff action shall initiate an alarm signal to genset control panel but shall not shut down engine-generator set.

2.4 CONTROL

- A. Automatic Starting System Sequence of Operation: When mode-selector switch on the generator control 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. Operation of a remote emergency-stop switch also shuts down generator set.
- 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. Operation of a remote emergency-stop switch also shuts down generator set.
- C. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a

common control panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.

- D. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control panel.
- E. Configuration: Operating and safety indications, protective devices, basic system controls, engine gages, instrument transformers, generator disconnect switch or circuit breaker, and other indicated components shall be grouped in a combination control and power panel. Control section of panel shall be isolated from power sections by steel barriers. Panel features shall include the following:
 - 1. Wall-Mounting Cabinet Construction: Rigid, self-supporting steel unit. Power bus shall be copper. Bus, bus supports, control wiring, and temperature rise shall comply with UL 891 (Switchboard).
 - 2. Switchboard Construction: Freestanding unit
 - 3. Switchgear Construction: Freestanding unit
 - 4. Current and Potential Transformers: Instrument accuracy class.
- F. Indicating and Protective Devices and Controls: As required by NFPA 110, and the following:
 - 1. AC voltmeter.
 - 2. AC ammeter.
 - 3. AC frequency meter.
 - 4. DC voltmeter (alternator battery charging).
 - 5. Engine-coolant temperature gage.
 - 6. Engine lubricating-oil pressure gage.
 - 7. Running-time meter.
 - 8. Ammeter-voltmeter, phase-selector switch(es).
 - 9. Generator-voltage adjusting rheostat.
 - 10. Fuel tank derangement alarm.
 - 11. Fuel tank high-level shutdown of fuel supply alarm.

12. Generator overload.

G. Indicating and Protective Devices and Controls:

1. AC voltmeter.
2. AC ammeter.
3. AC frequency meter.
4. DC voltmeter (alternator battery charging).
5. Engine-coolant temperature gage.
6. Engine lubricating-oil pressure gage.
7. Running-time meter.
8. Ammeter-voltmeter, phase-selector switch(es).
9. Generator-voltage adjusting rheostat.
10. Start-stop switch.
11. Overspeed shutdown device.
12. Coolant high-temperature shutdown device.
13. Coolant low-level shutdown device.
14. Oil low-pressure shutdown device.
15. Fuel tank derangement alarm.
16. Fuel tank high-level shutdown of fuel supply alarm.
17. Generator overload.

- 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 Data Link: A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication is reserved for connections for data-link transmission of indications to remote data terminals.

- J. Common Audible Alarm: Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control panel.

1. Overcrank shutdown.

2. Coolant low-temperature alarm.
 3. Control switch not in auto position.
 4. Battery-charger malfunction alarm.
 5. Battery low-voltage alarm.
- K. Common Audible Alarm: Signal the occurrence of any events listed below without differentiating between event types. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset.
1. Engine high-temperature shutdown.
 2. Lube-oil, low-pressure shutdown.
 3. Overspeed shutdown.
 4. Remote emergency-stop shutdown.
 5. Engine high-temperature prealarm.
 6. Lube-oil, low-pressure prealarm.
 7. Fuel tank, low-fuel level.
 8. Low coolant level.
- L. 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.
- M. Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

2.5 GENERATOR OVERCURRENT AND FAULT PROTECTION

- A. Generator Circuit Breaker: Air Circuit Breaker, electronic-trip type, 125 percent rated; complying with NEMA AB 1 and UL 489.

1. Tripping Characteristic: Designed specifically for generator protection.
 2. Trip Rating: Matched to generator rating.
 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 panel.
- B. Generator Circuit Breaker: Air Circuit Breaker, electronic-trip type; 125 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 panel.
- C. 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 panel.
- D. Generator Disconnect Switch: Air Circuit Breaker type, 100 percent rated.
1. Rating: Matched to generator output rating.
 2. Shunt Trip: Connected to trip switch when signaled by generator protector or by other protective devices.
- E. 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 shall perform 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.
 2. Under single or three-phase fault conditions, regulates generator to 300 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.
- F. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.

2.6 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.
- E. 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.
- F. Enclosure: Drip-proof.
- G. Instrument Transformers: Mounted within generator enclosure.

- H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.
 - 1. Adjusting rheostat on control panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.
- I. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.
- J. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.
- K. Sub-transient Reactance: 12 percent, maximum.

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 of 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 INSTALLATION

- A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.
- B. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.
- C. Install packaged engine generator with restrained spring isolators having a minimum deflection of 25 mm on 100-mm high concrete base.
- D. 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 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.
- E. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.3 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 engine exhaust pipe to engine with flexible connector.
- D. Ground equipment according to Section 16060 "Grounding and Bonding"
- E. Connect wiring according to Section 16120 "Conductors and Cables."

3.4 IDENTIFICATION

- A. Identify system components according to Section 16075 "Electrical Identification".

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections and prepare test reports.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- C. Perform tests and inspections and prepare test reports.
 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and

equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.
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 120 kPa. 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 under 25 percent and at 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 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 standards of NIST, and adequate for making positive observation of test results. Make calibration records available for examination on request.
 - G. Leak Test: After installation, charge system 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.
 - I. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

- J. Remove and replace malfunctioning units and re-test 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.

3.6 DEMONSTRATION

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

****END OF SECTION****

SECTION 16301

UNDERGROUND ELECTRICAL WORKS

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

Section 16011, "Electrical General Requirements" applies to this section with additions and modifications specified herein.

1.2 SUBMITTALS

Submit the following information for approval:

1.2.1 Manufacturer's Data and Shop Drawings:

- a. Conduit;
- b. Insulating Tape;
- c. Splice kits, medium and low voltage;
- d. Cable lubricants;
- e. Conduit Spacers

1.2.2 Manufacturer's Instructions:

- a. Manufacturer's directions for use of ground megger with proposed method indicated;
- b. Terminator manufacturer's installation instructions

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Materials and equipment shall conform to the respective specifications and standards and to the specifications herein. Electrical ratings shall be as indicated.

2.1.1 Conduit

- a. Rigid Plastic Conduit: PVC conduit shall be thick wall, "CROWN PIPES", "NELTEX" or "MOLDEX" brand.
- b. Conduit Spacers: PVC plastic duct spacers shall be provided, quantities and sizes, as required, "Carlton".

2.1.2 Tape

Plastic insulating tape shall be capable of performing in a continuous temperature environment of 80°C.

2.1.3 Power Wire and Cable

- a. Wire and Cable Conductor Sizes: Wire and cable conductor sizes are designated by Square Millimeter (mm²). Conductors shall be copper. Insulated conductors shall bear the date of manufacture imprinted on the wire insulation with other identification. Wire and cable manufactured more than 6 months before deliver to the job site shall not be used. Provide conductor identification within each enclosure where a tap, a splice or a termination is made.
- b. 600 Volt Wires and Cables: Conductor sizes are indicated by Square Millimeter (mm²) for copper conductors. Insulated wires and cables manufactured more than six months prior to delivery shall not be used. Wires and cables shall be "Phelps Dodge" or "Phillflex".
- c. Wire Conformation: Provide wires with type THW designation. Only wires with "W" in the type designation shall be used in wet or damp locations.
- d. 600 Volt Wire Connector and Terminals: Shall provide a uniform compression over the entire contact surface. Solderless terminal lugs shall be used on stranded conductors.

2.1.4 Indoor Terminations/Terminations Within Equipment Enclosures: Refer to equipment specifications.

2.1.5 Pull Wire: Pull wire shall be 2.0 mm² hot-dip galvanized steel or plastic having a minimum tensile strength of 91 kgs in each empty duct. Minimum 305 mm of slack shall be left at each end of pull wires.

2.1.6 Buried Warning and Identification Tape: Provide detectable aluminum foil plastic-backed tape or detectable magnetic plastic tape manufactured specifically for warning and identification of buried cable and conduit. Tape shall be detectable by an electronic detection instrument. Provide tape in rolls, 50 mm minimum width, color coded for the utility involved with warning and identification imprinted in bold black letters continuously and repeatedly over entire tape length. Warning and identification shall be CAUTION BURIED ELECTRIC.

2.1.7 Grounding and Bonding Equipment: Shall conform to UL.

PART 3 - EXECUTION

3.1 INSTALLATION

Underground cable installation shall conform to Philippine Electrical Code.

- 3.1.1 Concrete: Unless indicated on plans, concrete for electrical requirements shall be at least 211 kg per square centimeter concrete with 2.54 cm maximum aggregate.
- 3.1.2 Earthwork: Excavation, backfilling, and pavement repairs for electrical requirements shall conform to the requirements of existing Civil Works specifications.
- 3.1.3 Cast-in-Place Service Boxes: Provide cast-in-place service boxes as indicated.
- 3.1.4 Ground Rods: In each electric manhole, at a convenient point close to the wall, a 20 mm by 3048 mm copper-clad steel ground rod shall be driven into the earth before the floor is poured so that approximately 100 mm of the ground rod will extend above the trench manhole and handhole floor. When precast concrete manholes and handholes are used, the top of the ground rod may be below the floor and a 50 mm tinned ground conductor brought into the handhole through a watertight sleeve in the handhole wall.
- 3.1.5 Cable Pulling: Test duct lines with a mandrel and thoroughly swab out to remove foreign material before the pulling of cables. Pull cables down grade with the feed-in-point at the junction box or buildings of the highest elevation. Use flexible cable feeds to convey cables through the manholes/handholes opening and into the duct runs. Cable slack shall be accumulated at each manholes/handhole or junction box where space permits by training the cable around the interior to form one complete loop. Minimum allowable bending radii shall be maintained in forming such loops.
 - 3.1.5.1 Lubricants for assisting in the pulling of jacketed cables shall be those specifically recommended by the cable manufacturer. Cable lubricants shall be soapstone, graphite, or talk for rubber or plastic jacketed cables. The lubricant shall not be deleterious to the jacket or outer coverings.
 - 3.1.5.2 Cable pulling tensions shall not exceed the maximum pulling tension recommended by the cable manufacturer.
- 3.1.6 Grounding: Non-current carrying metallic parts associated with electrical equipment shall have a maximum resistance to "solid" earth ground not exceeding the following values:

When work in addition to that indicated or specified is directed in order to obtain the specified ground resistance, the provisions of the contract covering "Changes" shall apply.

3.1.6.1 Grounding electrodes: Provide cone pointed driven ground rods driven full depth plus 150 mm, installed to provide an earth ground of the appropriate value for the particular equipment being grounded.

3.1.6.2 Make grounding connections which are buried or otherwise normally inaccessible, and excepting specifically those connections for which access for periodic testing is required by exothermic type process. Make fusion-welding process strictly in accordance with the weld manufacturer's written recommendations. Welds which have "puffed up" or which show convex surfaces indicating improper cleaning is not acceptable. No mechanical connector is required at thermic weldments.

3.1.6.3 In lieu fusion-welding process, a compression ground grid connector of a type, which uses hydraulic compression tool to provide the correct circumferential pressure, may be used. Tools and dies shall be as recommended by the manufacturer. An embossing die code or other standard method shall provide visible indication that a connector has been adequately compressed on the ground wire.

3.1.6.4 Grounding conductors shall be bare soft-drawn copper wire 14 mm. minimum unless otherwise indicated or specified.

3.1.6.5 Connect copper-clad steel ground rods only to insulated THW copper ground conductor and weld the connection. Insulate the entire area of the rod in the vicinity of the weld and the connecting wire and seal against moisture penetration.

3.1.7 Provide all empty conduits with a 2.0 mm zinc coated steel wire or a plastic rope having a breaking strength of at least 90 kgs. Leave 610 mm of spare at each end of the pull.

3.2 FIELD TESTS

As an exception to requirements that may be stated elsewhere in the contract, the Owner shall be given 4 working days notice prior to each test.

3.2.1 Distribution Conductors 600 Volt Class: Test all 600-volt class conductors to verify that no short circuits or accidental grounds exist. Make tests using an instrument, which applies a voltage of approximately 500 volts to provide a direct reading in resistance.

3.2.2 Ground Rods: Test ground rods for ground resistance value before any wire is connected. Use a portable ground testing megger to test each ground or group of grounds. The instrument shall be equipped with a

meter reading directly in ohms or fractions thereof to indicate the ground value of the ground electrode under test. Provide one copy of the megger manufacturer's directions for use of the ground megger indicating the method to be used.

3.2.3 Test Report:

600-volt cables (identify each cable & test result).

Grounding Electrodes & Systems (identify electrodes and systems, each test).

***** END OF SECTION *****

SECTION 16410

ENCLOSED CIRCUIT BREAKERS AND DISCONNECT SWITCHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Disconnect Switches
 - 2. Individually mounted, enclosed circuit breakers.
 - 3. Molded-case switches.

1.3 DEFINITIONS

- A. NC: Normally closed.
- B. NO: Normally open.
- C. SPDT: Single pole, double throw.

1.4 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. Include evidence of NRTL listing for series rating of installed devices.
 - 5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
 - 6. 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. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Wiring Diagrams: For power, signal, and control wiring.
- C. Qualification Data: For qualified testing agency.
- D. Field quality-control reports.

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

E. Manufacturer's field service report.

Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section 01782 "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 QUALITY ASSURANCE

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

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

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

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. 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.

E. Comply with NFPA 70.

1.6 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 (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
2. Altitude: Not exceeding 6600 feet (2010 m).

1.7 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.

1.8 EXTRA MATERIALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. 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.

PART 2 - PRODUCTS

2.1 MOLDED-CASE SWITCHES

- A. General Requirements: MCCB with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.
- B. Features and Accessories:
 - 1. Standard frame sizes and number of poles.
 - 2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
 - 3. Ground-Fault Protection: Comply with UL 1053; remote-mounted and powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
 - 4. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
 - 5. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
 - 6. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic switch contacts, "b" contacts operate in reverse of switch contacts.
 - 7. Alarm Switch: One NC contact that operates only when switch has tripped.
 - 8. Key Interlock Kit: Externally mounted to prohibit switch operation; key shall be removable only when switch is in off position.
 - 9. Zone-Selective Interlocking: Integral with ground-fault shunt trip unit; for interlocking ground-fault protection function.
 - 10. Electrical Operator: Provide remote control for on, off, and reset operations.
 - 11. Accessory Control Power Voltage: Integrally mounted, self-powered 240-V ac.

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. Kitchen and 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 9.

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 specified in Division 16 Section 16074 "Vibration and Seismic Controls for Electrical Systems."
- 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 Division 16 Section 16075 "Electrical Identification."
 - 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 FILED 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, and to assist in testing.
- D. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each enclosed switch and circuit breaker, cable, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- E. Tests and Inspections:
 - 1. Perform each visual, electrical, and mechanical inspection and electrical test 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. Perform the following infrared scan tests and inspections and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.
 - c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- F. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
- G. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. 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 Division 16 Section 16055 "Overcurrent Protective Device Coordination".

****END OF SECTION****

SECTION 16415

TRANSFER SWITCHES

PART 1 – GENERAL

1.1 Related Documents

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

1.2 Summary

- A. This Section includes transfer switches rated 600 V and less, including the following:
 - 1. Automatic Transfer Switches, open transition.
 - 2. Bypass/isolation switches.
 - 3. Non-automatic transfer switches.
 - 4. Remote annunciation systems.
 - 5. Remote annunciation and control systems.
 - 6. Manual Transfer Switch Circuit Breaker Type with Mechanical-Electrical Interlock Mechanism

1.3 Submittals

- A. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.
 - 1. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.
- C. Manufacturer Seismic Qualification Certification: Submit certification that transfer switches accessories, and components will withstand seismic forces defined in Division 16 Section 16073 and 16074 "Hangers and Supports for Electrical Systems and Vibration and Seismic Controls for Electrical Systems" Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
 - b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Qualification Data: For manufacturer and testing agency.
- E. Field quality-control test reports.
- F. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section 01782 "Operation and Maintenance Data," include the following:
1. Features and operating sequences, both automatic and manual.
 2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.4 Quality Assurance

- A. Manufacturer Qualifications: Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than eight hours from time of notification.
- B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the International Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
- A. Testing Agency's Field Supervisor: Person currently certified by the International Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

- C. Source Limitations: Obtain automatic transfer switches, bypass/isolation switches, nonautomatic transfer switches, remote annunciators and remote annunciator and control panels through one source from a single manufacturer.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Comply with NEMA ICS 1.
- F. Comply with Philippine Electrical Code (PEC).
- G. Comply with NFPA 99.
- H. Comply with NFPA 110.
- I. Comply with UL 1008 unless requirements of these Specifications are stricter.

1.6 Coordination

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

PART 2 – PRODUCTS

2.1 General Transfer-Switch Product Requirements

- A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.
- B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.
- C. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.
- D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

- E. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.
- F. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
 - 1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.
 - 2. Switch Action: Double throw; mechanically held in both directions.
 - 3. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.
- G. Neutral Switching. Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles.
- H. Oversize Neutral: Ampacity and switch rating of neutral path through units indicated for oversize neutral shall be double the nominal rating of circuit in which switch is installed.
- I. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.
- J. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable tape markers are specified in Division 16 Section 16075 "Electrical Identification."
 - 1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
 - 2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
 - 3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
- K. Enclosures: General-purpose NEMA 250, Type 1, 3R, 12, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

2.3 Automatic Transfer Switches

- A. Comply with Level 1 equipment according to NFPA 110.

- B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.
- C. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.
- D. Manual Switch Operation: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation.
- E. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.
- F. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.
- G. Transfer Switches Based on Molded-Case-Switch Components: Comply with NEMA AB 1, UL 489, and UL 869A.
- H. Motor Disconnect and Timing Relay: Controls designate starters so they disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters is through wiring external to automatic transfer switch. Time delay for reconnecting individual motor loads is adjustable between 1 and 60 seconds, and settings are as indicated. Relay contacts handling motor-control circuit inrush and seal currents are rated for actual currents to be encountered.
- I. Automatic Transfer-Switch Features:
 - 1. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
 - 2. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.
 - 3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
 - 4. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes to automatically

defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.

5. Test Switch: Simulate normal-source failure.
6. Switch-Position Pilot Lights: Indicate source to which load is connected.
7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.
 - a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
 - b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."
8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
12. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:
 - a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
 - b. Push-button programming control with digital display of settings.
 - c. Integral battery operation of time switch when normal control power is not available.

2.4 Bypass/Isolation Switches

- A. Comply with requirements for Level 1 equipment according to NFPA 110.
- B. Description: Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and

from both power sources. Include the following features for each combined automatic transfer switch and bypass/isolation switch:

1. Means to lock bypass/isolation switch in the position that isolates transfer switch with an arrangement that permits complete electrical testing of transfer switch while isolated. While isolated, interlocks prevent transfer-switch operation, except for testing or maintenance.
2. Drawout Arrangement for Transfer Switch: Provide physical separation from live parts and accessibility for testing and maintenance operations.
3. Bypass/Isolation Switch Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with same phase arrangement and number of poles.
4. Contact temperatures of bypass/isolation switches shall not exceed those of automatic transfer-switch contacts when they are carrying rated load.
5. Operability: Constructed so load bypass and transfer-switch isolation can be performed by 1 person in no more than 2 operations in 15 seconds or less.
6. Legend: Manufacturer's standard legend for control labels and instruction signs shall describe operating instructions.
7. Maintainability: Fabricate to allow convenient removal of major components from front without removing other parts or main power conductors.

- C. Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars; plated at connection points and braced for the indicated available short-circuit current.

2.6 Remote Annunciator System

- A. Functional Description: Remote annunciator panel shall annunciate conditions for indicated transfer switches. Annunciation shall include the following:
 1. Sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
 2. Switch position.
 3. Switch in test mode.
 4. Failure of communication link.
- B. Annunciator Panel: LED-lamp type with audible signal and silencing switch.
 1. Indicating Lights: Grouped for each transfer switch monitored.
 2. Label each group, indicating transfer switch it monitors, location of switch, and identity of load it serves.

3. Mounting: Flush, modular, steel cabinet, unless otherwise indicated.
4. Lamp Test: Push-to-test or lamp-test switch on front panel.

2.7 Remote Annunciator and Control System

- A. Functional Description: Include the following functions for indicated transfer switches:
 1. Indication of sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
 2. Indication of switch position.
 3. Indication of switch in test mode.
 4. Indication of failure of digital communication link.
 5. Key-switch or user-code access to control functions of panel.
 6. Control of switch-test initiation.
- B. Malfunction of annunciator, annunciation and control panel, or communication link shall not affect functions of automatic transfer switch. In the event of failure of communication link, automatic transfer switch automatically reverts to stand-alone, self-contained operation. Automatic transfer-switch sensing, controlling, or operating function shall not depend on remote panel for proper operation.

2.8 Source Quality Control

- A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

PART 3 – EXECUTION

3.1 Installation

- A. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Division 16 Section 16073 and 16074 "Hangers and Supports for Electrical Systems and Vibration and Seismic controls for Electrical Systems" respectively.
- B. Floor-Mounting Switch: Anchor to floor by bolting.
 1. Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no more than 4 inches (100 mm) in all directions beyond the maximum dimensions of switch, unless otherwise indicated or unless required for seismic support. Construct concrete bases according to

Division 16 Section 16073 and 16074 "Hangers and Supports for Electrical Systems and Vibration and Seismic controls for Electrical Systems" respectively.

- C. Annunciator and Control Panel Mounting: Flush in wall, unless otherwise indicated.
- D. Identify components according to Division 16 Section "Electrical Identification."
- E. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

3.2 Connections

- A. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.
- B. Ground equipment according to Division 16 Section 16060 "Grounding and Bonding."
- C. Connect wiring according to Division 16 Section 16120 "Conductors and Cables."

3.3 Field Quality Control

- A. Testing Agency: **Engage** a qualified independent testing and inspecting agency to perform tests and inspections and prepare test reports.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- C. Perform tests and inspections and prepare test reports.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installation, including connections, and to assist in testing.
 - 2. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.

3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
 - a. Check for electrical continuity of circuits and for short circuits.
 - b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
 - c. Verify that manual transfer warnings are properly placed.
 - d. Perform manual transfer operation.
5. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
 - a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
 - b. Simulate loss of phase-to-ground voltage for each phase of normal source.
 - c. Verify time-delay settings.
 - d. Verify pickup and dropout voltages by data readout or inspection of control settings.
 - e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
 - f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
 - g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
6. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
 - a. Verify grounding connections and locations and ratings of sensors.

D. Testing Agency's Tests and Inspections:

1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

3. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
 - a. Check for electrical continuity of circuits and for short circuits.
 - b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
 - c. Verify that manual transfer warnings are properly placed.
 - d. Perform manual transfer operation.
 4. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
 - a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
 - b. Simulate loss of phase-to-ground voltage for each phase of normal source.
 - c. Verify time-delay settings.
 - d. Verify pickup and dropout voltages by data readout or inspection of control settings.
 - e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
 - f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
 - g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
 5. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
 - a. Verify grounding connections and locations and ratings of sensors.
- E. Coordinate tests with tests of generator and run them concurrently.
- F. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- G. Remove and replace malfunctioning units and retest as specified above.

- H. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.
 - 1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 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 switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

3.4 Demonstration

- A. Engage a factory-authorized service representative to train EMPLOYER's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below.
- B. Coordinate this training with that for generator equipment.

**** END OF SECTION ****

SECTION 16442

PANELBOARD

PART 1 – GENERAL

1.1 SCOPE OF WORK

The Contractor shall furnish and install distribution and lighting panelboard as hereinafter specified or as shown on the Drawings.

1.2 SUBMITTALS:

- A. Catalog sheets of panelboard, circuit breakers.
- B. Shop drawing of panelboard.

PART 2 – PRODUCTS

2.1 RATING

Panelboard ratings shall be as shown on the Drawings. All panelboard shall be rated for the intended voltage.

2.2 STANDARDS

Panelboard shall be in accordance with the Underwriters Laboratories, Inc. "Standard for Panelboard" and "Standard for Cabinets and Boxes" and shall be so labeled where procedures exist. Panelboard shall also comply with NEMA Standards for Panelboard, and the PEC.

2.3 CONSTRUCTION

A. Interiors

- All interiors shall be completely factory assembled with circuit breakers, wire connectors, etc. All wire connectors, except screw terminals, shall be of the anti-turn solderless type and shall be suitable for copper or aluminum wire of the sizes indicated.
- Interiors shall be designed that circuit breakers can be replaced without disturbing adjacent units and without removing the main bus connectors and shall be so designed that circuit may be changed without machining, drilling or tapping.
- Branch circuits shall be arranged using double row construction. Branch circuits shall be numbered by the manufacturer.
- A nameplate shall be provided with a listing panel type, number of circuit breakers and ratings.
- Shall be dead front with sealed bushings with indoor side pocket for circuit directory.

B. Buses

- Bus bars for the main shall be copper. Full size neutral bars shall be included. Bus bar taps for panels with single pole branches shall be arranged for sequence phasing of the branch circuit devices. Busing shall be braced throughout to conform to industry standard practice governing short circuit stresses in panelboard. Phase busing shall be full height without reduction. Cross connectors shall be copper.
- Neutral busing shall have a suitable lug for each outgoing feeder requiring a neutral connection.
- Spaces for future circuit breakers shall be bussed for the maximum device that can be fitted into them.

C. Boxes

- Boxes shall be made from galvanized code gauge steel having multiple knockouts unless otherwise noted. Surface mounted boxes shall be painted to match the trim. Boxes shall be of sufficient size to provide a minimum gutter space of 100 mm on all sides.
- At least four interior mounting studs shall be provided.

D. Trim

- Hinged doors covering all circuit breakers handles shall be included in all panel trims.
- Doors shall have semi-flush type cylinder lock and catch except that doors over 1.25 m in height shall have a vault handle and 3-point catch complete with lock, arranged to fasten door at top, bottom and center. Door hinges shall be concealed. Two keys shall be supplied for each lock. All locks shall be keyed alike; directory frame and card having a transparent cover shall be furnished on each door.
- The trim shall be fabricated from standard gauge sheet steel.
- All interior and exterior steel surfaces of the panelboard shall be properly cleaned and finished with light gray enamel paint over rust inhibiting phosphatized coating. The finished paint shall be of a type to which field applied paint will adhere.
- Trim for flush mounted panels shall overlap the box by at least 20 mm all around. Surface trim shall have the same width and height as the box. Trim shall be fastened with quarter turn clamps.

E. Circuit Breakers

- Panelboard shall be equipped with circuit breakers with frame size and trip settings shown on the Drawings.
- Branch circuit breakers shall be molded case, bolt-on type.
- Circuit breakers used in 230 volts panelboard shall have an interrupting capacity of not less than 10,000 amperes, RMS, symmetrical.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Surface mounted boxes shall be mounted so there is at least 15 mm air space between the box and the wall.
- B. Mount panelboard so the height of the operating handle is at its highest position will not exceed two (2) meters from the floor.

3.2 TESTING:

- A. Operate circuit breakers three times, demonstrating satisfactory operation each time.

**** END OF SECTION ****

SECTION 16450 GROUNDING SYSTEM

PART 1 – REFERENCE

Requirements of Section 16050 Electrical General Provision apply to all work under this Section.

PART 2 - GENERAL

Furnish all materials and labor required to ground the panelboards, motor frames, conduit systems, and all other electrical equipment.

PART 3 - MATERIALS

- A. Ground Rods: Copper clad, 20mm dia. X 3000 mm, length, manufacturer's brand shall be KUMWELL or approved equal. Detail as shown on the drawings.
- B. Ground Cable: Stranded soft-drawn copper.
- C. Insulators and miscellaneous installation materials: As shown on drawings.
- D. Ground Bar: shall be made of Copper.

PART 4 - INSTALLATION:

- A. Raceway Grounding: Ground all conduit systems. Use double locknuts at all panels; use bonding jumpers if conduits are installed in concentric knockouts.
- B. Equipment Grounding
 - 1. Ground separately-mounted motor controllers, motor frames, distribution boards, switches and outlets through grounded conductor.
 - 2. Connect all receptacles to grounding conductor.
 - 3. Ground transformer cases and neutrals as required.
 - 4. All conduit systems shall be provided with a ground wire sized as per PEC.

PART 5 - TESTS

- A. Ground rod-earth resistance test:
 - 1. Test each ground rod by single test "Megger" method.
 - 2. Test equipment: To be furnished by CONTRACTOR, equal to "Megger".
- B. Test report: Submit typewritten report, equipment used, person or persons performing the tests, date tested, circuits or equipment tested, and results of tests.

END OF SECTION

SECTION 16510

INTERIOR LIGHTING SYSTEM

PART 1 – GENERAL

1.1 SCOPE OF WORK

The Contractor shall furnish and install lighting fixtures, photocell switches, contactors, and battery-powered units and systems for interior use, including lighting fixtures and accessories mounted on the exterior surfaces of the building.

1.2 STANDARDS

All lighting fixtures shall be in accordance with the latest edition of the PEC and shall be constructed in accordance with the latest edition of the Underwriters Laboratories "Standards for Safety, Electric Lighting Fixtures" and shall be labeled where procedures exist. All lighting fixtures are for operation on a nominal 230 volts power supply.

1.3 SUBMITTALS

- A. Catalog for lighting fixtures, including lamps, photocell, and ballasts.
- B. Shop Drawing/Samples of proposed lighting fixtures are required by the Engineer for approval prior to installation.

PART 2 – PRODUCTS

2.1 Lighting Fixtures

Provide lighting fixtures as indicated in the drawings:

A. LED Lighting fixtures

- LED ballast shall be UL listed, high power factor type and shall be designed to operate on the voltage system to which they are connected. Ballast shall be Class P and shall have sound rating "A" unless otherwise noted. Fixtures and ballast shall be designed and constructed to limit the ballast case temperature to 90° C when installed in an ambient temperature of 40° C.

2.2 Emergency Lighting Units

- Emergency lighting units shall be fully automatic with 2 x PAR 36 W lamps, LED and 12 volts sealed nickel cadmium, calcium-alloy grid batteries. Each unit shall be designed for 230 volts, 60 Hz input and have an automatic two-rate solid state charger, ready/off switch, press-to-test switch, amber "ready" light, red "charge" light, and front mounted voltmeter.

- Each emergency lighting unit shall be equipped with a time delay relay to maintain emergency lighting on for three (3) minutes after return of normal power.

PART 3 - EXECUTION

3.1 INSTALLATION

- Install lighting fixtures plumb, square, and level with ceiling walls, in alignment with adjacent lighting fixture, and secure in accordance with manufacturer's directions and approved shop drawings.
- The installation shall meet with the requirements of the Philippine Electrical Code (PEC).
- Mounting heights specified or indicated shall be to bottom of fixture for ceiling-mounted fixtures and to center of fixture for wall-mounted fixtures.
- Obtain approval of the exact mounting for lighting fixtures on the job before installation is commenced and where applicable, after coordinating with the type, style, and pattern of the ceiling being installed.
- Recessed and semi-recessed fixtures may be supported from suspended ceiling support system ceiling tees if the ceiling system support rods or wires are provided at a minimum of four rods or wires per fixture and located not more than 152 mm from each corner of each fixture. Four round fixtures or fixtures smaller in size than the ceiling acoustical panels, support such fixtures independently or with at least two 19 mm metal channels spanning, and secured to, the ceiling tees. Provide rods or wires for lighting fixture support under this section of the specifications. Additionally, for recessed fixtures, provide support clips securely fastened to ceiling grid members, a minimum of one at one at or near each corner of each fixture.
- Emergency Lights: Wire emergency lights ahead of the switch to the normal lighting circuit located in the same room or area.

- 3.2 GROUNDING: Ground noncurrent-carrying part of equipment as specified in Section 16450, "Grounding System". Where the copper-grounding conductor is connected to a metal other than copper, provide specially treated or lined connectors suitable for this purpose.

3.3 FIELD TESTS:

The Contractor will provide electric power required for field tests:

- Operating Test: Upon completion of the installation, conduct an operating test to show that the equipment operates in accordance with the requirements of this section.

**** END OF SECTION ****

SECTION 16542

OUTDOOR LIGHTING SYSTEM

PART 1 – GENERAL

1.1 SCOPE OF WORK

The Contractor shall furnish and install lighting fixtures, photocell switches, contactors, and battery-powered units and systems for outdoor use, including lighting fixtures and accessories mounted on the exterior surfaces of the building/structures.

1.2 STANDARDS

All lighting fixtures shall be in accordance with the latest edition of the PEC and shall be constructed in accordance with the latest edition of the Underwriters Laboratories "Standards for Safety, Electric Lighting Fixtures" and shall be labeled where procedures exist. All lighting fixtures are for operation on a nominal 230 volts power supply.

1.3 SUBMITTALS

- A. Catalog for lighting fixtures, including lamps and ballasts.
- B. Shop Drawing/Samples of proposed lighting fixtures are required by the Engineer for approval prior to installation.

PART 2 – PRODUCTS

2.1 Lighting Fixtures

Provide lighting fixtures as indicated in the drawings:

A. LED Lighting fixtures

- LED ballast shall be UL listed, high power factor type and shall be designed to operate on the voltage system to which they are connected. Ballast shall be Class P and shall have sound rating "A" unless otherwise noted. Fixtures and ballast shall be designed and constructed to limit the ballast case temperature to 90° C when installed in an ambient temperature of 40° C.
- The CCT shall have a minimum of 5000K.
- LEDs shall have power supplies that shall operate within the current specification of the manufacturer.
- LED power supplies shall have short circuit and overload protection.

2.2 Lighting Poles

- Lighting poles and arm assembly shall be designed for wind loading based on wind loading conditions of the site.

- Lighting poles shall be anchor bolt type designed for use with underground supply conductors. Poles shall have handhole with covers and shall be secured with stainless steel captive screws.
- Lighting poles shall have all necessary hardware accessories and shall be the product of the pole manufacturer.
- Lighting poles shall be round galvanized with minimum 11-gauge steel and shall comply with ASTM A123 and A153.

PART 3 - EXECUTION

3.1 INSTALLATION

- Install lighting fixtures plumb, square, and level with ceiling walls, in alignment with adjacent lighting fixture, and secure in accordance with manufacturer's directions and approved shop drawings.
- The installation shall meet with the requirements of the Philippine Electrical Code (PEC).
- Foundations for lighting poles shall be cast-in-place concrete, minimum of 3000 psi 28 day compressive strength.
- Excavate only as necessary to provide sufficient working clearance for installation of forms and proper use of tamper to the full depth of the excavation. Prevent surface water from flowing into the excavation. Thoroughly compact backfill with compacting arranged to prevent pressure between conductor, jacket, or sheath, and the end of conduit.
- Set anchor bolts according to anchor-bolt templates furnished by the pole manufacturer.
- Install poles as necessary to provide a permanent vertical position with the bracket arm in proper position for luminaire location.
- After the poles have been installed, shimmed, and plumbed, grout the spaces between the pole bases and the concrete base with non-shrink concrete grout material.
- Install LED lamps in each luminaire.
- Adjust luminaires that require field adjustment or aiming.

3.2 GROUNDING: Ground noncurrent-carrying part of equipment as specified in Section 16450, "Grounding System". Where the copper-grounding conductor is connected to a metal other than copper, provide specially treated or lined connectors suitable for this purpose.

3.3 FIELD TESTS:

The Contractor will provide electric power required for field tests:

- Operating Test:** Upon completion of the installation, conduct an operating test to show that the equipment operates in accordance with the requirements of this section.

**** END OF SECTION ****

SECTION 16690 LIGHTNING PROTECTION SYSTEM

PART 1 - GENERAL

1.1 SCOPE OF WORKS

The Contractor shall furnish and install conventional lightning protection system as shown on the Drawings.

1.2 SUMMARY

- A. Section includes lightning protection for structure using conventional lightning arrester.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For air terminals and mounting accessories.
 - 1. Layout of the lightning protection system, along with details of the components to be used in the installation.
 - 2. Include indications for use of raceway, data on how concealment requirements will be met, and method of bonding of grounded and isolated metal bodies.
- C. Field quality-control reports.
- D. Other Informational Submittals: Plans showing dimensioned as-built locations of grounding features, including the following:
 - 1. Ground rods and ground loop conductors.
 - 2. Lightning Air Terminals.
 - 3. Lightning Counter.
- E. Certificate of approving authorities

1.4 QUALITY ASSURANCE

- A. The system to be provided shall be the standard product of a manufacturer regularly engaged in the production of lightning protection systems and shall be the manufacturers latest approved design.

1.5 COORDINATION

- A. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.

- B. Coordinate installation of air terminals attached to roof systems with roofing manufacturer and Installer.
- C. Flashings of through-roof assemblies shall comply with roofing manufacturers' specifications.

PART 2 - PRODUCTS

2.1 LIGHTING PROTECTION SYSTEM COMPONENTS

- A. Air terminals shall be solid, round copper bar of 3/4 inch minimum diameter, or 5/8 inch min. diameter aluminum, and shall project 10-inches min. above the object to be protected. Locate and space according to L.P.I., NFPA, PEC, and U.L requirements.
- B. The air termination shall not cause high frequency radio interference except during the millisecond intervals associated with the progress of the lightning leader and during the main return strike of lightning levels in the region.
- C. The air termination shall be non radioactive and require no special licensing.
- D. The air termination shall be insulated from the protected structure under all conditions.
- E. The air termination shall be installed strictly to the manufacturer's instructions. It shall not be installed in corrosive environments or atmospheres without written approval from the manufacturer.
- F. The protective zone provided by the air termination shall be such that it becomes the preferred strike point for all discharges.
- G. Down conductors shall be made of electrical grade copper of minimum cross section area of 50mm². The down conductor after routing must be kept in constant physical contact with structure via conductive clamps.
- H. Cable fasteners shall be substantial in construction, electrolytically compatible with the conductor and mounting surface and shall be spaced in according to PEC and NFPA, L.P.I., and UL standard requirements.
- I. The ground rods shall be minimum of 1 inch diameter and 10 ft.(3m) long. They shall be connected to the system with two-bolt cast bronze clamp having a minimum length of 1-½ inch and employing stainless steel cap screws.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install lightning protection components and systems according to Manufacturer's recommendation and as per LPI 780.

- B. Install conductors with direct paths from air terminals to ground connections. Avoid sharp bends.
- C. Conceal the following conductors:
 - 1. System conductors.
 - 2. Down conductors.
 - 3. Interior conductors.
- D. Cable Connections: Use crimped or bolted connections for all conductor splices and connections between conductors and other components. Use exothermic-welded connections in underground portions of the system.
- E. Cable Connections: Use exothermic-welded connections for all conductor splices and connections between conductors and other components.
 - 1. Exception: In single-ply membrane roofing, exothermic-welded connections may be used only below the roof level.
- F. Bond extremities of vertical metal bodies exceeding 20 m in length to lightning protection components.
- G. Ground Loop: Install ground-level, potential equalization conductor and extend around the perimeter of structure.
 - 1. Bury ground ring not less than **(600 mm)** from building foundation.
 - 2. Bond ground terminals to the ground loop.
 - 3. Bond grounded building systems to the ground loop conductor within 3.6 m of grade level.
- H. Bond lightning protection components with intermediate-level interconnection loop conductors to grounded metal bodies of building at 60-foot (18-m) intervals.

3.2 CORROSION PROTECTION

- A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.
- B. Use conductors with protective coatings where conditions cause deterioration or corrosion of conductors.

3.3 FIELD QUALITY CONTROL

- A. Notify EMPLOYER'S REPRESENTATIVE at least 48 hours in advance of inspection before concealing lightning protection components.

**** END OF SECTION Revise this Section by deleting and inserting text to meet Project-specific requirements.**

SECTION 34005

MISCELLANEOUS EQUIPMENT

PART 1 – GENERAL

1.1 SCOPE OF WORK

The Contractor shall furnish and install all materials and miscellaneous equipment as hereinafter specified and as shown on the Drawings.

PART 2 – PRODUCTS

2.1 CIRCUIT BREAKERS

- A. Circuit breakers shall be molded case with current and voltage ratings as indicated in the Drawings. Symmetrical RMS amperes interrupting capacity for 400/230 volts breakers shall not be less than 10,000AIC. An external handle that can be locked in either "ON" or "OFF" position shall be provided.
- B. Enclosure type shall be NEMA 1 in dry locations and NEMA 3R in wet locations.
- C. NEMA Type 4X enclosures shall be cast iron or stainless steel.

2.2 WIRING DEVICES

A. Switches

Switches shall be rated at HVAC EQUIPMENT voltage rating as required. Switches shall be of the silent type, spring operated, toggle action and flush mounting. The color, plating and appearance of wall plates shall be as selected by the Engineer and appropriate samples shall be submitted prior to the purchase of switches and faceplates.

B. Device Plates

Plates for flush mounted devices shall be of the required number of gangs for the application involved and shall be Type 302 (18-8) high nickel stainless steel of the same manufacturer as the device.

PART 3 - EXECUTION

3.1 INSTALLATION

All miscellaneous equipment shall be installed as indicated on the Drawings.

3.2 TESTS AND CHECKS

The following minimum tests and checks shall be made before energizing the circuit breakers:

- A. Inspect and test all systems and repair or replace defective parts of works and make all necessary adjustments to the system.
- B. Megger terminals for grounds after disconnecting devices sensitive to megger voltage.

**** END OF SECTION ****