SEC DAVAO EXTENSION OFFICE (DAVEO)

SEC Davao Extension Office, 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

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Contents

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:

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.

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:

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. Section16060 - 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 RERESENTATIVE 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 al 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 (½") 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 Hardwares: 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 (½") 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 (½").

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 or 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, "Scothfil", 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.

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 mm^2 or larger unless otherwise noted. Sizes larger than 3.5 mm^2 are noted on the drawings.
2. Conductors shall be stranded copper.
3. Conductors for motor control shall be 2 mm^2 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.