



Securities and Exchange Commission

University Avenue, Juna Subdivision, Matina, Davao City,
Davao del Sur



Proposed Retrofitting And Renovation Of The SEC Davao Extension Office

University Avenue, Juna Subdivision Matina, Davao

Technical Specifications – Electrical

September 2024

Alden C. Ong, M.Eng., ASEP
Civil/Structural Engineer

PRC No.: 68251
PTR No.: 10077889
Issued in: Makati City
Date: Jan. 05, 2024

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Document Status					
Rev No.	Author	Reviewer	Approved for Issue		
			Name	Signature	Date
0	J.C. P. Almazan	ACO	A.C.Ong		Sep 2024

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SECTION 16011

ELECTRICAL GENERAL REQUIREMENTS

PART 1 – GENERAL

1.1 APPLICATION

This section applies to all sections of Division 16, "Electrical," of this project except as specified otherwise in each individual section.

1.2 SUBMITTALS

Obtain approval before procurement, fabrication, or delivery of items to the job site. Partial submittals will not be acceptable and will be returned without review. Submittals shall include the manufacturer's name, trade name, place of manufacture, catalog model or number, nameplate data, size, layout dimensions, capacity, project specification and paragraph reference and technical society publication references, and other information necessary to establish contract compliance of each item to be furnished.

1.2.1 Shop Drawings

In addition to the requirements of the Contract Clauses, shop drawings shall meet the following requirements. Drawings shall be a minimum of 216 mm by 280 mm in size, except as specified otherwise. Drawings shall include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to assure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. If equipment is disapproved, revise drawings to show acceptable equipment and resubmit.

1.2.2 Manufacturer's Data

Submittals for each manufactured item shall be current manufacturer's descriptive literature of cataloged products, equipment drawings, diagrams, performance and characteristic curves, and catalog cuts.

1.2.3 Certificates of Compliance

Submit manufacturer's certifications as required on products, materials, finish, and equipment indicated in the technical sections. Certifications shall be documents prepared specifically for this contract. Preprinted certifications and copies of previously submitted documents will not be acceptable. The manufacturer's certifications shall name the appropriate products, equipment, or materials and the publication specified as controlling the quality of that item. Certification shall not contain statements to imply that the item does not meet requirements specified, such as "as good as"; "achieve the same end

use and results as materials formulated in accordance with the referenced publications"; or "equal or exceed the service and performance of the specified material". Certifications shall simply state that the item conforms to the requirements specified. Certificates shall be printed on the manufacturer's letterhead and shall be signed by the manufacturer's official authorized to sign certificates of compliance.

1.3 DELIVERY AND STORAGE

Handle, store, and protect equipment and materials in accordance with the manufacturer's recommendations and with the requirements of NFPA 70B, Appendix I, titled "Equipment Storage and Maintenance during Construction." Replace damaged or defective items with new items:

1.4 CATALOG PRODUCTS/SERVICE AVAILABILITY

Materials and equipment shall be current products by manufacturers regularly engaged in the production of such products. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The 2-year period shall be satisfactorily completed by a product for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures. Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished. The equipment items shall be supported by service organizations, which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.5 MANUFACTURER'S RECOMMENDATIONS

Where installation procedures or any part thereof are required to be in accordance with manufacturer's recommendations, furnish printed copies of the recommendations prior to installation. Installation of the item shall not proceed until recommendations are received. Failure to furnish recommendations shall be cause for rejection of the equipment or material.

1.6 ELECTRICAL CHARACTERISTICS

Electrical characteristics for this project shall be 400 volts, three phase, 4 wire + G, 60 Hz, and 230 volts secondary, single phase, 2 wire + G, 60 Hz.

PART 2 – PRODUCTS

Products conforming to other internationally known publications and standards are acceptable however, proofs or certificates shall be submitted indicating they equal or surpass standards as referenced herein. Local products are acceptable subject to the approval of the Engineer.

PART 3 – EXECUTION

3.1 PAINTING OF EQUIPMENT

3.1.1 FACTORY APPLIED

Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA ICS 6 corrosion resistance test, except equipment specified to meet requirements of ANSI C37.20 shall have a finish as specified in ANSI C37.20.

**** END OF SECTION ****

SECTION 16050

ELECTRICAL – GENERAL PROVISION

PART 1 – GENERAL

1.1 GENERAL REQUIREMENTS

The WORK to be done under this classification is included in the following Sections:

Section 16123	Wires and Cables
Section 16442	Panel boards
Section 34005	Miscellaneous Equipment
Section 16510	Interior Lighting System

1.2 SCOPE OF WORK

The Contractor shall furnish and install all materials and equipment necessary for a complete electrical system as hereinafter specified and shown on the Drawings.

1.3 INTENT

It is the intent of these Specifications that the electrical system shall be suitable in every way for the service required, and the Contractor shall supply all materials and do all the work which may be reasonably implied as being required, at no extra cost.

1.4 INSPECTION AND FEES

All materials and installation shall be in accordance with the latest edition of the Philippine Electrical Code (PEC).

The Contractor shall pay all fees required for permits and inspections.

1.5 TESTS

The Contractor shall test all systems and repair or replace all defective works. The Contractor shall make all the necessary adjustments to the systems and shall instruct the Owner's personnel in the proper operation of the system.

1.6 EXCAVATIONS AND BACKFILLINGS

The Contractor shall do all necessary excavation and backfilling as part of the electrical work required. Backfill materials shall be thoroughly tamped in place and excavated surfaces restored, equal to their original condition.

1.7 SLEEVES AND FORMS FOR OPENINGS

The Contractor shall provide and place all sleeves for conduits penetrating floors, walls, partitions, etc. The Contractor shall locate all necessary slots for his work, and these shall be formed before concrete is poured.

1.8 CUTTING AND PATCHING

All cutting and patching shall be done in a thoroughly workmanlike manner.

1.9 INTERPRETATION OF DRAWINGS

- A. The Drawings are diagrammatic only and are not intended to show exact locations of outlets and conduit runs.
- B. All three-phase circuits shall be run in separate conduits unless otherwise shown on the Drawings.
- C. Any work installed contrary to the Drawings and Specifications, or without approval by the Engineer, shall be subject to change as directed by the Engineer, and no extra compensation will be allowed the Contractor for making these changes.
- D. The locations of equipment, fixtures, outlets, and similar devices shown on the Drawings are approximate only. Exact locations shall be as approved by the Engineer during construction. The Contractor shall obtain in the field all information relevant to the placing of electrical work and, in case of any interference with other work, shall proceed as directed by the Engineer and shall furnish all labor and materials necessary to complete the work in an approved manner.
- E. Surface mounted panel boxes, junction boxes, conduit, etc., shall be supported by spacers to provide a clearance between wall and equipment.
- F. Circuit diagrams shown are diagrammatic and functional only and are not intended to show exact circuit layouts, number of fittings, or other installation details. The Contractor shall furnish all labor and materials necessary to install and place in satisfactory operation all power lighting, and other electrical systems shown. The Contractor shall install additional circuits wherever needed to conform to the specific requirements of the equipment.
- G. The ratings of motors and other electrically operated devices, together with the size shown for their branch circuit conductors and conduits, are approximate only and are indicative of the probable power requirements insofar as they can be determined in advance of the purchase of equipment. The ratings shown for motor branch circuit protective devices are the maximum ratings permitted. Lower ratings may be used where approved as being proper for the dynamic characteristics of the motor and its connected load.
- H. Unless otherwise specified, all conduits, wires, cables and the support systems for the conduits and cables that are required to make the electrical connections to equipment shall be furnished and installed by the Contractor. All connections to equipment shall be as shown, specified and directed and in accordance with the approved shop and setting drawings.

1.10 SIZE OF EQUIPMENT

The Contractor shall investigate each space in the building through which equipment must pass to reach its final location. If necessary, the manufacturer shall be required to ship his material in sections sized to permit passing through such restricted areas in the building.

1.11 SHOP DRAWINGS

- A. Shop drawings shall be submitted for the following equipment:
 - Lighting fixtures

- Panel Boards
 - Emergency power unit
 - Miscellaneous equipment
 - Pad Mounted Cast Coil Transformer
 - Automatic Transfer Switches
 - Circuit Breakers
 - Disconnect Switches
 - Convenience Outlets
- B. The manufacturer's name and product designation or catalog numbers shall be submitted for the following materials:
- Conduit
 - Wiring devices
 - Boxes and fittings
 - Wires and cables
 - Lamps/lighting fixtures
 - Miscellaneous equipment & devices

If requested by the Engineer, samples shall also be submitted.

- C. All shop drawings shall be checked by the Contractor for accuracy and contract requirements before submittal to the Engineer. Shop drawings shall bear the signature of the Contractor and date checked and shall be accomplished by the statement that the shop drawings have been examined for conformity to Specifications and Drawings. Shop drawings not so checked and noted by the Contractor may be returned to him.
- D. The Engineer check shall be only for conformance with the design concept of the project and compliance with the Specifications and Contract Drawings. The Engineer review shall in no way relieve the Contractor from the responsibility of, or the necessity of, furnishing materials and workmanship required by the Contract Drawings and specifications which may not be indicated on the shop drawings.
- E. The Contractor shall be responsible for all dimensions to be confirmed and correlated to the job site and for coordination of his work with the work of all other trades.
- F. No material shall be ordered or shop work started until the Engineer's review of shop drawings has been completed.

PART 2 – PRODUCTS

2.1 GENERAL

- A. Electrical equipment shall be adequately protected against mechanical injury or damage by water or humidity. Equipment or materials do damaged shall be

repaired to the satisfaction of the Engineer, or entirely replaced by the Contractor at his own expense. Such injured materials and equipment, and are suspected of damage by water or humidity, shall be subjected by vigorous testing before being accepted for the work.

- B. The Contractor shall be responsible for offering all materials and products as specified sufficiently in advance, taking into account manufacturer's delivery time, temporary shortages and other similar considerations. Any departure from the materials and products specified will be authorized only if it is shown that the non-availability of such items was not due to a lack of timely and diligent effort on the part of the Contractor to procure such items.
- C. Provide laminated plastic nameplates for each panelboard, equipment, enclosure, relay, switch, and device. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 3.17 mm thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the black core. Minimum size of nameplates shall be 25.4 mm by 63.5 mm. Lettering shall be on minimum of 6.35 mm high normal block style.

PART 3 – EXECUTION

- A. Nameplate Mounting: Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two-rivets.
- C. Painting of Equipment: Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet NEMA requirements.

**** END OF SECTION ****

SECTION 16051

COMMON WORK RESULTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, the following section of Division 16 and Division 1 Specification Sections, apply to this Section.
 - 1. 16123 – Conductors & Cables
 - 2. 16410 – Enclosed Circuit Breakers and Disconnect Switches
 - 3. 16442 – Panelboards

1.2 SUMMARY

- A. Section Includes:
 - 1. Electrical equipment coordination and installation.
 - 2. Sleeves for raceways and cables.
 - 3. Sleeve seals.
 - 4. Grout.
 - 5. *Common electrical installation requirements.*

1.3 DEFINITIONS

- A. EPDM: Ethylene-propylene-diene terpolymer rubber.
- B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

- A. Product Data: For sleeve seals.

1.5 COORDINATION

- A. Coordinate arrangement, mounting, and support of electrical equipment:
 - 1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
 - 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
 - 3. To allow right of way for piping and conduit installed at required slope.

4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.
- B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- C. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 8 Section "Access Doors and Frames."
- D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 7 Section 078413 "Penetration Firestopping".

PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND CABLES

- A. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- B. Sleeves for Rectangular Openings: Galvanized sheet steel.
 1. Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side more than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
 - b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches (1270 mm) and 1 or more sides equal to, or more than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.2 SLEEVE SEALS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
 1. Acceptable Manufacturers: See Section 16007 "Alternative Equipment and Suppliers"
 2. Sealing Elements: EPDM, NBR interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
 3. Pressure Plates: Carbon steel. Include two for each sealing element.

4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.3 GROUT

- A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, non-staining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

- A. Comply with NECA 1.
- B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- E. Right of Way: Give to piping systems installed at a required slope.

3.2 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

- E. Cut sleeves to length for mounting flush with both surfaces of walls.
- F. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.
- G. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable, unless indicated otherwise.
- H. Seal space outside of sleeves with grout for penetrations of concrete and masonry
 - 1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
- I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 7 Section "Joint Sealants."
- J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 7 Section "Through-Penetration Firestop Systems."
- K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.3 SLEEVE-SEAL INSTALLATION

- A. Install to seal exterior wall penetrations.
- B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.4 FIRESTOPPING

- A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 7 Section "Through-Penetration Firestop Systems."

****END OF SECTION****

SECTION 16055

OVERCURRENT PROTECTIVE DEVICE COORDINATION

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 computer-based, fault-current and overcurrent protective device coordination studies. Protective devices shall be set based on results of the protective device coordination study.
 - 1. Coordination of series-rated devices is permitted where indicated on Drawings.

1.3 SUBMITTALS

- A. Product Data: For computer software program to be used for studies.
- B. Product Certificates: For coordination-study and fault-current-study computer software programs, certifying compliance with IEEE 399.
- C. Qualification Data: For coordination-study specialist.
- D. Other Action Submittals: The following submittals shall be made after the approval process for system protective devices has been completed. Submittals may be in digital form.
 - 1. Coordination-study input data, including completed computer program input data sheets.
 - 2. Study and Equipment Evaluation Reports.
 - 3. Coordination-Study Report.

1.4 QUALITY ASSURANCE

- A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are not acceptable.

- B. Coordination-Study Specialist Qualifications: An entity experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
 - 1. Professional Engineer, licensed in the state where Project is located, shall be responsible for the study. All elements of the study shall be performed under the direct supervision and control of engineer.
- C. Comply with IEEE 242 for short-circuit currents and coordination time intervals.
- D. Comply with IEEE 399 for general study procedures.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

- A. Comply with IEEE 399.
- B. Analytical features of fault-current-study computer software program shall include "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.
- C. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.
 - 1. Optional Features:
 - a. Arcing faults.
 - b. Simultaneous faults.
 - c. Explicit negative sequence.
 - d. Mutual coupling in zero sequence.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.
 - 1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.2 POWER SYSTEM DATA

- A. Gather and tabulate the following input data to support coordination study:
1. Product Data for overcurrent protective devices specified in other Division 16 Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
 2. Impedance of utility service entrance.
 3. Electrical Distribution System Diagram: In hard-copy and electronic-copy formats, showing the following:
 - a. Circuit-breaker and fuse-current ratings and types.
 - b. Relays and associated power and current transformer ratings and ratios.
 - c. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios.
 - d. Generator kilovolt amperes, size, voltage, and source impedance.
 - e. Cables: Indicate conduit material, sizes of conductors, conductor material, insulation, and length.
 - f. Busway ampacity and impedance.
 - g. Motor horsepower and code letter designation according to NEMA MG 1.
 4. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:
 - a. Special load considerations, including starting inrush currents and frequent starting and stopping.
 - b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
 - c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
 - d. Generator thermal-damage curve.
 - e. Ratings, types, and settings of utility company's overcurrent protective devices.
 - f. Special overcurrent protective device settings or types stipulated by utility company.
 - g. Time-current-characteristic curves of devices indicated to be coordinated.
 - h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
 - i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.

- j. Panelboards, switchboards, motor-control center ampacity, and interrupting rating in amperes rms symmetrical.

3.3 FAULT-CURRENT STUDY

- A. Calculate the maximum available short-circuit current in amperes rms symmetrical at circuit-breaker positions of the electrical power distribution system. The calculation shall be for a current immediately after initiation and for a three-phase bolted short circuit at each of the following:
 - 1. Distribution panelboard.
 - 2. Branch circuit panelboard.
- B. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions.
- C. Calculate momentary and interrupting duties on the basis of maximum available fault current.
- D. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with IEEE 141, IEEE 241 and IEEE 242. See "Referenced Standards" Article in the Evaluations for scope of transformer standards referenced in four subparagraphs and associated subparagraphs below. Delete standards for transformers not used in this Project.
 - 1. Transformers:
 - a. ANSI C57.12.10.
 - b. ANSI C57.12.22.
 - c. ANSI C57.12.40.
 - d. IEEE C57.12.00.
 - e. IEEE C57.96.
 - 2. Medium-Voltage Circuit Breakers: IEEE C37.010.
 - 3. Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.20.1.
 - 4. Low-Voltage Fuses: IEEE C37.46.
- E. Study Report:
 - 1. Show calculated X/R ratios and equipment interrupting rating (1/2-cycle) fault currents on electrical distribution system diagram.
 - 2. Show interrupting (5-cycle) and time-delayed currents (6 cycles and above) on medium- and high-voltage breakers as needed to set relays and assess the sensitivity of overcurrent relays.

F. Equipment Evaluation Report:

1. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
2. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
3. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

3.4 COORDINATION STUDY

- A. Perform coordination study using approved computer software program. Prepare a written report using results of fault-current study. Comply with IEEE 399.
1. Calculate the maximum and minimum 1/2-cycle short-circuit currents.
 2. Calculate the maximum and minimum interrupting duty (5 cycles to 2 seconds) short-circuit currents.
 3. Calculate the maximum and minimum ground-fault currents.
- B. Comply with IEEE 141, IEEE 241, IEEE 242 recommendations for fault currents and time intervals.
- C. Transformer Primary Overcurrent Protective Devices:
1. Device shall not operate in response to the following:
 - a. Inrush current when first energized.
 - b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
 - c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
 2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.
- D. Motors served by voltages more than 600 V shall be protected according to IEEE 620.
- E. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

F. Coordination-Study Report: Prepare a written report indicating the following results of coordination study:

1. Tabular Format of Settings Selected for Overcurrent Protective Devices:
 - a. Device tag.
 - b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.
 - c. Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.
 - d. Fuse-current rating and type.
 - e. Ground-fault relay-pickup and time-delay settings.
2. Coordination Curves: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
 - a. Device tag.
 - b. Voltage and current ratio for curves.
 - c. Three-phase and single-phase damage points for each transformer.
 - d. No damage, melting, and clearing curves for fuses.
 - e. Cable damage curves.
 - f. Transformer inrush points.
 - g. Maximum fault-current cutoff point.

G. Completed data sheets for setting of overcurrent protective devices.

****END OF SECTION****

SECTION 16060

GROUNDING AND BONDING

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract apply to this Section.

1.2 SUMMARY

- A. This Section includes methods and materials for grounding systems and equipment.
 - 1. Common ground bonding with lightning protection system.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings:
 - 1. Showing the location of system grounding electrode connections and the routing of grounding electrode conductor.
- C. Other Informational Submittals: Plans showing dimensioned as-built locations of grounding features including the following:
 - 1. Ground Test wells.
 - 2. Ground rods.
 - 3. Ground rings.
 - 4. Grounding arrangements and connections for separately derived systems.
 - 5. Grounding for sensitive electronic equipment.
- D. Qualification Data: For testing agency and testing agency's field supervisor.
- E. Field quality-control test reports.
 - 1. Certified test reports of ground resistance.
- F. Operation and Maintenance Data: For grounding to include the following in emergency, operation, and maintenance manuals:
 - 1. Instructions for periodic testing and inspection of grounding features at test wells based on NETA Maintenance Testing Specifications(MTS).

- a. Tests shall be to determine if ground resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if they do not.
- b. Include recommended testing intervals.

1.4 QUALITY ASSURANCE

- A. 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.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in PEC, Article 1.0, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with UL 467 for grounding and bonding materials and equipment.

1.5 IDENTIFICATION

- A. Provide an identification nameplate for each ground bus cabinet.

1.6 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

PART 2 – PRODUCTS

2.1 GENERAL

- A. Grounding connections shall be brazed molded exothermic welded, bolted clamp terminal or pressure connector type.

2.2 CONDUCTORS

- A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B 3.

2. Stranded Conductors: ASTM B 8.
 3. Tinned Conductors: ASTM B 33.
 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 6. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
- C. Bare Grounding Conductor and Conductor Protector for Wood Poles:
1. No. 4 AWG minimum, soft-drawn copper.
 2. Conductor Protector: Half-round PVC or wood molding. If wood, use pressure-treated fir or cypress or cedar.
- D. Grounding Bus: Rectangular bars of annealed copper, 1/4 by 2 inches (6 by 50 mm) in cross section, unless otherwise indicated; with insulators.

2.3 CONNECTORS

- A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.
- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.
1. Pipe Connectors: Clamp type, sized for pipe.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.4 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad Stainless steel; 3/4 inch by 10 feet (19 mm by 3 m) 5/8 by 96 inches (16 by 2400 mm) in diameter.
- B. Chemical-Enhanced Grounding Electrodes: Copper tube, straight or L-shaped, charged with nonhazardous electrolytic chemical salts.
1. Termination: Factory-attached No. 4/0 AWG bare conductor at least 48 inches (1200 mm) long.
 2. Backfill Material: Electrode manufacturer's recommended material.

PART 3 – EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger, unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2/0 AWG minimum.
 - 1. Bury at least 24 inches (600 mm) below grade.
 - 2. Duct-Bank Grounding Conductor: Bury 12 inches (300 mm) above duct bank when indicated as part of duct-bank installation.
- C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
- D. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 - 1. Install bus on insulated spacers 1 inch (25 mm), minimum, from wall 6 inches (150 mm) above finished floor, unless otherwise indicated.
 - 2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, down to specified height above floor, and connect to horizontal bus.
- E. Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Welded connectors, except at test wells and as otherwise indicated.
 - 3. Connections to Ground Rods at Test Wells: Bolted connectors.
 - 4. Connections to Structural Steel: Welded connectors.
- F. Primary Equipment And Circuits
 - 1. Switchgear: Provide a bare grounding electrode conductor from the switchgear ground bus to the grounding electrode system, metal underground water pipe or driven ground rods for the grounding electrode.
 - 2. Duct Banks and Manholes:
 - 1. Provide a bare equipment grounding conductor in each duct containing medium or high voltage cables. Connect the grounding conductors to the switchgear ground bus, to all manhole hardware, to the cable shielding of medium or high voltage cable splices and terminations and equipment enclosures.

2. Provide a grounding conductor having at least 50 percent ampacity of the largest phase conductor in the duct bank.
 3. Connect the equipment grounding conductor to the ground rod.
3. Power Transformers:
1. Provide a driven ground rod and connect with a grounding electrode conductor to the grounding facilities at the transformer.
 2. Ground the secondary neutral.
 3. Connect lightning arrester grounds to the pad ground per PEC.
4. Lightning Arresters: Connect lightning arresters grounds to the equipment ground bus or ground rods, as applicable.
5. Outdoor Fences: Connect outdoor fences around electrical equipment to the grounding electrode system.
6. Metallic Conduit: Metallic conduits which terminate without mechanical connection to a housing of electrical equipment by means of locknut and bushings or adapters, provided with grounding bushings. Connect bushings with a bare grounding conductor to the equipment ground bus.

3.2 EQUIPMENT GROUNDING

- A. Main Bonding Jumper: Connect the secondary service neutral to the ground bus in the service equipment.
- B. Water Pipe and Supplemental Electrode:
1. Provide a ground conductor connection between the service equipment ground bus and the metallic water pipe system and Jumper insulating joints in the water pipe.
 1. Provide a supplemental ground electrode and bond to the water pipe ground or connect to the service equipment ground bus.
- C. Service Disconnect (Separate Individual Enclosure): Provide a ground bar bolted to the enclosure with lugs for connecting the various grounding conductors.
- D. Switchgear, Switchboards, Unit Substations:
1. Connect the various feeder green grounding conductors to the ground bus in the enclosure with suitable pressure connectors.
 2. Connect the grounding electrode conductor to the ground bus.
 3. Connect the neutral to the ground bus (main bonding jumper).
 4. Connect metallic conduits, which terminate without mechanical connection to the housing, by grounding bushings and ground wire to the ground bus.
- E. Transformers:

1. Exterior: Exterior transformers supplying interior service equipment shall also have the neutral grounded at the transformer secondary. Provide a grounding electrode at the transformer.
2. Separately derived systems (transformers downstream from service equipment): Ground the secondary neutral at the transformer. Provide a grounding electrode conductor from the transformer to the nearest cold water pipe.

F. Conduit Systems:

1. Ground all metallic conduit systems.
2. Non-metallic conduit systems shall contain a grounding conductor.
3. Conduit provided for mechanical protection containing only a grounding conductor, bond to that conductor at the entrance and exit from the conduit.

G. Feeders and Branch Circuits: Install green grounding conductors with feeders and branch circuits as follows:

1. Feeders.
2. Circuits serving preparation and kitchen equipment.
3. Receptacle outlets.
4. Directly connected laboratory equipment.
5. Motors and motor controllers.
6. Fixed equipment and appliances.
7. Items of equipment where the final connection is made with flexible metal conduit shall have grounding wire
8. Additional locations and systems as shown.
9. Provide an insulated, isolated grounding conductor for branch circuits serving isolated ground and isolated ground surge suppressor type receptacles. Isolated grounding conductors shall be isolated from other grounding systems back to the system point of origin.

H. Boxes, Cabinets, Enclosures and Panelboards:

1. Bond the grounding wires to each pullbox, junction box, outlet box, cabinets and other enclosures through which the ground wires pass (except for special grounding systems for intensive care units and other critical units shown).
2. Provide lugs in each box and enclosure for ground wire termination.
3. Provide ground bars in panelboards, bolted to the housing, with sufficient lugs for terminating the ground wires.

I. Motors and Starters:

1. Provide lugs in motor terminal box and starter housing for ground wire termination.

2. Make ground wire connections to ground bus in motor control centers.
- J. Receptacles are not approved for grounding through their mounting screws. It should be grounded with a ground wire from green ground terminal on the receptacle to the outlet box ground screw.
- K. Ground lighting fixtures to the green grounding conductor of the wiring system when the green ground is provided; otherwise, ground the fixtures through the conduit systems. Fixtures connected with flexible conduit shall have a green ground wire included with the power wires from the fixture through the flexible conduit to the first outlet box.
- L. Fixed electrical appliances and equipment shall have ground lug installed for termination of the green ground conductor.

3.3 Conductive Piping

- A. Bond all conductive piping systems in the building to the electrical system ground. Bonding connections shall be made as close as practical to the water pipe ground or service equipment ground bus.

3.4 Lightning Protection

Bond the lightning protection system to the electrical system grounding electrode.

3.5 Ground Resistance

- A. Grounding system ground resistance must not exceed 5 ohms (1 ohm for telecommunication systems). Final tests shall assure that this requirement is met.
- B. Services at power company interface points shall comply with the power company ground resistance requirements.
- C. Make necessary modifications needed to the ground electrodes for compliance, without additional cost to the Owner, including the provisions of a multi-rod system.

3.6 Installation

- A. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding

conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

- C. Ground Rods: Drive rods until tops are 2 inches (50 mm) below finished floor or final grade, unless otherwise indicated.
 - 1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.
 - 2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes shall be at least 12 inches (300 mm) deep, with cover.
 - 1. Test Wells: Install at least one test well for each service, unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.
- E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
 - 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 - 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
 - 3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.
- F. Grounding and Bonding for Piping:
 - 1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 - 2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 - 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install

tinned bonding jumper to bond across flexible duct connections to achieve continuity.

3.7 Field Quality Control

- A. Testing Agency: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.
- B. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
- C. Perform the following tests and inspections and prepare test reports:
 - 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 - 2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal at individual ground rods. Make tests at ground rods before any conductors are connected.
 - a. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - b. Perform tests by fall-of-potential method according to IEEE 81.
 - 3. Prepare dimensioned drawings locating each test well, ground rod and ground rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
- D. Report measured ground resistances that exceed the following values:
 - 1. Power and Lighting Equipment or System with Capacity 500 kVA and Less: 5 ohms.
 - 2. Power and Lighting Equipment or System with Capacity 500 to 1000 kVA: 5 ohms.
 - 3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 5 ohms.
 - 4. Power Distribution Units or Panelboards Serving Electronic Equipment: 5 ohm(s).
 - 5. Manhole Grounds: 5 ohms.
- E. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify MEEPF CONSULTANT promptly and include recommendations to reduce ground resistance.

****END OF SECTION****

SECTION 16073

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Hangers and supports for electrical equipment and systems.
 - 2. Construction requirements for concrete bases.

1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. IMC: Intermediate metal conduit.
- C. RMC: Rigid metal conduit.
- D. NECA: National Electrical Contractor's Association (Standard Practices for Good Workmanship in Electrical Contracting)

1.4 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
- C. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- D. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.5 SUBMITTALS

- A. Product Data: For the following:
 - 1. Steel slotted support systems.
 - 2. Nonmetallic slotted support systems

- B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:
 - 1. Trapeze hangers. Include Product Data for components.
 - 2. Steel slotted channel systems. Include Product Data for components.
 - 3. Nonmetallic slotted channel systems. Include Product Data for components.
 - 4. Equipment supports.
- C. Welding certificates.

1.6 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Comply with NFPA 70.

1.7 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.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

PART 2 – PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
 - 1. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 - 2. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 - 3. Channel Dimensions: Selected for applicable load criteria.
- B. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 9/16-inch- (14-mm-) diameter holes at a maximum of 8 inches (200 mm) o.c., in at least 1 surface.
 - 1. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.
 - 2. Fitting and Accessory Materials: Same as channels and angles, except metal items may be stainless steel.
 - 3. Rated Strength: Selected to suit applicable load criteria.

- C. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
 - D. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
 - E. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.
 - F. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
 - G. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
 - 1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - 2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated stainless steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
 - 3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
 - 4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
 - 5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
 - 6. Toggle Bolts: All-steel springhead type.
 - 7. Hanger Rods: Threaded steel.
- 2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES
- A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
 - B. Materials: Comply with requirements in Division 5 Section "Metal Fabrications" for steel shapes and plates.

PART 3 – EXECUTION

3.1 APPLICATION

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.
- B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.
- C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
 - 1. Secure raceways and cables to these supports with two-bolt conduit clamps, single-bolt conduit clamps, single-bolt conduit clamps using spring friction action for retention in support channel.
- D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 - 1. To Wood: Fasten with lag screws or through bolts.
 - 2. To New Concrete: Bolt to concrete inserts.
 - 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - 4. To Existing Concrete: Expansion anchor fasteners.
 - 5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
 - 6. To Steel: Spring-tension clamps.

7. To Light Steel: Sheet metal screws.
 8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Division 5 Section "Metal Fabrications" for site-fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated but not less than 4 inches (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- B. Anchor equipment to concrete base.
 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).
- B. Touchup: Comply with requirements in Division 9 painting Sections Section "High-Performance Coatings" for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

**** END OF SECTION ****

SECTION 16075

ELECTRICAL IDENTIFICATION

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. Section Includes:
 - 1. Identification for raceways.
 - 2. Identification of power and control cables.
 - 3. Identification for conductors.
 - 4. Underground-line warning tape.
 - 5. Warning labels and signs.
 - 6. Instruction signs.
 - 7. Equipment identification labels.
 - 8. Miscellaneous identification products.

1.3 SUBMITTALS

- A. Product Data: For each electrical identification product indicated.
- B. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.
- C. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.

1.4 QUALITY ASSURANCE

- A. Comply with ANSI A13.1 and IEEE C2.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- D. Comply with ANSI Z535.4 for safety signs and labels.
- E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.5 COORDINATION

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop

Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout project.

- B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- C. Coordinate installation of identifying devices with location of access panels and doors.
- D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 POWER RACEWAY IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.
- B. Colors for Raceways Carrying Circuits at 600 V or Less:
 - 1. Black letters on an orange field
 - 2. Legend: Indicate voltage and system or service type.
- C. Colors for Raceways Carrying Circuits at More Than 600 V:
 - 1. Black letters on an orange field.
 - 2. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- (75-mm-) high letters on 20-inch (500-mm) centers.
- D. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- E. Snap-Around Labels for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- F. Snap-Around, Color-Coding Bands for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- G. Tape and Stencil for Raceways Carrying Circuits More Than 600 V: 4-inch- (100-mm-) wide black stripes on 10-inch (250-mm) centers diagonally over orange background that extends full length of raceway or duct and is 12 inches (300 mm) wide. Stop stripes at legends.
- H. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch (50 by 50 by 1.3 mm), with stamped legend, punched for use with self-locking cable tie fastener.

- I. Write-On Tags: Polyester tag, 0.010 inch (0.25 mm) 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
 1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
 2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.2 ARMORED AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
- B. Colors for Raceways Carrying Circuits at 600 V and Less:
 1. Black letters on an orange field
 2. Legend: Indicate voltage
- C. Colors for Raceways Carrying Circuits at More Than 600 V:
 1. Black letters on an orange field.
 2. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- (75-mm-) high letters on 20-inch (500-mm) centers.
- D. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- E. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches (50 mm) wide; compounded for outdoor use.

2.3 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
- B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- C. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch (50 by 50 by 1.3 mm), with stamped legend, punched for use with self-locking cable tie fastener.
- D. Write-On Tags: Polyester tag, 0.010 inch (0.25 mm) 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
 1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
 2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

- E. Snap-Around Labels: Slit, pretension, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- F. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

2.4 CONDUCTOR IDENTIFICATION MATERIALS

- A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.
- B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- C. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- D. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- E. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
- F. Write-On Tags: Polyester tag, 0.010 inch (0.25 mm) 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
 - 1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
 - 2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.5 FLOOR MARKING TAPE

- A. 2-inch- (50-mm-) wide, 5-mil (0.125-mm) pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

2.6 UNDERGROUND-LINE WARNING TAPE

- A. Tape:
 - 1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
 - 2. Printing on tape shall be permanent and shall not be damaged by burial operations.
 - 3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.

B. Color and Printing:

1. Comply with ANSI Z535.1 through ANSI Z535.5.
2. Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE.
3. Orange-Colored Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.

2.7 WARNING LABELS AND SIGNS

A. Comply with PEC and 29 CFR 1910.145.

B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

C. Baked-Enamel Warning Signs:

1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
2. 1/4-inch (6.4-mm) grommets in corners for mounting.
3. Nominal size, 7 by 10 inches (180 by 250 mm).

D. Metal-Backed, Butyrate Warning Signs:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for application.
2. 1/4-inch (6.4-mm) grommets in corners for mounting.
3. Nominal size, 10 by 14 inches (250 by 360 mm).

E. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 MM)."

2.8 INSTRUCTION SIGNS

A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch (1.6 mm) thick for signs up to 20 sq. inches (129 sq. cm) and 1/8 inch (3.2 mm) thick for larger sizes.

1. Engraved legend with black letters on white face
2. Punched or drilled for mechanical fasteners.
3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

- B. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm).
- C. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm). Overlay shall provide a weatherproof and UV-resistant seal for label.

2.9 EQUIPMENT IDENTIFICATION LABELS

- A. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm).
- B. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm). Overlay shall provide a weatherproof and UV-resistant seal for label.
- C. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch (10 mm).
- D. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 3/8 inch (10 mm).
- E. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch (25 mm)

2.10 CABLE TIES

- A. General-Purpose Cable Ties: Fungus inert, self extinguishing, one piece, self locking, Type 6/6 nylon.
 - 1. Minimum Width: 3/16 inch (5 mm).
 - 2. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 12,000 psi (82.7 MPa).
 - 3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
 - 4. Color: Black except where used for color-coding.
- B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self extinguishing, one piece, self locking, Type 6/6 nylon.
 - 1. Minimum Width: 3/16 inch (5 mm).
 - 2. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 12,000 psi (82.7 MPa).
 - 3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
 - 4. Color: Black.
- C. Plenum-Rated Cable Ties: Self extinguishing, UV stabilized, one piece, self locking.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 7000 psi (48.2 MPa).
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F (Minus 46 to plus 140 deg C).
5. Color: Black.

2.11 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in Division 9 painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).
- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Verify identity of each item before installing identification products.
- B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- C. Apply identification devices to surfaces that require finish after completing finish work.
- D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- E. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
- F. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.
- G. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.
- H. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:
 1. Outdoors: UV-stabilized nylon.
 2. In Spaces Handling Environmental Air: Plenum rated.

Technical Specifications

- I. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches (400 mm) overall.
- J. Painted Identification: Comply with requirements in Division 9 painting Sections for surface preparation and paint application.

3.2 IDENTIFICATION MODULE

- A. Concealed Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil 4-inch- (100-mm-) wide black stripes on 10-inch (250-mm) centers over orange background that extends full length of raceway or duct and is 12 inches (300 mm) wide. Stencil legend "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- (75-mm-) high black letters on 20-inch (500-mm) centers. Stop stripes at legends. Apply to the following finished surfaces:
 - 1. Floor surface directly above conduits running beneath and within 12 inches (300 mm) of a floor that is in contact with earth or is framed above unexcavated space.
 - 2. Wall surfaces directly external to raceways concealed within wall.
 - 3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.
- B. Accessible Raceways, Armored and Metal-Clad Cables, More Than 600 V: Self-adhesive vinyl labels. Install labels at [10-foot (3-m)] [30-foot (10-m)] maximum intervals.
- C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A, and 220 V to ground: Identify with self-adhesive vinyl label. Install labels at [10-foot (3-m)] [30-foot (10-m)] maximum intervals.
- D. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend and system voltage. System legends shall be as follows:
 - 1. Emergency Power.
 - 2. Power.
 - 3. UPS.
- E. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.

1. Color-Coding for Phase Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder, and branch-circuit conductors.
 - a. Color shall be factory applied
 - b. Colors for 220V, 1Ø Circuits:
 - 1) Phase: Red
 - 2) Neutral: White
 - 3) Ground: Green
 - c. Colors for 400/230V, 3Ø Circuits:
 - 1) Phase A: Red
 - 2) Phase B: Yellow
 - 3) Phase C: Blue
 - 4) Neutral: White
 - 5) Ground: Green
 - d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.
- F. Power-Circuit Conductor Identification, More than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use write-on tags.
- G. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.
- H. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source.
- I. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
 1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
 2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
 3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.

- J. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.
 - 1. Limit use of underground-line warning tape to direct-buried cables.
 - 2. Install underground-line warning tape for both direct-buried cables and cables in raceway.
- K. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
- L. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Metal-backed, butyrate warning signs.
 - 1. Comply with 29 CFR 1910.145.
 - 2. Identify system voltage with black letters on an orange background.
 - 3. Apply to exterior of door, cover, or other access.
 - 4. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:
 - a. Power transfer switches.
 - b. Controls with external control power connections.
- M. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.
- N. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer load shedding.
- O. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
 - 1. Labeling Instructions:

Technical Specifications

- a. Indoor Equipment: Adhesive film label Adhesive film label with clear protective overlay. Engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.
 - b. Outdoor Equipment: Engraved, laminated acrylic or melamine label] [Stenciled legend 4 inches (100 mm) high.
 - c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
 - d. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.
2. Equipment to Be Labeled:
- a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be laminated acrylic or melamine label.
 - b. Enclosures and electrical cabinets.
 - c. Enclosed switches.
 - d. Enclosed circuit breakers.
 - e. Dry-Type Transformers.

**** END OF SECTION ****

SECTION 16080

STARTUP, TESTING AND COMMISSIONING OF ELECTRICAL EQUIPMENT

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. This Section shall be used in conjunction with the following other specifications and related Contract Documents to establish the total requirements for startup testing and commissioning of electrical equipment:
1. Section 16051 - Common Work Results For Electrical
 2. Section 16055 - Overcurrent Protective Device Coordination
 3. Section 16060 - Grounding and Bonding
- B. In the event of conflict regarding startup testing and commissioning of electrical equipment requirements between this Section and any other section, the provisions of this Section shall govern.

1.2 SUMMARY

- A. The GENERAL CONTRACTOR shall engage the services of an approved testing organization to provide startup testing and commissioning of the electrical equipment and/or systems listed in Section 16000, Electrical General Provisions.
- B. Section 16050 Basic Electrical Materials and Method. GENERAL CONTRACTOR refers to electrical contractor engaged for the purposes of installing and assembling electrical equipment
- C. It is the intent of these test to assure that all electrical equipment, both GENERAL CONTRACTOR and EMPLOYER-Furnished, is operational within industry and the manufacturer's tolerances and is installed in accordance with design specifications and the manufacturer's recommendations.
- D. Where applicable, the tests and inspections shall determine the suitability for energization.

1.3 TESTING CRITERIA

- A. General:
1. The testing company shall provide the supervision, material, equipment, labor and technical personnel to perform all tests and inspections according to NETA. The GENERAL CONTRACTOR shall, at his expense, furnish any personnel necessary to assist in the testing and inspection.
 2. When the tests and inspections have been completed, a label shall be attached to all devices tested. The label shall provide the name of the testing company, the date the tests were completed, and the initials of the

person who performed the tests.

B. Responsibilities:

1. The GENERAL CONTRACTOR shall clean the equipment, torque down all accessible bolts according to the equipment manufacturer's instructions, perform routine insulation resistance tests on all branch and feeder circuits, continuity checks on all branch and control wiring, and rotation tests for all distribution and utilization equipment.
2. The GENERAL CONTRACTOR shall furnish a complete set of current plans and specifications to the testing company prior to commencement of any testing. At each test site, the GENERAL CONTRACTOR shall provide any test control power necessary to perform the tests specified. The test organization shall be consulted as to the specific power requirements. The GENERAL CONTRACTOR shall notify the testing organization when the equipment and systems are ready for their inspection and testing. After review by the testing engineer, the GENERAL CONTRACTOR shall correct any deficiencies noted by the testing company.
3. The GENERAL CONTRACTOR shall be responsible for having the manufacturer of each equipment and/or system provide factory-trained representative(s) that will perform all required functional testing, checkout, and repairs in order to pronounce the equipment and/or systems meet the requirements of these specifications and Drawings and it is ready for startup testing and commissioning by the testing organization as specified hereafter.
4. The GENERAL CONTRACTOR shall furnish settings of protective devices.
5. The testing organization shall notify the EMPLOYER'S REPRESENTATIVE prior to the commencement of any testing. The testing organization shall set and adjust the protective devices and associated auxiliary timing devices in accordance with the values furnished by the MEEPF CONSULTANT.
6. The testing organization shall maintain a written record of all tests and, upon completion of the tests, include them in a final report. The report shall detail any deficiencies in the system material, workmanship or design. The testing company shall, upon identification, report deficiencies to the EMPLOYER'S REPRESENTATIVE in written form. The EMPLOYER'S REPRESENTATIVE will report these deficiencies to the Contractor or manufacturer to schedule remedies.
7. When directed, the testing organization shall enter "address" codes for power monitoring devices or similar instrumentation where shown. Test monitoring instrumentation for accuracy in combination with associated PTs and CTs.

C. Safety:

1. Safety practices shall comply with applicable state and local safety orders, as well as with the Occupational Safety and Health Act of 1970 (OSHA) and IEEE Standard 510. Compliance with the National Fire Protection Association (NFPA) Standard NFPA 70E, and the Accident Prevention Manual for Industrial Operations of the National Safety Council shall be observed.
2. Tests shall only be performed on apparatus that is deenergized. The testing company's lead test engineer for the project shall be a designated safety representative and shall supervise testing observations and safety requirements. Work shall not proceed until he has determined that it is safe to do so.
3. Power circuits shall have conductors shorted to ground by a hotline-grounding device approved for the purpose. Warning signs and protective barriers shall be provided as necessary to conduct the tests safely.

D. Reports:

1. General: Provide full documentation of all tests in the form of a report.
2. The test report shall include the following sections:
 - a. Scope of testing.
 - b. Equipment tested.
 - c. Description of test.
 - d. Test results.
 - e. Conclusions and recommendations.
 - f. Appendix, including test forms.
3. Each piece of equipment shall be recorded on a data sheet listing the condition of the equipment as found and as left. Included shall be recommendations for any necessary repair and/or replacement parts. The data sheets shall indicate the name of the engineer who tested the equipment and the date of the test completion. The EMPLOYER'S REPRESENTATIVE shall be notified within 24 hours of any defects found during testing.
4. Record copies of the completed test report shall be submitted to the EMPLOYER'S REPRESENTATIVE no more than 30 days after completion of the testing and inspection.
5. Test reports for circuit breakers shall be provided at equipment startup.

1.4 QUALITY ASSURANCE, REFERENCES AND REGULATORY REQUIREMENTS

- A. The testing and inspection shall comply with all applicable sections of the applicable codes and standards listed in Division 1 of the project specifications.
- B. The inspection and testing shall comply with the project plans and

specifications, as well as with the manufacturer's drawings, instruction manuals, and other applicable data that may be provided by the Owner, for the apparatus tested.

C. Conform to the following Standards:

1. ANSI/IEEE Standard 43-2000 – IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
2. ANSI/IEEE 112-1996 – Test Procedures for Polyphase Induction Motors and Generators.
3. ANSI/IEEE Standard 400-1991 – IEEE Guide for Making High-Direct-Voltage Tests On Power Cable Systems in the Field.
4. ANSI/IEEE C62.45-2002 – IEEE Guide on Surge Testing for Equipment Connected to Low Voltage AC Power Circuits.
5. ASTM D 877-2004 – Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
6. ICEA S-93-639 / NEMA WC74-2000 – Shielded Power Cable 5-46 kV.
7. IEEE Standard 81-1983 – IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potential of a Ground System.
8. IEEE Standard 510-1983 (R1992) – Recommended Practices For Safety In High-Voltage And High-Power Testing.
9. IEEE Standard 576-2000 – Recommended Practice for Installation, Termination and Testing of Insulated Power Cables as Used in Industrial and Commercial Applications.
10. IEEE Standard C57.12.90-1999 – Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers.
11. IEEE Standard C57.12.91-2001 – Standard Test Code for Dry-Type Distribution and Power Transformers.
12. NECA – National Electrical Contractors Association.
13. NETA – International Electrical Testing Association.
14. NETA ATS-2003 – Acceptance Testing Specifications for Electric Power Distribution Equipment and Systems. A copy of this is in Section 16080_app.
15. NFPA 70E-2004 – Standard for Electrical Safety Requirements for Employee Workplaces.
16. NICET – National Institute of Certification in Engineering Technologies.

1.5 QUALIFICATIONS

- A. The testing organization shall be an independent, third party testing organization, which will function as an unbiased testing authority, professionally independent of the manufacturers, suppliers and installers of equipment or systems evaluated by the testing organization.

- B. Manufacturer's representative or equally qualified individual shall be present during all testing to ensure the testing is performed properly and that any deficiencies discovered are promptly corrected.
- C. The testing organization shall be a full-service company and shall be regularly engaged in the testing of electrical equipment, devices, installations, and systems. The testing organization shall utilize factory-trained test engineers who are regularly employed for testing services and who are capable of troubleshooting, as well as identifying power equipment problems.
- D. All work outlined shall be performed under the full-time, onsite supervision of a graduate engineer with a minimum of 5 years of field-testing experience. Supervisor shall hold a current registered certification in electrical testing applicable to each type of apparatus to be inspected or tested. Certification in electrical testing shall be issued by an independent, nationally recognized, technician certification agency. Acceptable agencies and certifications:
 - 1. NETA: Certified Technician/Level III or Certified Senior Technician/Level IV.
 - 2. NICET: Engineering Technician/Level III or Senior Engineering Technician/Level IV.
- E. Upon request, the testing company shall submit proof of its qualifications.

1.6 CALIBRATION

- A. Any system material or workmanship, which is found defective on the basis of acceptance tests, shall be reported directly to the EMPLOYER'S REPRESENTATIVE.
- B. GENERAL CONTRACTOR shall replace the defective material or equipment and have test repeated until test proves satisfactory without additional cost to the EMPLOYER.

1.7 FAILURE TO MEET TEST

- A. Any system material or workmanship, which is found defective on the basis of acceptance tests, shall be reported directly to the EMPLOYER'S REPRESENTATIVE.
- B. Contractor shall replace the defective material or equipment and have test repeated until test proves satisfactory without additional cost to the EMPLOYER.

1.8 NOTIFICATION OF TESTING

- A. Notify the GENERAL CONTRACTOR, MEEPF CONSULTANT and the EMPLOYER'S REPRESENTATIVE ten (10) working days before any scheduled testing begins.

PART 2 – PRODUCTS (Not used)

PART 3 – EXECUTION

3.1 EQUIPMENT TO BE TESTED

A. Section 16134, Wiring Devices:

1. Receptacles or Outlets

a. Ground Fault Circuit Interrupters (GFCI)

- i. All GFCI outlets and protected outlets will be tested individually to ensure they all meet protection requirements. A full GFCI test involves the Test/Reset Button Test, Wiring Test and GFCI Circuit Challenge.

(a) Test/Reset Button Test:

- (1) Ensure the energized circuit can be appropriately de-energized.
- (2) It is preferable to have a light, a fan, or a circuit tester connect to the outlet to ensure the energization status of the circuit.
- (3) Press the Test Button.
- (4) The Reset Button should pop out. If it does not, proceed to step (8).
- (5) If the Reset Button pops out, check to ensure the electrical equipment has become de-energized. If the electrical equipment has not de-energized, proceed to step (8).
- (6) If the electrical equipment has de-energized, press the Reset Button. The Reset Button should stay reset and the electrical equipment should re-energize. If the Reset Button does not reset or the electrical equipment does not re-energize, proceed to step (8).
- (7) Repeat steps (3) through (6) with the light, fan, or circuit tester plugged into the other receptacles.
- (8) If the outlet fails any part of the Reset Button test, either the outlet is miswired or needs to be replaced. If the repair cannot be accomplished immediately and the outlet must remain in service, place a caution label over the outlet to prevent usage until the repairs or replacement are completed. Once repaired or replaced the outlet must be fully tested before use is allowed.
- (9) When testing slaved outlets, repeat steps (3) through (8) with a device plugged into the slaved outlet. Use the Test and Reset Buttons on the GFCI that provides protection for the outlet to perform the Test/Reset Button Test.

(b) Wiring Test:

- (1) Acquire an accepted wiring test similar to the Greenlee GFCI Circuit Tester with a wiring tester, catalog number 5708, NAED/DCI# 78-3310/34523.
- (2) If using a combination GFCI/Wiring Tester, set the nominal leakage current knob to zero mA.
- (3) Plug the tester into a receptacle on the outlet to be tested.
- (4) Check the tester display to ensure proper wiring.
- (5) If the wiring is improper and cannot be immediately repaired, proceed no further, cover the outlet with a caution label until the outlet has been properly wired and then repeat the tests prior to allowing the outlet to be used.

(c) GFCI Circuit Challenge:

- (1) Test the current that causes the GFCI to trip.
 - (i) Turn the current selector knob to the next higher current setting;
 - (ii) Wait for the test light to flash;
 - (iii) If the GFCI trips out;
 - Reset the knob to zero current;
 - Press the Reset Button on the GFCI the outlet the GFCI is wired to or the GFCI circuit;
 - Check for test lights to indicate the circuit is re-energized;
 - Remove the tester from the outlet.
 - (iv) If the circuit does not trip out, repeat steps (i) through (iv).
 - (v) If the GFCI fails to trip within 4 to 7 mA and the GFCI cannot be currently replaced, proceed no further, place a caution label over the outlet, indicate faulty GFCI and once the outlet has been replaced repeat the tests prior to allowing the outlet to be used.
- (2) After the GFCI has tripped, repeat the tests in (a), (b) and (c) for the other receptacle (on a 2-receptacle GFCI outlet) and all GFCI protected outlets.

(d) Placing a Test Sticker:

- (1) If the outlet passes all of the above tests, place a GFCI test sticker on the outlet cover with the following

information:

- (i) The test date;
- (ii) The tester's initials and company;
- (iii) The current level where the interruption occurred;
- (iv) The wiring status;
- (v) And the number of the outlet (to distinguish the GFCI protected outlets from each other for documentation purposes).

B. Section 16060, Grounding and Bonding:

1. Test, in the EMPLOYER'S REPRESENTATIVE'S presence, the ground resistance of the grounding system. Test by means of the [fall-of-potential][two terminal or direct] method per IEEE Standard 81.
 - a. Testing Instrument: Battery-powered or hand-cranked AC tester.
 - i. Indicates ground resistance in ohms from digital decade switches when the unit's self-contained meter indicates a null condition.
 - ii. Range: 0.01 ohm to 9,990 ohms in four overlapping ranges.
 - iii. Null condition occurs when no current flows through the potential electrodes.
 - iv. Instrument Accuracy: Plus or minus 2 percent or greater.
 - v. Manufacturer: Biddle Instruments Model 250241 (battery powered) or 250220-2 (hand-cranked) Megger Null Balance Earth Tester.
 - b. Fall-of-Potential Test (Intersecting Slope Method):
 - i. Connect instrument as shown on the Drawings.
 - ii. Place Rod P2 at various locations in line between the tested electrode and Probe C2 and plot the results on a graph (distance versus resistance). Take sufficient readings to yield a portion of the plotted curve as being constant (rate-of-resistance change becomes so small with respect to distance as to be insignificant).
 - c. Two-Terminal Test (Direct Method):
 - i. Connect jumper between terminals C1 and P1 and between C2 and P2.
 - ii. Connect terminal P1 and C1 to the electrode under test. Connect P2 and C2 to an all metallic water pipe system extensive enough to have a negligible resistance and metallic throughout, without insulating couplings or flanges.
 - d. Conduct two separate tests on opposite sides of the grounding grid.
 - e. Report failure to obtain specified ground resistance to the EMPLOYER'S REPRESENTATIVE.

- f. Test report shall be in writing, and shall show temperature, humidity, and condition of the soil at the time of the tests.
- C. Not Used.
- D. Not Used.
- E. Section 16410, Disconnect Switches:
 - 1. Visual and Mechanical Inspection:
 - a. Inspect cover and case, and check for broken or loose terminals.
 - b. Operate breaker to check operation.
 - 2. Electrical Tests (all breakers with frames rated 600A and above plus 10 percent of breakers with frames rated 250A frame to 600A frame):
 - a. Insulation Resistance Test: Megger main poles of breaker pole to pole, from each pole to ground, and across the open contacts of each pole.
 - b. Contact Resistance Test: Measure contact resistance in microhms across main pole contacts with breaker closed and latched to check for good, low-resistance contact. Investigate any value exceeding 500 microhms or deviation of 50 percent or more from adjacent contacts or similar breakers.
 - c. Test overcurrent trip device by primary current injection and calibrate to settings provided on all circuit breakers 600A and larger and 10 percent of circuit breakers 200A-599A and calibrate to settings provided by A/E.
 - i. All trip units shall be tested by primary injection.
 - ii. Static overcurrent trip devices shall be tested per manufacturer's instructions.
 - iii. Test for minimum pickup current.
 - iv. Apply 300 percent of pickup current and measure time necessary to trip breaker (long-time delay).
 - v. Where short-time delay characteristics are provided, test short-time pickup and delay.
 - vi. Test instantaneous trip by passing current sufficiently high to trip breaker instantaneously.
 - vii. Where ground fault protection is provided, test ground fault pickup and delay.
 - viii. Check reset characteristics of trip unit.
 - d. For the 10 percent group of breakers tested, if one of these breakers fails the test, then 10 more breakers shall be tested.
 - 3. Electrical Tests:
 - a. Insulation Resistance Test: Megger main secondary bus and feeder

circuits phase to phase and phase to ground.

b. Energize any space heater circuits to ensure proper operations.

4. Circuit Breakers:

a. Visual and Mechanical Inspection:

- i. Remove each drawout type circuit breaker.
- ii. Inspect arc chutes of power circuit breakers.
- iii. Inspect circuit breaker for defects or damage.
- iv. Inspect and check contacts. Check alignment, overtravel, and pressure. Adjust if necessary.
- v. Inspect finger clusters on line and load stabs of drawout circuit breakers.
- vi. Check for proper mechanical operation. Lubricate where necessary.
- vii. Check auxiliary devices for proper operation.
- viii. Check breaker racking-device (if applicable) for alignment and friction-free operation. Lubricate if necessary.

b. Electrical Tests:

- i. Insulation Resistance Test: Megger main poles of breaker pole to pole, from each pole to ground, and across the open contacts of each pole.
- ii. Contact Resistance Test: Measure contact resistance in microhms across main pole contacts with breaker closed and latched to check for good, low-resistance contact. Investigate any value exceeding 500 microhms or deviation of 50 percent or more from adjacent contacts or similar breakers.
- iii. Test overcurrent trip device by primary injection and calibrate to settings provided by A/E. Static overcurrent trip devices shall be tested per the manufacturer's instructions. Test each pole of the breaker individually. Data shall be compared with manufacturer's published data.
 - (a) Test for minimum pickup current.
 - (b) Apply 300 percent of pickup current and measure time necessary to trip breaker (long-time delay).
 - (c) Where short-time delay characteristics are provided, test short-time pickup and delay.
 - (d) Test instantaneous trip by passing current sufficiently high to trip breaker instantaneously.
 - (e) Where ground fault protection is provided, test ground fault pickup and delay.

- (f) Check reset characteristics of trip unit.
- c. Electrically test any auxiliary devices, such as shunt trips, undervoltage trips, alarm contacts, and auxiliary contacts.

Section 16442, Panelboards:

1. Visual and Mechanical Inspection - Circuit Breakers:
 - a. Inspect cover and case, and check for broken or loose terminals.
 - b. Operate breaker several times to check proper operation.
 - c. Glastic and phenolic components to be inspected for cracks.
 - d. Contacts, shunts, etc to be visually inspected for alignment.
2. Electrical Tests - Circuit Breakers (all breakers with frames rated 600A and above plus 10 percent of breakers with frames rated 200A through 599A). For CPS and emergency power switchboard and panelboards, test all main circuit breakers regardless of size:
 - a. Insulation Resistance Test: Megger main poles of breaker pole to pole, from each pole to ground, and across the open contacts of each pole.
 - b. Contact Resistance Test: Measure contact resistance in microhms across main pole contacts with breaker closed and latched to check for good, low resistance contact. Investigate any value exceeding 500 microhms or deviation of 50 percent or more from adjacent contacts or similar breakers.
 - c. For the 10 percent group of breakers tested, if one of these breakers fails the test, then 10 more breakers shall be tested.
 - d. Test overcurrent trip device by primary current injection and calibrate to settings provided on all circuit breakers 600A and larger and 10 percent of circuit breakers 200A-599A.

3.2 COMMISSIONING

3.3 DEMONSTRATION

- A. Engage a factory authorized service representative to train EMPLOYER'S maintenance personnel to adjust, operate, and maintain the electrical equipment and systems.

**** END OF SECTION ****

SECTION 16100

BASIC MATERIALS AND METHODS

PART 1 - REFERENCE

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

PART 2 – GENERAL

- A. Furnish and install all conduits, cable troughs, wireways, joint and outlet boxes, conductor and miscellaneous materials required for wiring, as specified herein and shown on drawings.
- B. Furnish and install all power and control wiring to all equipment, except as otherwise specified. Equipment includes motor, motor starters, and miscellaneous devices.

PART 3 - INTERMEDIATE METAL CONDUIT (IMC):

- A. General: NEMA standard trade sizes, UL approved or equivalent to McGill or approved equal.
- B. Material: mild steel, hot dipped galvanized with inside enamel or epoxy coating.
- C. Size: 15mm (1/2") minimum.
- D. Coupling, unions and fittings : standard, threaded
- E. Use limitation: as specified in the latest edition of PEC and/or NEC.
- F. Expansion fittings: use for runs spanning expansion joints.
- G. Paint field cuts and repair damaged protected coating with red lead or Zinc chromate. Conduit threads shall not be painted.

PART 4 - POLYVINYL CHLORIDE (PVC) CONDUIT

- A. General: Standard trade sizes, heavy wall, manufactured to NEMA TC-2 Type 40, rated 90 deg Celsius cable as manufactured by Crown, Emerald, Neltex and Atlanta.
- B. Material: Polyvinylchloride, extruded.
- C. Nominal size: 20 mm (1/2") minimum.
- D. Couplings and Fittings: Standard joint by solvent weld process.
- E. Use Limitation:
 - 1. As specified in the latest edition of PEC and/or NEC.
 - 2. Not permitted where subject to mechanical damage.
 - 3. Indicated in the drawings.

- F. Pulling Hardware: Flat fish tape with ball and flexible leader or polyethylene or Manila rope. Use of steel pulling cable not permitted.

PART 5 - ELECTRICAL METALLIC TUBING (EMT):

- A. General: Standard sized, UL approved
- B. Material: Steel, zinc coated outside, enamel coated inside.
- C. Nominal Size: 15mm (1/2") minimum, 50 mm (2") maximum.
- D. Fittings: Compression type with plastic insert.
- E. Use limitation:
 - a. As specified in the latest edition of PEC.
 - b. Only where approved by the CONSULTANT.
- F. Repair damaged protective coating with red lead or zinc chromate.

PART 6 - FLEXIBLE GALVANIZED STEEL CONDUIT:

- A. General: Standard sized, UL approved or equivalent
- B. Material : Steel, galvanized.
- C. Nominal size: 15 mm (1/2") minimum.
- D. Fittings: Standard.
- E. Use Limitation:
 - a. Between motor terminal boxes or vibration producing devices and rigid conduit.
 - b. Short lengths of concealed wiring to lighting fixtures.
 - c. Other applications: only where approved or where shown on plans.

PART 7 - FLEXIBLE LIQUID TIGHT CONDUIT:

- A. General: Standard trade sizes. UL approved or equivalent.
- B. Material: Galvanized steel with outer liquid-tight plastic jacket.
- C. Size: 15 mm (1/2").
- D. Fittings: Liquid-tight.
- E. Use limitation:
 - 1. Short lengths to vibration producing devices situated in wet or potentially wet locations.
 - 2. Between motor terminal boxes or vibration producing devices and rigid conduit.
 - 3. Other applications: Only where approved or where shown on plans.

PART 8 - CONDUIT INSTALLATION:

- A. General: Install in accordance with applicable codes and recognized standards of good practice.
- B. Location: Approximately as shown on drawings; actual routing subject to approval.
- C. Wall and floor sleeves:
 - 1. General: Provide passage of conduits through walls, floors, or partitions. Set sleeves in masonry during construction; set sleeves through concrete before pouring begins.
 - 2. Material: Galvanized pipe, securely fastened in position.
 - 3. Sleeves through exterior building walls: Install conduit in center of sleeve, fill annular space with loosely packed oakum. Seal interior and exterior of packing with hot applied asphalt. Fit the conduit on each side of the wall with round galvanized steel flange fastened to conduit by two set screws to retain sealing compound.
 - 4. Sleeves through waterproof constructions: Flanged type.
 - 5. Opening required after footings, walls, floors, or ceilings are constructed shall be provided and patched at Contractor's expense in an approved manner.
- D. Embedded Conduit:
 - 1. General: Set before pouring of concrete begins. Route in as direct line as possible and where a bend is required, turn with a long radius.
 - 2. Underground installation: Encase conduits with concrete, 75mm (3") from outer face of conduits.
 - 3. Conduit joints shall be half-wrapped with 3M Scotch wrap #50 PVC tape or approved equivalent.
- E. Joints: Make with approved couplings and unions to provide electrically continuous and moisture-tight system.
- F. Expansion joints: Use expansion fittings and bonding jumpers wherever conduit spans building expansion joints.
- G. Drainage: Avoid pockets in conduit runs as much as possible; provide suitable fittings at low spots in exposed conduits where pocket cannot be avoided. Weep holes not permitted.
- H. Bends: Not more than the equivalent of three 90 deg bends between pulling joints.
- I. Wiring of fire related motors shall be embedded or encased in concrete.
- J. Field cuts and threads:
 - 1. Cut ends of conduit square with hand or power saw and ream to remove burrs and sharp edges. Do not use wheel cutter.
 - 2. Threads cut on job shall have same effective lengths, thread dimensions, and taper as factory cut threads.

3. Carefully removed burrs from threads. Conduit threads shall not be painted.
 4. Apply coat of protective paint through conduits where protective coating is damaged.
- K. Supports:
1. Manufacturer: Nova or approved equal.
 2. Hangers, supports, or fastenings: Provide at each elbow and at end of every straight run terminating in a box or cabinet. Rigid fastenings spaced in accordance with the PEC.
 3. Clamps: Galvanized malleable iron one-hole straps, beam clamps, or other approved device with necessary bolts and expansion shields.
 4. Adjustable hangers:
 - a. Use to support horizontal runs only.
 - b. Trapeze hangers: For parallel runs of conduits. Install pipe clamps every third intermediate hanger for each conduit. Paint hangers one prime coat of red lead or zinc chromate, one finish coat of approved color. Hangers are not detailed but must be adequate to support the combined weights of conduit, conductors, and hangers.
 5. Submit shop drawings for approval.
- L. Concealing: Conceal conduits in all areas except mechanical equipment rooms and areas as specified. Run exposed conduits parallel with, or at right angle to, lines of buildings.
- M. Conduit ends:
1. Cap conduit.
 2. Open conduit ends terminating in panels for enclosures where exposed to entrance of foreign material: Plug space around cables with commercial duct sealing compound.
 3. Cap conduit ends during construction to prevent entrance of foreign materials and moisture before wires or cables are installed.
- N. Cleaning: Clean inside by mechanical means to remove all foreign materials and moisture before wires or cables are installed.
- O. Conduit connections at panels and boxes: Double locknuts and bushings.

PART 9 - JUNCTION BOXES AND OUTLET BOXES:

- A. Manufacturer: Steel City or approved equal.
- B. General: Provide junction boxes for pulling and splicing wires, and outlet boxes for installation of wiring devices as required, or as shown on drawings. As a rule, provide junction boxes in all runs of greater than 30 meters (100 ft) in length. For other lengths, provide boxes as required for splicing or pulling. Boxes be in accessible locations.

- C. Construction: Welded sheet steel, galvanized finish. Provide removable covers attached with round head machine screws.
- D. Support: Support boxes independently of conduits entering, by means of materials described in Section 16100, sub-section 6.0J.
- E. Finish: Galvanized.

PART 10 - WIREWAY:

- A. General: Furnish and install wireway as indicated on drawings or as required.
- B. Size and arrangement: As indicated on drawings.
- C. Construction: Minimum 1.519mm (#16 MSG) thick galvanized steel sheet metal with snap-on cover or as shown on plans.
- D. All screws installed towards the inside shall be guarded to prevent wire insulation damage.
- E. Provide all necessary supports, fittings and miscellaneous materials for a complete installation.

PART 11 - CONDUCTOR:

- A. Manufacturer: Philflex, Phelps Dodge or approved equal.
- B. Material : Copper, annealed.
- C. Stranding: Standard stranding for 3.5 sq mm and larger.
- D. Minimum sizes: 3.5 sq mm THW or THHN for lighting and power as noted in the plans.
- E. Standards: ICEA or Philippine Electrical Code.
- F. Color Code:
 - 1. Color coding for all ground and neutral conductors shall be as follows in accordance with the Code:
 - 2. Multi-wire branch circuits, feeders to distribution, lighting, receptacle and power panels shall be color coded.
 - 3. Color coding shall be maintained all throughout the installation.
- G. 600-Volt Class Conductors Insulation:
 - 1. Feeders and general use conductors: THW or THHN insulation as shown in the plans.
 - 2. Fixture wires: In accordance with Philippine Electrical Code.
 - 3. Wiring in fluorescent fixtures: In accordance with Philippine Electrical Code.
 - 4. Wire insulation in wet or potentially wet locations: TW insulation.

PART 12 - CONDUCTOR INSTALLATION:

- A. Place all wiring, in raceway of type of types indicated. Provide all required and indicated accessories for proper installation of all wiring.
- B. Bending radii: Not less than permitted by Philippine Electrical Code.
- C. Supports in vertical runs: As prescribed by Philippine Electrical Code.
- D. Splicing:
 - 1. Permissible only in junction boxes or similar accessible locations. Number of splices held to absolute minimum.
 - 2. Use solderless, compression-type wire terminators at devices. Use wire nuts with screws not bearing directly on the wires.
- E. Insulation of splices or taps:
 - 1. Three layers 20mm wide 3M Company "Scotch no.33" or "Scotch no.88", or approved equal, electrical tape, half lapped.
 - 2. Use filler compound, "Scotchfil", or approved equal, at sharp edges to provide smooth surface before taping.
 - 3. Use 3M wire nut for splices in wireways.
- F. Marking: Mark each end of every power or control cable with a plastic tag securely fastened to it bearing circuit use identification. Also mark cables in pull or junction boxes.
- G. Connections:
 - 1. Apparatus lugs: Solderless pressure-type lugs. Thoroughly clean lug conductor and coat with suitable oxidation inhibiting compound prior to connection.
 - 2. Terminal blocks: Use retaining cup washers where solid wire is used. Use pressure type terminal lugs where stranded wire is used.
 - 3. All feeder cable terminations shall be torqued and properly marked.

PART 13 - NAMEPLATES:

- A. General: Provide and install nameplates wherever indicated as required in these specifications. Wording shall be approved prior to purchase of nameplates.
- B. Material: Red Bakelite engraving stock, white core.
- C. Lettering: Engraved, approximately 5.0 mm high. Wording shall identify function of device to which nameplate is attached, or identify equipment served by device.
- D. Installation (except for factory-installed nameplates): Attach with sheet metal screws after painting of equipment is completed.
- E. All receptacle outlets/switches, plates shall be identified with circuit and panel homerun numbers using "dymo" tape labeler.

PART 14 - FIELD TESTS AND ADJUSTMENTS:

- A. Test reports: Typewritten, listing equipment used, person or persons performing the tests, date tested, circuits tested and results of tests.
- B. Insulation resistance tests, general:
 - 1. Perform insulation resistance tests on wires listed herein.
 - 2. Test equipment: Furnished by Contractor; equal to Megger as manufactured by James G. Biddle Company, motor driven or rectifier type ranges of 500, 1000, and 2500 volts DC.
 - 3. Resistance measured: Line to ground.
 - 4. Disconnect all solid state equipment before making wire or cable tests. Contractor is responsible for damage to any such equipment caused by these tests.
- C. Insulation resistance tests, wires.
 - 1. Test all 600 volt class power and lighting circuits at 1000-volt rating of "Megger" for one minute duration.
 - 2. Spot test control circuits with "Megger" as directed.
- D. Voltage level test:
 - 1. When performed: After all equipment is installed, ready for operation.
 - 2. Contractor shall measure voltage at five points in the system as directed.
 - 3. Load conditions: No-load and full load, in so far as practicable.
 - 4. Test report: Required, as specified under item "A".
- E. Continuity test: Test all socket outlet and control circuits to determine continuity of wiring and connections. Submit written statement that this test has been performed.
- F. Correction of defects:
 - 1. If tests disclose any unsatisfactory workmanship, wiring or equipment furnished under this Contract, Contractor shall repair or replace, at his expense, such defects in an approved manner.
 - 2. If any wiring or equipment is damaged by tests, Contractor shall repair or replace, at his expense, such wiring or equipment in an approved manner.

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

SECTION 16123

WIRES AND CABLES

PART 1 - GENERAL

1.1 SCOPE OF WORK

- A. Provide building wires, power cables, control cables, flexible cords, splices, taps, and terminations as required for electrical work covered by the Contract Documents.

PART 2 - PRODUCTS

2.1 BUILDING WIRES FOR 600 VOLTS AND LESS

A. General

1. Conductors shall be new and shall show the name and trademark of the manufacturer and shall be tagged showing acceptance by Underwriter's Laboratories. Conductors shall be identified in accordance with Philippine Electrical Code color coding. Conductors shall be 600 volt insulated and shall be 3.5 mm² or larger unless otherwise noted. Sizes larger than 3.5 mm² are noted on the drawings.
2. Conductors shall be stranded copper.
3. Conductors for motor control shall be 2 mm² stranded type THW.
4. Conductors for signal and communication systems shall be as specified under specification section for those systems.
5. Conductors used in fluorescent fixture channels shall be rated 90°C.
6. Conductors for power circuits shall be type THWN and THW.
7. Equipment grounding conductors shall be green or have the ends taped with green tape and shall be type TW.

B. Insulation Types shall be as follows:

1. Type THW conductor insulation shall be moisture and heat-resistant thermoplastic. Rating shall be 75°C in wet or dry locations.
2. THHN conductor insulation shall be heat-resistant thermoplastic. Rating shall be 90°C in dry locations

C. Approved Product Manufacturers or approved equal.

1. American Wire & Cable Co.
2. Phelps Dodge Phils. Corp.

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	$\frac{1}{2}$
20	$\frac{3}{4}$
25	1
32	$1 \frac{1}{4}$
40	$1 \frac{1}{2}$
50	2
65	$2 \frac{1}{2}$
80	3
90	$3 \frac{1}{2}$
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 "Phiflex".
- 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

- A. 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.
 - B. The installation shall meet with the requirements of the Philippine Electrical Code (PEC).
 - C. Foundations for lighting poles shall be cast-in-place concrete, minimum of 3000 psi 28 day compressive strength.
 - D. 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.
 - E. Set anchor bolts according to anchor-bolt templates furnished by the pole manufacturer.
 - F. Install poles as necessary to provide a permanent vertical position with the bracket arm in proper position for luminaire location.
 - G. 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.
 - H. Install LED lamps in each luminaire.
 - I. 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:

- A. 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 ****