

DIVISION 7 ELECTRICAL WORKS

7.1 ELECTRICAL GENERAL REQUIREMENTS

7.1.1 GENERAL

7.1.1.1 APPLICATION

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

7.1.1.2 WORK INCLUDED

The work to be done under this division shall include the furnishing of all tools, labor, supervision, equipment, fixtures and all necessary materials, each complete and in proper working condition unless one or other is specifically excluded or stated otherwise in this specifications but not limited to the following items of works.

[Shown below are the standard scope of electrical works. Indicate the scope of work applicable to the subject Project]

1. All works and material for a complete lighting and power systems including cables and conduits, circuit breakers, panelboard and connection to all lighting fixtures and power outlets, motor appliances, switches, supports and accessories.
2. All excavation works, backfilling, dewatering, removal of surplus earth, preparation of formworks and pouring of concrete envelopes as indicated on the drawings or as required to complete the installation.
3. All steel support for conduits, wires, panelboard, boxes, lighting fixtures, etc. as indicated or as required to complete the installation.
4. A complete grounding system as required by the governing codes.
5. A complete testing of all electrical systems.
6. Where material are furnished and supplied by the Engineer, the Contractor shall receive, unload, handle and transport to the site, assemble and install completely. This Contractor shall be responsible for safekeeping and warehousing of such materials/equipment from the time of his acceptance.
7. All items incidentals to and or required for the proper completion such as painting of boxes, conduits and the likes.
8. Coordination with other trade Contractors.

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9. Coordination with other companies/offices including handling of all material related to material testing and application of electrical permits.
 10. Preparation of necessary shop drawings required for the proper execution of the works subject to the approval of the Engineer.
 11. Preparation of "As-Built" drawings.

7.1.1.3 WORK NOT INCLUDED UNDER ELECTRICAL WORKS

The work excludes the furnishing of the following:

1. Supply and installation of all motors, pumps and their associated control equipment.
 - a. All electrical system installation beyond the motor branch circuit breakers.
 - b. All motor controllers as indicated to be supplied with equipment.
 - c. Structural foundation of the above.

7.1.1.4 SUBMITTALS

Obtain approval before procurement, fabrication or delivery of items to the job site. Partial submittals will not be entertained and will be returned without review. Submittals shall include the manufacturer's name, trade name, place of manufacturer, catalogue 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. Shop Drawings

In addition to the requirements of the contract clauses, shop drawings shall meet the following requirements:

- a. Drawings shall be a minimum of 210 mm x 297 mm in size or in A3 size, except as specified otherwise.
- b. Drawings shall include wiring diagrams and installation details indicating the proposed location layout and arrangement, control panels, accessories, and other items that must be shown to assure a coordinated installation.
- c. Wiring diagrams shall identify circuit termination and the internal wiring for each item of equipment and its interconnection.

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- d. Drawings shall indicate adequate clearances for operation, maintenance and replacement of equipment devices. If the layout is disapproved, revise the layout and resubmit.

2. Manufacturer's Data

Submittal for each manufactured item shall be current descriptive literature of cataloged products.

3. Publication Compliance

Where equipment or materials are specified to conform to industry and technical society publications of organizations such as American National Standard Institute (ANSI), American Society for Testing and Materials (ASTM) and Underwriters Laboratories, Inc. (UL), submit proof of such compliance. The label or listing by the specified organization will be acceptable evidence of compliance. In each of the publications referred to herein, consider the advisory provisions to be mandatory as though the word "shall" had been substituted for "should" wherever it appears. Interpret reference in these publications to the authority having jurisdiction, or words of similar meaning, to mean the Engineer. In lieu of the label or testing, submit a certificate from an approved independent testing organization, adequately equipped and component to perform such services, organization's test methods and not the item conforms to the specified organizations publications.

The edition or the revised version of such codes and standards current at the date twenty eight (28) days prior to date of bid submission shall apply. During Contract execution, any changes in such codes and standards shall be applied after approval by the Owner.

7.1.1.5 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 specially for the contract. Preprinted certifications and copies of previously submitted documents are not acceptable. The manufacturer's certification shall name the appropriate products, equipment or materials and the publication specified as controlling the quality of the item. Certification shall not contain statement to imply that the item does not meet requirements specified such as "Good As", "Achieves the same end use and results as materials formulated in accordance with referenced publications" or "Equal or exceeds the service and performance of the specified materials". Certifications shall simply state that the item conforms to the requirements specified; and shall be printed on the manufacturer's letterhead and shall be signed by the manufacturer's official, authorized to sign certificates of compliance.

7.1.1.6 OPERATION AND MAINTENANCE MANUALS

Submit as required for systems and equipment indicated in the Technical Sections. Furnish three (3) copies, bound in hardback binders or an approved equivalent. Furnish one complete manual prior to performance of system or equipment tests, and furnish the remaining manual prior to contract completion. Inscribe the following identification on the cover: the word "Operation and Maintenance Manual", the name and location of the system equipment, building, name of Contractor and contract number. Include in the manual the names, addresses and telephone numbers of each sub-Contractor installing the system or equivalent and the local representatives for the system or equipment. Include a table of contents and assemble the manual to conform to the table of contents with the tab sheets placed before instruction covering the subject. The instructions shall be legible and easily read with large sheets of drawings folded in the manual shall include the following:

1. Internal and interconnecting wiring and control diagrams with data to explain detailed operation and control of the system or equipment.
2. A control sequence describing start-up, operation and shut-down.
3. Description of the function of each principal item of equipment.
4. Installation and maintenance manual.
5. Safety precaution
6. Diagrams and illustrations
7. Testing methods
8. Performance data
9. Lubrication schedule including type, grade, temperature range and frequency
10. Part list
11. Appendix

List qualified permanent servicing organization for support of the equipment, including addresses and certified qualifications.

7.1.1.7 POSTED OPERATING INSTRUCTIONS

Furnish approved operating instructions for systems and equipment indicated in the technical sections for use by operation and maintenance personnel. The operating instructions shall include diagrams, control diagrams and control sequence for each principal system and equipment. Print or engrave operating instructions and frame under glass or in

approved laminated plastic. Attach or post the operating instructions adjacent to each principal system and equipment including start-up, proper adjustment, operating, lubrication, shutdown, safety precautions, procedure in the event of equipment failure, and other items of instruction recommended by the manufacturer of each system for operating instruction exposed to the weather. Operating instructions shall not fade when exposed to the weather and shall be secured to prevent easy removal or peeling.

7.1.1.8 INSTRUCTIONS TO PERSONNEL

Where indicated in the technical sections, furnish the services of competent instructors to give full instructions to personnel in the adjustment, operation and maintenance of systems and equipment, including safety precautionary measures. Each Contractor shall be thoroughly familiar with all parts of the installation and shall be trained in operating theory as well as practical operation and maintenance work, instructions shall be given during the first regular work week after the equipment or system has been accepted and turned over to the Engineer for regular operation. The number of man-days (8 hours) of instruction shall be as specified in each individual section.

7.1.1.9 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 1, titled "Equipment Storage and Maintenance during Construction". Replace damaged or defective items with new one.

7.1.1.10 CATALOGUE 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 two (2) years prior to bid opening. The two (2) year period shall include applications of equipment and materials under similar circumstances and of similar size. The two (2) year period shall be satisfactory completed by a manufacturer's catalog or brochures. Products having less than two (2) year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6,000 hours, exclusive of the manufacturer's factory or laboratory tests is furnished. The equipment item shall be supported by service organization, which are reasonably convenient to the equipment on a regular and emergency basis during the warranty period of the contract.

7.1.1.11 MANUFACTURER'S RECOMMENDATIONS

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

7.1.1.12 "AS-BUILT" DRAWINGS

The cost of as-built drawings shall be borne by the Contractor. Submittal of such drawings shall be a condition to final payment.

7.1.1.13 MATERIALS/SUBSTITUTION/TESTS

All materials to be installed shall be brand new and shall conform with specifications except as otherwise noted on the drawings. All materials where not specified shall be of the best of their respective kind. Samples of said material including its manufacturer's data shall be submitted for approval. Necessary tests on the installations shall be made by the Contractor in the presence of the Engineer. These tests shall include but not limited to ground test, performance test, phase sequence test, etc. Records of approved tests result shall be relayed to the Engineer in writing. This Contractor shall within ten (10) days after the award of the contract, submit a list of materials he proposes to use. All materials installed without prior approval shall be at the risk of the Contractor.

7.1.1.14 COORDINATION/GUARANTEES/SUSPENSION OR DELAY

The Contractor shall be familiar with the specifications of the other trades and coordinate with them thoroughly so that he can arrange his work and dispose his materials without interfering the work of other Contractors. The Contractor shall guarantee that the electrical systems shall be free from all defects of workmanship and of materials, and that it will remain so for a period of one year from the date of acceptance by the Engineer. Any remedy to correct defects deemed to be caused by such shall be made at the expense of the Contractor.

The Contractor shall not suspend or delay the work without justifiable cause. Subsequent delays shall be deemed as a sufficient cause for penalties or termination of contract in which the Engineer shall have the right to take-over the work and all materials on the site and make arrangements necessary to complete the work. It shall be the sole responsibility of the Contractor to ensure that the Electrical sub-contractor conducts coordination of his activities to other trades.

7.1.1.15 SLEEVES/INSERTS/CUTTING/PATCHING/BACKFILL

The Contractor shall provide all openings, sleeves, also inserts in walls, floors, and beams as required for his work. All unused openings shall be grouted in. the Contractor shall do all patching requirements necessary and these shall be done so as to exactly match the surrounding area without the evidence of alteration or patching. The Contractor shall provide all necessary backfill on all excavation works of his doing.

7.1.1.16 TEMPORARY LIGHT AND POWER

The Contractor shall make all arrangements and pay for the provisions of the necessary electrical power of the type and capacity required for the performance of the work of all trades engaged in the construction of the building.

7.1.1.17 CLEANING UP

The Contractor shall remove all dirt, debris, and rubbish and waste materials caused by him in the process of his work. He shall also remove all tools, temporary power installation, scaffolding and surplus materials after completion and acceptance of work.

7.1.1.18 ELECTRICAL CHARACTERISTICS

The electrical characteristics for this project shall be 230V, 3 wire, single phase and 60Hz or as per system requirements.

7.1.2 MATERIAL REQUIREMENTS

7.1.2.1 NAMEPLATES

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. Nameplate shall be melamine plastic, 3.2mm 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 25mm x 38mm. Lettering shall be a minimum of 6mm, high normal block style.

7.1.3 EXECUTION

7.1.3.1 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.

7.1.3.2 PAINTING OF EQUIPMENT

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 C37.30.
2. Field Applied: Paint electrical equipment as required to match finish or to meet safety criteria.

7.1.4 MEASUREMENT AND PAYMENT

The work under this section shall be incidental to other items of work and shall not be measured for payment unless otherwise specified in the Bill of Quantities.

7.2 DIESEL ENGINE GENERATOR SET

7.2.1 GENERAL

Work under this Contract shall be in accordance with Section 7.1 "Electrical General Requirements" of these Specifications and shall be applicable to this Section, whether herein referred to or not.

7.2.1.1 SCOPE OF WORK

The Work covered shall include but not be limited to all labor, materials, tools, equipment and incidentals necessary for the Contractor to furnish/provide diesel electric generating unit with accessories, auxiliary equipment, and associated work as specified and indicated.

7.2.1.2 APPLICABLE PUBLICATIONS

The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only. The edition or the revised version of such codes and standards current at the date twenty eight (28) days prior to date of bid submission shall apply. During Contract execution, any changes in such codes and standards shall be applied after approval by the Owner.

1. American National Standards Institute, Inc. (ANSI)

B15.1-72	Safety Standard for Mechanical Power Transmission Apparatus.
C50.10-77	General Requirements for Synchronous Machines

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2. American Society of Mechanical Engineers (ASME) Publication:
PTC 26-62 Speed-Governing Systems for Internal Combustion Engine-Generator Units.
 3. Diesel Engine Manufacturers Association (DEMA) Publications:
(Sixth Edition 1972) Standard Practices for Stationary Diesel and Gas Engines
 4. Institute of Electrical and Electronics Engineers (IEEE) Publication:
126-59 Recommended specification for Speed Governing of Internal Combustion Engine-Generator Units
- PEC (2000) Philippine Electrical Code
5. Underwriter's Laboratories, Inc. (UL) Publications:
142-1981 Steel Above ground Tanks for flammable and Combustible Liquids
(AM 85)
1236-1978 Electric Battery Charges
(1994; R 1999)
 6. Bureau of Product Standard (BPS)
- PNS (2000) Philippine National Standard

7.2.1.3 QUALITY ASSURANCE

Engines installed shall meet all of the operating experience requirements listed below:

1. Only electrical generation service is considered as equivalent experience. Engine driving pumps or compressors, or those in marine propulsion or railroad service, are not acceptable.
2. Only experience on the same engine model is acceptable. Engine model is considered to be a given series or class of identical bore and stroke and of the same type of engine, such as in-line or Vee. In-line and Vee engines with identical bore and stroke are considered as two separate models of engines.
3. Only experience at the identical rotative speed as that which is offered is acceptable.

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4. Only experience at the identical or higher brake mean effective pressure as that which is offered is acceptable.
 5. Only experience with fuel oil is acceptable.

7.2.1.4 SUBMITTAL

The Contractor shall furnish certificate(s) within twenty eight (28) days after commencement of works certifying that no less than two engines of identical number of cylinder size, identical rotative speed, and identical or higher Brake Mean Effective Pressure (BMEP), and of the same basic configuration (in-line or Vee) as the engine to be furnished, shall have driven generators which have produced in satisfactory operation not less than 500 KWH of electricity for each KW of generator nameplate capability within a two (2) year period. Certificate(s) shall include:

1. A list of at least two engine installation meeting the experience requirements set forth in Sub-section 7.2.1.3 entitled "Quality assurance".
2. Owner and location of each such installation.
3. Date of initial operation of each such installation.
4. Number of KW hours produced per KW of generator rated capability of each installation.
5. Horsepower rating, KW rating, and rotative speed of each unit.
6. Brake Mean Effective Pressure (BMEP) rating of each engine.
7. Design characteristics of each unit, such as bore and stroke, number of cylinders, and configuration (in-line or Vee).

7.2.1.5 SHOP DRAWINGS AND CALCULATIONS

The Contractor shall submit shop drawings and calculation for diesel engine generating unit and auxiliary equipment, including the following:

1. Certified outline, general arrangement (setting plan), and anchor bolt details. Drawings shall show the total weight and center of gravity of the assembled equipment of the mounting skid.
2. General arrangement drawings showing location of all auxiliary equipment in relation to the diesel generating unit.
3. Piping schematic for compressed air starting, fuel oil, lubricating oil, jacket water, and cooling water integral with diesel engine.

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4. BMEP calculations.
 5. Air Starting and Cranking time calculations.
 6. Battery sizes.
 7. Critical speed calculations.
 8. Electrical elements, schematics and wiring diagrams, including details of the safety shutdown systems and main generator circuit breaker trip system.

7.2.1.6 CERTIFIED TEST REPORTS

1. Diesel engine shop tests
2. Generator shop tests
3. Diesel engine driven electric generator set shop test tests
4. Radio-interference suppression.

7.2.1.7 MANUALS

The Contractor shall provide three (3) sets of operation and maintenance manuals for equipment. Identification symbols for all replaceable parts and assemblies shall be included. Information in manuals shall be comprehensive and specific.

7.2.1.8 SAFETY REQUIREMENTS

Safety requirements shall comply with ANSI B15.1 or with the manufacturer's recommendation.

7.2.2 MATERIALS REQUIREMENTS

7.2.2.1 MATERIALS

1. Standard Commercial Product

Generator set shall, as a minimum, be in accordance with the requirements of this specification and shall be the manufacturer's standard commercial product with any added features needed to comply with the requirements. Additional or better features which are not specifically prohibited by this specification, but which are apart of the manufacturer's "standard commercial product " is defines as a product which has been or will be sold on the commercial market through advertisement or manufacturer's catalogs, or brochures, and represents the latest production mode(s).

2. Materials and Equipment

The Contractor shall furnish new materials of high quality which will give long life and reliable operation. Equipment shall not have been in prior service except as required by factory tests. Workmanship shall be of highest quality in every detail.

7.2.2.2 DIESEL-ELECTRIC GENERATOR SET AND AUXILIARY EQUIPMENT

Each generator set shall consist of a diesel engine connected to an alternating current generator with brushless excitation system mounted on a steel subbase and provide with all necessary accessories, auxiliaries, and control equipment resulting in a complete self-contained unit people capable of operation.

Set shall be arranged for manual starting. Generator set must be capable of providing full rated power within 10 seconds after starting.

1. Equipment Rating and Capability

Diesel-electric generating set shall have a net continuous rating as indicated at 0.8 power factor for 3-phase unit. Both the engine and generator of the generator set shall be capable of satisfactorily carrying a load 10% in excess of the net continuous rated generating capacity at 0.8 power factor for a period of 2 continuous hours out of any 24 consecutive hours.

Gross kW rating of each diesel generating set shall be not more than the figure obtained by multiplying the delivered shaft horse power rating of the engine by 0.746 and by the overall efficiency of the generator at the corresponding load. Overall efficiency of the generator shall allow for power required to operate the exciter, including power consumed in losses and in windage and friction for generator and rotating exciter.

Rated net capacity of each generating set is defined as gross electrical power output of generator minus total electrical power requirements of "engine assembly," as defined in NEMA publication "Standard Practices for Stationary Diesel and Gas Engine". All auxiliary equipment furnished shall be designed for continuous duty at 110% of rated net capacity of generating set.

The generating set shall be rated for [] kW, 0.8 power factor [] ϕ , [], [] volts.

2. Critical Speeds

Each complete diesel-electric generating set shall be free of electrical speeds of either a major or minor order that will endanger satisfactory operation will be considered endangered if torsional vibration stresses exceed 390 kg/cm^2 with 10% above or below rated engine speed. The Contractor shall submit three (3) copies of a summary of computations of critical speeds to the Engineer.

7.2.2.3 DESIGN AND CONSTRUCTION

Rotating or reciprocating parts, or other parts that may present a hazard to operating personnel shall be isolated or shielded to minimize danger. Design characteristics shall limit operating temperatures at critical points of maximum wear at full-load operating conditions.

7.2.2.4 DIESEL ENGINE AND ACCESSORIES

1. Type and Requirements

The diesel engine to be furnished shall drive the A/C generator and shall be base mounted.

The diesel engine shall be of vertical, single acting, solid injection, 4-stroke cycle, cold starting, water cooled diesel engine.

Main parts shall possess excellent properties against heat, pressure, erosion and wear. All parts shall be manufactured to ensure the highest accuracy and precision by means of limit gages, special jigs, fixtures, etc., so that they are entirely interchangeable with each other.

The diesel engine shall be furnished with a cooling water pump to circulate the cooling water for the diesel engine. The pump shall be driven by the main diesel engine. The requirements of the cooling water pump shall be of the engine manufacturer's standard.

The design conditions for the main diesel engines shall be as follows:

Type and Requirements	Power Plant
1. Continuous rating output: (Approx,) PS	[] x [] RPM
2. 1 Hour rating output 110% load for continuous rating: (Approx.) PS	
3. Continuous operating speed: rpm	
4. Bore of Cylinders: mm	
5. Number of Cylinders	[] - []
6. Specific fuel Consumption: g/ps.hr	[] - []
7. Starting System	Compressed air starting
8. Location of Operation:	At Site and operation room
9. Engine cooling system	Forced water cooling by cooling water pump
10. Engine Lubrication System:	Forced lubrication by use of gear pump mounted on engine
11. Fuel Oil Recommended	Diesel light oil ASTM D 975

2. Manufacturing and Materials

a. Cylinder Block Head and Crankcase

The cylinder block, head and crankcase shall be made of cast iron.

Replaceable wet type cylinder liners shall be made of high grade cast iron.

b. Crankshaft

The crankshaft shall be of the forged, one piece-type, made of carbon steel. Bearing surfaces shall be of sufficient size to safely sustain all bearing loads imposed, and shall be heat-treated to provide resistance against shocks and wear.

c. Camshaft

The camshaft shall be made of carbon steel, driven by gears from the crankshaft. The hard-wearing surfaces shall be treated by high frequency induction hardening.

d. Piston and Piston-Pin

Pistons shall be of trunk type and made of special cast iron or high grade heat treated light alloy, and shall have sufficient resistance against heat and pressure. Piston rings shall consist of two or

three compression rings and one or two oil scraping rings. The piston-pins shall be of full floating type and completely carbonized.

e. Connecting Rods

Connecting rods shall be made of forged steel and designed for using replaceable and precision insert type crank pin bearings. A drilled passage for piston-pin lubrication shall be incorporated.

f. Bearings

The bearings for both main and crank pin journals shall be of precision insert bearings and readily replaceable. The piston-pin metals shall be of the special phosphorous bronze.

g. Fuel Injection Nozzle

Each one set of fuel pump with plunger, for adjusting injection volume and timing, shall be provided for each cylinder.

The injection nozzle shall be pin hole type and designed to adjust the needed injection pressure automatically and to meet with any load conditions immediately.

h. Governor

The governor is of mechanical and/or hydraulic type and so sensitive in operation that it is able to adjust the fuel injection volume at any sudden change of loads automatically and immediately. Engine speed variation is calculated not more than 10% (instantaneous) and 5% (steady).

i. Exhaust System

The diesel engine exhaust gas shall be released to atmosphere outside the house through exhaust pipe works and silencers. All exhaust pipe work inside the house shall be lagged by thermal insulation materials with aluminum sheet.

Each silencer shall be positioned as shown on the Drawings. The exhaust system shall be complete with expansion below, support structures and brackets where necessary.

3. Accessories

The accessories of the diesel engine to be furnished shall be as follows:

a. Gauges

Tachometer, lubrication oil pressure, cooling water pressure, suction air pressure, fuel oil pressure, etc.

b. Thermometer

Lubrication oil, cooling water, exhaust gas, etc.

c. Auxiliary Priming Pump

Wing type lubrication oil pump.

d. Strainer and Cooler

Fuel oil strainer, lubrication oil strainer, lubrication oil cooler, suction air cooler, etc.

e. Safety Devices

Lubrication oil pressure relay, cooling water high temperature relay, over and under speed relay, cooling water flowsight glass, etc.

f. Miscellaneous

Exhaust system has turbo-supercharger, pressure indicator cock for each cylinder, flywheel and dual air reservoir tanks, flexible pipe joints, installation bolts, etc.

4. Fuel Oil System

Conform to NFPA 30 and NFPA 37 and the requirements herein. Provide motors and flange connections in accordance with paragraphs entitled "Motors" and "Flange Connections."

a. Tanks

Tanks may be standard design as recommended or used by the engine manufacturer or shall be constructed as specified in paragraph entitled "Tank Construction."

(i) Fuel Oil Day Tanks

Provide tanks with a minimum capacity of 8 hours of engine-generator unit operation at full rated load for the engine-generator unit. Provide tanks with a level gage and makeup control valve. Include connections of the indicated size for inlet, outlet, overflow, drain, vent, and level controller, and a high and low level alarm switches.

(ii) Fuel Oil Drip Tank

Provide tank to receive dirty fuel oil drips from the engine. Working capacity of tank shall be not less than 38 L per engine. Include connections of the indicated size for inlet, outlet, overflow, drain, vent, and level gage, and high level alarm switch. Locate high level alarm switch 150 mm below the top of the tank.

(iii) Level Alarm Switches

Provide tank-top mounted or external float cage, single-pole, single-throw type designed for use on fuel oil tanks. Arrange high level alarm switches to close on rise of liquid level, and low level alarm switches to close on fall of liquid level. Mount float cage units with isolating and drain valves. Contacts shall be suitable for the station battery voltage. Contact ratings shall be A150 in accordance with NEMA ICS 2.

(iv) Tank Gages

Provide tank gages conforming to CID A-A-50568. Gages for fuel oil day tanks shall be buoyant force type, with dial indicator not less than 100 mm in size and arranged for side mounting. Each reading dial or scale shall be calibrated for its specific tank to read from empty to full, with intermediate points of 1/4, 1/2, and 3/4.

b. Fuel Oil Pumps

Each pump unit shall consist of a horizontal, positive-displacement, rotary pump driven by a three-phase electric motor. Direct connect each pump to its driving motor through a flexible coupling. Mount pump and motor on a common steel or cast-iron base plate and provide a coupling guard. Equip each pump with a bypass relief valve. Each pump shall conform to CID A-A-50561. Pumps shall be capable of pumping the following quantities of fuel oil at a temperature of 32°C.

c. Duplex Fuel Oil Strainer

Provide the type having two straining chambers and arranged to divert the flow from one chamber to the other without interruption at any point of the changeover. Design shall allow for cleaning, by permitting removal of the strainer basket not in use while the other strainer basket is in use. Construct strainer baskets of corrosion-resistant metal. Strainer mesh, type, and size shall be as recommended by the engine manufacturer. Construct body of cast iron suitable for 861 kPa (gage) working pressure. Provide a remote differential pressure gage between inlet and outlet of duplex-strainer to indicate the pressure drop of strainer chamber on line.

d. Fuel Oil Meters

Provide positive displacement type. Maximum variation from absolute accuracy measurement over entire range of meter shall be not greater than plus or minus five-tenths of one percent. Provide meters with horizontal setback registers calibrated to read in liters and tenths of liters. Construct meters with cast-iron bodies, with working parts made of material to resist wear, friction, and corrosion and can handle oil containing a small percentage of sulphur.

e. Day Tank Makeup Control Valve

Provide one control switch and solenoid type control valve for each fuel oil day tank as indicated. Valve body shall have a minimum working pressure rating of 1033.5 kPa (gage) at 93°C. The level control switch shall energize to open the solenoid control valve and start the fuel oil transfer pump at low level conditions and close the valve and stop the transfer pump at high level conditions. For multiple day tank installations, the level control switches shall actuate their respective solenoid valves and the selected fuel pump through the necessary relays and control switches. The day tank system control shall be controlled by an "OFF-AUTO" switch on the engine control panel with a contact rating of not less than A150 in accordance with NEMA ICS 2.

f. Fuel Oil Filters

Provide two filters of the throwaway filter element type, consisting of shell, filter elements, drains, and necessary connections and fittings. Equipment and component parts shall be the standard product of the filter manufacturer to ensure prompt and continuing service and delivery of repair or maintenance parts and shall be standard with the engine manufacturer. Component parts of the

unit need not be the product of the same manufacturer. Each filter shall be capable of removing not less than 95 percent of all particles larger than 5 microns. Filter elements shall be factory-assembled type, with compression type end seal gaskets at top and bottom and with suitable pullout device. Filter material shall be cellulose, laminated fiber discs, or acid resistant textile material. Elements shall be designed for an initial pressure drop not in excess of 35 kPa at a flow rate of 0.0972 L/s per element. Construct filters with sides having double walls. Install insulating material between the inner and outer walls. Inner shell shall be pressed steel or welded steel construction enclosing, supporting, and protecting all elements. Filters shall have flanged, removable bolted top cover for access to all components without disconnecting any connections or fittings. Provide compartments for clean and dirty oil. Provide supports for base mounting. There shall be tie-bolts, or equivalent means, for holding down the filter elements and cover, and recesses or other means for receiving and locating the elements. Design and construction shall conform to the ASME BPVC SEC VIII D1. Filter cover shall be steel and secured to the shell by swing-type bolts with hex nuts. Use lifting devices with integral supports for covers weighing over 14 kg. Arrange connections so that filter elements may be removed without breaking outside connections. Mount pressure gages on filter shell to indicate pressure before and after the filter elements. Provide a tapped drain and exterior valved pipe connection. A duplex gage may be provided. Gages shall conform to ANSI/ASME B40.1 and shall be pressure detecting class, 108 mm size, and 0 to 689 kPa range. Provide a needle valve and fittings for mounting each gage and differential pressure switch. Equip each unit with instruction plates and diagrams, suitably located, describing special or important procedures to be followed in operating and servicing the equipment. Plates shall be copper or zinc base alloy, adequately secured to the unit. Provide an adjustable pressure switch with contacts suitable for the starting battery voltage to indicate high differential fuel-oil filter pressure.

g. Fuel Oil Centrifuges

Provide two identical fuel oil centrifuges. Centrifuges shall be capable of removing and discharging water and sludge from incoming fuel oil. Each centrifuge shall be of the unit type, including inlet and outlet oil transfer pumps with integral bypass relief valves, interconnecting piping, sight flow indicators, thermometer, sampling cocks, and three-phase electric motor all mounted on a common steel or cast-iron base plate. Bowls shall be corrosion-resistant construction and arranged for self draining. Provide each centrifuge with an air-tight cover hinged to the frame of the unit, locking it in either the open or closed position. Arrange

check valve to automatically shut off the oil when cover is raised. Provide each unit with a friction clutch to ensure that the machine will be properly and automatically brought up to speed without danger of overloading either motor or gears. Provide safety shutdown interlocks for dangerous vibration, open bowl, low-flow operation, low-water pressure, and bowl completely stopped before cover can be opened.

7.2.2.5 GENERATORS AND EXCITATION SYSTEMS

1. Generators

The generator for the unit shall be as indicated, 60 Hertz, 0.8 power factor, 3-phase, alternating-current type with revolving field. The speed of the generator shall be that of the engine. The generator shall be capable of carrying continuously a 0.80 power factor load equal to the gross kilowatt rating of the diesel generating unit and to carry a 0.80 power factor load 10% in excess of the gross kilowatt rating of the diesel generating unit for 2 continuous hours out of any period of 24 consecutive hours at normal voltage and with a temperature rise of not more than 80°C as measured by resistance based on 40°C ambient temperature. Enclosures shall be the general-purpose open type with ventilating openings covered with removable screens having a mesh not larger than 12 mm.

The generator shall conform to ANSI C50.10 and to NEMA MG-1. The generator shall have form-wound coils and Class H sufficient flywheel effect to meet the requirements of regulation and operation as specified. The rotor shall be mounted on an extended shaft which shall be coupled rigidly to the engine. Crankshaft. Impellers shall be mounted on the rotor for cooling the generator. The rotor shall be capable of safe operation at a speed 25% in excess of its rated synchronous speed. The generator armature, field, and ground leads shall clamp or crimp-type lugs or connectors for electrical connections. Terminal markings shall conform to NEMA MG-1.

2. Excitation and Voltage Regulation System

The excitation system shall be integral brushless-type consisting of a rotating AC exciter and rectifier diode assembly together with a static-type voltage regulating system and including surge protection and the required accessories. The system shall serve as an individual excitation and regulation system for the generator specified herein, and there is no requirement for parallel operation with other exciters.

The excitation system shall have a continuous current rating of not less than the generator excitation current required when the generator operates at 105% rated voltage under the condition of continuous

rating requiring maximum field current. The voltage rating of the system shall be as required to match the generator field requirements. The excitation system response ratio shall not be less than 0.5 and the ceiling voltage shall not be less than 120% of rated voltage.

3. Exciter

The exciter shall be a rotating AC generator having a rotating armature on the rotor spider and a stationary field on the stator frame. The exciter insulation shall be Class B and the temperature rise shall not exceed 70°C when measured by resistance based on a 40 °C ambient temperature.

4. Rectifiers

Rectifiers shall be full-wave silicon diode type, with each diode protected by individual fuses. The rectifiers shall be mounted on the rotating part of the exciter to convert AC exciter output to DC for the main generator excitation. Connection shall be provided between, the exciter, rectifier, and generator field without uses of brushes or slip rings.

5. Voltage Regulator

The voltage regulator shall be completely solid-state type for control of generator voltage by control of the exciter field. The regulator shall be suitable for mounting in the generator control panel. The regulator shall control the generator exciter field as required to maintain a constant and stable generator output voltage within plus or minus ¼ of 1% of nominal for all steady-state loads from no load to full load including a 5% variation in frequency and the effects of field heating. The regulator shall be designed for single-phase voltage sensing. Electromagnetic interference suppression shall be an integral part of the regulator. Thermal protection for power semi-conductors, inherent overvoltage protection, and fuse protection shall be provided internally in the regulator. No electrolytic capacitors, vacuum tubes, or electro-mechanical relays shall be used in the voltage regulator. The regulator shall have provisions for switching to manual control to allow the generator voltage to be controlled either manually or automatically. The following regulator components shall be mounted on the front of the generator control panel.

- a. Voltage adjusting rheostat
- b. Manual voltage control with adjusting rheostat

6. Engine Generator Instruments and Controls

NEMA ICS 1,2,3,4, and 6 shall be applied.

7. Engine Instrument

Engine instruments shall include the following as minimum components:

a. Lubricating Oil Pressure Gauge

Lubricating oil pressure gauge shall be indicating dial type utilizing a Bourdon tube for confining the pressure medium. The Bourdon tube shall be seamless and made of phosphor bronze. Gauge shall be accurate to within 2 percent of full scale reading. Gauge subject to rapid pressure surges shall be properly suppressed

b. Coolant temperature Indicators

Coolant temperature indicators shall be indicating dial type. Capillary tubing shall be covered with a protective casing throughout its entire length and reinforced with an additional casing at the connection to the bulb or socket. The temperature indicator shall be accurate to within 2 percent of full scale reading.

c. Generator Controls and Instruments

NEMA ICS 1,2,3, and 4 shall include the components listed below. Instruments shall comply with ANSI C39.1.

1) Voltmeter and Ammeter:

Semi-flush mounted direct indicating type, not less than 110 mm inch nominal round or square, 180° arc, with accuracy of 2% of full scale.

2) Frequency Controls and Instruments

3) Control Switches:

Voltage and ampere ratings suitable for the intended use. Contacts shall be rated in accordance with NEMA Standards ICS 2-125.

4) Generator Output Circuit Breaker:

Molded case type, trip-free, and shall be mounted to allow operation from outside the control panel. Frame size shall be

adequate for generator amperage when operating at standby rating, and an adjustable trip shall be provided. Lugs shall be provided for electrical connections.

- 5) Voltage adjustment rheostat
- 6) Panel lights and control switch
- 7) Alarm indicating panel

7.2.2.6 BASE ASSEMBLY AND ENCLOSURE: NEMA ICS 6

1. Engine Generator

Engine Generator shall be mounted on a fabricated steel skid base suitable for supporting, transportation, and skidding engine and generator without damage to equipment or alignment.

2. Vibration Isolators

Vibration isolators shall be provided to isolate the engine-generator set from the building floor, at least four isolators, as recommended by the isolator manufacturer, are required. The isolators shall be manufactured by a firm specializing in this product, and the unit shall be specifically listed for this application and have a maximum deflection of 25 mm.

7.2.2.7 TREATMENT AND PAINTING

All parts, including engine subject to high temperature, shall be treated and painted in accordance with manufacturer's standards. The generator and all associated electrical equipment shall be thoroughly cleaned and treated prior to painting. Color shall be manufacturer's standard.

7.2.3 EXECUTION

7.2.3.1 INSTALLATION

Installation shall conform to the requirements of NFPA 70.

7.2.3.2 DIESEL ENGINE GENERATOR

Diesel generating unit shall be installed on a concrete foundation as indicated. Vibration isolators shall be provided to isolated vibrations from the diesel generating unit to the foundations.

7.2.3.3 TESTING

The following tests shall be performed on the generator set system provided. The Engineer shall be given seven (7) working days notice prior to each test. The Contractor shall provide all test equipment and personnel and submit three (3) copies of all test results.

1. Factory Tests

The engine-generator shall be subject to the manufacturer's standard run-in and conditioning tests.

Following the run-in tests, the engine-generator set shall be tested at rated speed and voltage for 8 hours of continuous operations with 2 hours each at 50, 74, 100 and 110 percent of rated load, consecutively, 0.8 power factor. The Contractor shall determine generator frequency, phase current, and voltage and record at 15 minute intervals. The Contractor shall tests run on the voltage regulator to determine the variation in terminal voltage under conditions of constant load, and under conditions of abrupt load changes to determine the maximum voltage change during the surging period and the time required.

2. Speed Governing Test

Engine speed governing system shall be tested in accordance with ASME PTC26.

3. Field Tests and Inspections

The Contractor shall perform all field tests and trial operations, and conduct all field inspections (except final field inspection). The Contractor shall provide all labor, equipment, and incidentals requirements, including water, fuel, and lubricants required for tests. The Contractor shall give ample notice of the dates and times scheduled for tests, trial operations, and inspections which require the presence of the Engineer. All deficiencies found shall be rectified and work affected by such deficiencies shall be completely retested at the Contractor's expense. Field tests shall include the following:

- a. Demonstrate proper operation of all system
- b. Conduct three (3) hour run utilizing Contractor-furnished portable load bank or dummy load as follows:
 - ½ load - one hour
 - Full load - two hours

7.2.4 MEASUREMENT AND PAYMENT

The quantity of standby diesel engine generating set shall be measured and paid for by the number of sets supplied, installed and certified by the Engineer to have passed the quality and operation test and for full payment. The set shall include accessories and other complimentary equipment and parts necessary for satisfactory performance of the above mentioned set.

The quantity of above ground fuel tank shall be measured and paid for by the number of set of fuel tank supplied, installed and accepted by the Engineer. Payment shall include cost of concrete work, fuel tank, plumbing work and all valves and gauge necessary including the supply of fuel transfer pump and all the necessary plumbing and electrical works.

Payment above shall include the cost of furnishing materials, supplies, labor, equipment, tools including accessories and complimentary electrical equipment and other incidentals and subsidiary work necessary to complete the installation, and certified by the Engineer for full payment

7.3 OVERHEAD ELECTRICAL WORKS

7.3.1 GENERAL

7.3.1.1 GENERAL REQUIREMENTS

Section 7.1 "Electrical General Requirements" applies to this section with additions and modifications specified herein.

7.3.1.2 SUBMITTALS

Submit the following information for approval.

1. Catalog Information
 - a. Conductor (list each size and type)
 - b. Insulator (list each size and type)

7.3.2 MATERIAL REQUIREMENTS

7.3.2.1 MATERIALS

All materials shall be new and shall conform with the standard of Underwriter's Laboratory (UL), the latest edition of Philippine Electrical Code, the local utility company and other local enforcing authority. Samples of any material shall be submitted to the Engineer for approval prior to installation.

7.3.2.2 POLES

Unless otherwise indicated on the Drawings, creosoted wood poles shall be used. Provide at least two (2) secondary rack insulators on each new poles and one (1) on the existing wherein termination of wires are to be made. Provide messenger wire if necessary. Install the racks at least one (1) meter from the top of the poles or as required to site conditions.

7.3.2.3 CONDUCTORS

Overhead secondary conductors shall be of recent manufacture and no case shall be more than six (6) months old. Any conductor that shows sign of deterioration within one (1) year from final acceptance of work shall be replaced by the Contractor at his own expense.

7.3.3 EXECUTION

7.3.3.1 INSTALLATION

Provide overhead pole line installation conforming to the requirements of Philippine Electrical Code (PEC), and the local enforcing authority.

1. Pole Setting

Pole holes shall be at least as large at the top as at the bottom and shall be large enough to provide 100 mm clearance between the pole and the side of the hole.

- a. Unless otherwise indicated on the Drawings, pole setting depths all be as follows:

Length of Pole (m)	Setting in Soil (m)	Setting in Solid Rock (m)
10	1.7 (5.5 ft)	1.04 (3.5 ft)

- b. Setting in soil depths shall apply where pole holes are in soil, and or gravel or any combination of these; where the soil layer over solid rock is more than 600 mm deep; where the hole in solid rock is not substantially vertical; or where the diameter of the hole at the surface of the rock exceeds twice the diameter of the pole at the same level. At corners, dead ends and other points of extra strain, poles 10 meters or more shall be set 150 mm deeper.
- c. Setting in solid rock shall apply where poles are to be set in solid rock and where the hole is substantially vertical of an approximately uniform diameter and large enough to permit the use of tamping bars the full depth of the hole.

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- d. Where there is a layer of soil 600 mm or less in depth over solid rock, the depth of the hole shall be the depth of the soil in addition to the depth specified under "Setting in solid rock" provided, however, that such depth shall not exceed the depth specified under "Setting in soil."
 - e. On sloping ground, always measure the depth of the hole from the low side of the hole.
 - f. Thoroughly tamp pole backfill for the full depth of the hole and mound the excess fill around the pole.
 - g. Provide plastic pole caps with 6.4 mm sealing rings and four screwing tabs. Fill sealing area with sealing compound to the level of the sealing ring, place on pole top and screw each tab down with a 32 mm long screw.

2. Conductors

Conductors shall be handled with all necessary care to prevent nicking, kinking, ganging, flattening or otherwise deforming or weakening the conductor or impairing its conductivity and insulation resistivity. Remove all damaged sections of conductor and splice the conductor.

- a. Conductor splices, as installed shall exceed the ultimate rated strength of the conductor and shall be of the type recommended by the conductor manufacturer. No splice shall be permitted within 3 meters of any support.
- b. Ties on insulators shall be tight against the conductor and insulator and end shall be turned down flat against the conductor so that no wire ends project.
- c. Existing conductors to be reinstalled or resagged shall be strung to "Final" sag table values for the particular conductor type and size involved.
- d. String new conductors to "Initial" sag table values recommended by the manufacturer for the conductor type and size of conductor and ruling span indicated.
- e. Dead end fittings, clamp, or compression type shall conform to the written recommendations of the conductor manufacturer and shall develop the full ultimate strength of the conductor.

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- f. Make copper connections to any other materials using only splices, connectors, lugs, or fittings designed for that specific purposes. Submit the manufacturer's directions for applying these fittings for reference and one additional copy maintained at the job site for the use of the inspector.
 - g. All conductors shall be cleaned thoroughly by wire busing before splicing.

3. Taps and Jumpers

- a. Jumpers and other leads connected to the line conductors shall have sufficient slack to allow free movement of the conductors. Where slack is not shown on the drawings it will be provided by at least two bends in a vertical plane, or one in a horizontal plane, or the equivalent.

7.3.4 MEASUREMENT AND PAYMENT

The work under this Section shall be measured either by lengths, pieces, set and linear meters actually placed and installed as shown on the approved drawings.

Measurement and payment for poles shall be by the number of set of poles including the necessary accessories shown on the drawings for each type of pole supplied, delivered to site, installed, tested, commissioned, and accepted by the Engineer.

All works performed and measured and as provided for in the Bill of Quantities shall be paid or at the Contract Unit Price which payment shall constitute full compensation including labor, material, tools, equipment and incidentals necessary whether shown on the drawings or not but necessary for the successful completion and operation of the system.

7.4 UNDERGROUND ELECTRICAL WORKS

7.4.1 GENERAL

7.4.1.1 GENERAL REQUIREMENTS

Section 7.1, "Electrical General Requirements" applies to this section with additions and modifications specified herein.

7.4.1.2 SUBMITTALS

Submit the following information for approval:

1. Manufacturer's Data and Shop Drawings:

- a. Conduit
- b. Handholes
- c. Electrical Cables

2. Certificates:

a. Materials and Equipment:

- 1. Cables
- 2. Conduit

7.4.2 MATERIAL REQUIREMENTS

7.4.2.1 MATERIALS AND EQUIPMENT

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

1. Conduit:

- a. Rigid Plastic Conduit: UL 651, Schedule 40 PVC.
- b. Rigid Steel Conduit (RSC): Hot dip galvanized.
- c. Intermediate Metal Conduit: UL 1242.

2. Fittings and Outlet Boxes:

- a. PVC Fittings: UL 651.
- b. Fittings for Metal Conduit: UL 514B. Ferrous fittings shall be hot dip galvanized in accordance with UL 514.

Fittings for RSC: shall be threaded type.

Split couplings are not acceptable.

3. Tape:

UL 510. Plastic insulating tape shall be capable of performing in a continuous temperature environment of 80°C.

4. Power Wire and Cable:

a. Wire and Cable Conductor Sizes:

Wire and cable conductor sizes are designated by square millimeters. Conductors shall be copper. Insulated conductors shall bear the date of manufacture imprinted on the wire insulation with other identification. Wire and cable manufactured more than 6 months before delivery to the job site shall not be used. Provide conductor identification within each enclosure where a tap, a splice or a termination is made.

5. Wire Conformation:

Provide wires conforming to UL 83. Only wires with "W" in the type designation shall be used in wet or damp locations.

a. 600 Volt Wires and Cables:

Conductor sizes are indicated by square millimeters (mm²) for copper conductors. Insulated wires and cables manufactured more than six months prior to delivery shall not be used.

6. Connector and Terminals:

a. Wire Connectors and Terminals for use with Copper Conductors: UL-486A.

7. Pull Wire:

Pull wire shall be 2.0 mm hot-dip galvanized steel or plastic having a minimum tensile strength of 90 kg in each empty duct. A minimum of 300 mm of slack shall be left at each extremity of pull wires.

8. Grounding and Bonding Equipment:

Shall conform to UL 467.

9. Underground Structures:

Handholes shall have a smooth trowel finish for floors and horizontal surfaces. Top and bottom shall consist of reinforced concrete. Walls shall consist of concrete hollow blocks. Bottom shall be monolithic concrete construction. Duct entrances and windows shall be located near the corners of structures to facilitate cable racking. Covers shall fit the frames without undue play. Steel and iron shall be formed to shape and size with sharp lines and angles. Castings shall be free from warp and blow holes that may impair their strength or

appearance. Exposed metal shall have a smooth finish and sharp lines and arises. Provide all necessary brackets. Set pulling-in irons and other built-in items in place before depositing concrete. A pulling-in iron shall be installed in the wall opposite each duct line entrance. The words "Electric" shall be cast in the top face of all handhole covers.

a) Drainage Pipe and Fittings:

Cast-iron, extra strength. Drains shall be cast-iron, coated or uncoated, plain pattern, bottom outlet with perforated or slotted hinged cover.

7.4.3 EXECUTION

7.4.3.1 INSTALLATION

Underground cable installation shall conform to PEC, NFPA 70 and ANSI C2.

1. Concrete:

Concrete for electrical requirements shall be at least [21 MPa (3000 psi)] concrete with 19 mm maximum aggregate.

2. Earthworks:

Excavation, backfilling, and pavement repairs for electrical requirements shall conform to the requirements of Section 4.2, "Excavation and Backfilling for Buildings."

3. Concrete Hollow Block Handholes:

Provide concrete hollow block handholes as indicated. Masonry works shall conform to the requirements of Section 4.5, "Masonry."

a. Ground Rods:

In each electrical handhole, at a convenient point close to the wall, a 20 mm by 3.0 meter copper-clad steel ground rod shall be driven into the earth before the floor is cast so that approximately 100 mm of the ground rod will extend above the handhole floor.

b. Handhole Grounding:

Ground rods installed in electrical distribution system handholes shall be properly connected to the cable shielding, metallic sheaths, and armor at each cable joint or splice by means of 8.0

mm² or equivalent braided tinned copper wire. Connections to metallic cable sheaths shall be by means of tinned terminals soldered to ground wires and to cable sheaths. Care shall be taken in soldering not to damage metallic cable sheaths or shields. Ground rods shall be protected with a double wrapping of pressure-sensitive plastic tape for a distance of 50 mm above and 150 mm below concrete penetrations. Ground wires shall be neatly and firmly attached to handhole walls and the amount of exposed bare wire shall be held to a minimum.

4. Underground Ducts with Concrete Encasement:

Construct underground duct lines of individual conduits encased in concrete. Except where rigid galvanized steel conduit is indicated or specified, the conduit shall be of Schedule 40 PVC. Do not mix the kinds of conduit used in any one duct bank. Ducts shall be as indicated on the drawings. The concrete encasement surrounding the bank shall be rectangular in cross section and shall provide at least 76 mm of concrete cover for ducts.

- a. The top of the concrete envelope shall not be less than 600 mm below grade.
- b. Duct lines shall have a continuous slope downward toward handholes and away from buildings with a pitch of not less than 76 mm in 30 meters. Except at conduit risers, accomplish changes in direction of runs exceeding a total of 10 degrees, either vertical or horizontal, by long sweep bends having a minimum radius of curvature of 7.6 meters. Sweep bends may be made up of one or more curved or Straight sections or combinations thereof. Manufactured bends shall have a minimum radius of 457 mm for use with conduits of less than 80 mm in diameter and a minimum radius of 900 mm for ducts of 80 mm in diameter and larger.
- c. Terminate conduits in end-bells where duct lines enter handholes. Separators shall be of precast concrete, high impact polystyrene, steel, or any combination of these. Stagger the joints of the conduits by rows and layers so as to provide a duct line having a maximum strength. During construction, protect partially completed duct lines from the entrance of debris such as mud, sand and dirt by means of suitable conduit plugs. As each section of a duct line is completed from handhole, draw a brush through having the diameter of the duct and having stiff bristles until the conduit is clear of all particles of earth, sand, and gravel then immediately install conduit plugs.

5. Cable Pulling:

Test duct lines with a handhole and thoroughly swab out to remove foreign materials before the pulling of cables.

Pull cables down grade with feed-in points at the handholes or buildings at the highest elevation. Use flexible cable feeds to convey cables through the handhole openings and into the duct runs. Cable slack shall be accumulated at each handhole where space permits by training the cable around the interior to form one complete loop. Minimum allowable bending radii shall be maintained in forming such loops.

- a. Lubricants for assisting in the pulling of jacketed cables shall be those specifically recommended by the cable manufacturer. Cable lubricants shall be soapstone, graphite, or talc for rubber or plastic jacketed cables. The lubricant shall not be deleterious to the cable sheath, jacket, or outer coverings.
- b. Cable pulling tensions shall not exceed the maximum pulling tension recommended by the cable manufacturer.
- c. Secondary cable runs, 600 volts and less, in non-metallic duct conduit shall, although not indicated, include and insulated copper equipment grounding conductor sized as required by the rating of the overcurrent device supplying the phase conductors.
- d. Installation of Cables in Handholes:

Do not install cables utilizing the shortest route, but route along those walls providing the longest route and the maximum spare cable lengths. All cables shall form to closely parallel walls, not to interfere with duct entrances, and support on brackets and cable insulators at a maximum of 457 mm. Support cable splices in underground structures by racks on each side of the splice. Locate splices to prevent cyclic bending in the spliced sheath.

6. Grounding:

Non-current carrying metallic parts associated with electrical equipment shall have a maximum resistance to solid "earth" ground not exceeding the following values:

Grounds in handholes	10 ohms
Grounded secondary distribution system neutral and non-current carrying metal parts associated with distribution systems and grounds not otherwise covered.	25 ohms

-
- a. Grounding electrodes shall be cone pointed driven ground rods driven full depth plus 150 mm, installed when indicated to provide an earth ground of the value stated for the particular equipment being grounded.
 - b. Make grounding connections which are buried or otherwise normally inaccessible, and excepting specifically those connections for which access for periodic testing is required by exothermite type process. Make thermit welds strictly in accordance with the weld manufacturer's written recommendations. Welds which have "puffed up" or which show convex surfaces indicating improper cleaning are not acceptable. No mechanical connector is required at thermit weldments.
 - c. In lieu of an exothermic type process, a compression ground grid connector of a type which uses hydraulic compression tool to provide the correct circumferential pressure may be used. Tools and dies shall be as recommended by the manufacturer. An embossing die code or other standard method shall provide visible indication that a connector has been adequately compressed on the ground wire.
 - d. Grounding conductors shall be bare soft-drawn copper wire minimum unless otherwise indicated or specified.
 - e. Connect copper-clad steel ground rods only to insulated TW copper ground conductor and weld the connection. Insulate the entire area of the rod in the vicinity of the weld and the connecting wire and seal against moisture penetration.

7.4.3.2 FIELD TESTS

As an exception to requirements that may be stated elsewhere in the contract, the Engineer shall be given a five (5) working day notice prior to each tests.

1. Distribution Conductors 600 Volt Class:

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

2. Test Report

Grounding electrodes and systems (identify electrodes and systems, each test)

7.4.4 MEASUREMENT AND PAYMENT

7.4.4.1 GENERAL

Payment for all items stated and described in this Section shall be full compensation for all labor, materials, tools and equipment, test and all incidentals necessary whether shown on the Drawings or not but necessary for the proper operation of the system.

7.4.4.2 HANDHOLES

The quantity of handholes with cover shall be measured and paid for by the number of units constructed/installed complete and certified by the Engineer for full payment. Excavation and backfilling shall be deemed included in the cost of each unit of handhole.

7.4.4.3 DUCT BANK

The quantity of duct bank to be measured and paid for shall be in linear meters of each type of duct bank installed and completed including earthworks, conduits, concrete and reinforcing steel bars, if reinforced.

7.4.4.4 SERVICE ENTRANCE

Lump sum price will be allocated for providing service entrance as shown on the Drawings. Payment shall be full compensation for all earthworks, concrete, rebars, conduits and other incidental and necessary fixtures needed for the complete installation of the service entrance except conductor wire which will be measured and paid for separately.

7.4.4.5 CONDUCTOR WIRE

The quantity of conductor wire installed to be measured and paid for shall be in linear meters installed complete including splicing and other appurtenant items and incidentals and certified by the Engineer for full payment.

7.4.4.6 CONDUITS

The quantity of conduits shall be measured and paid for in linear meter of each size and type of conduit materials installed complete including joints, bends, fittings, locknut bushing, supports, adaptor, coupling and all other incidentals and appurtenances. It shall be certified by the Engineer for full payment.

7.4.4.7 CONCRETE ENCASEMENT

The quantity of concrete encasement for conduits shall be measured and paid for in cubic meter of concrete placed and accepted by the Engineer. Payment shall be full compensation for all labor, material, and equipment and other incidental necessary to complete the work. Earthwork shall be included in the unit cost of concrete encasement.

7.4.4.8 GROUNDING SYSTEM

The quantity of ground electrode shall be measured and paid for in number of electrodes supplied, installed, tested and accepted by the Engineer for payment.

The quantity of counter poise wire shall be measured and paid for in meter of counter poise wire supplied, installed and accepted by the Engineer for payment.

7.5 INTERIOR WIRING SYSTEMS

7.5.1 GENERAL

Section 7.1, "Electrical General Requirements," applies to this section with additions and modifications specified herein.

7.5.1.1 SUBMITTALS

1. Shop Drawings: Submit for the following:

- a. Panelboards

2. Manufacturer's data:

Submit for the following:

- a. Circuit breakers
 - b. Switches
 - c. Conduit and fittings (each type)
 - d. Ground rods
 - e. Device plates
 - f. Insulated conductors
 - g. Outlet and junction boxes

3. Test Reports: Submit test results for approval in report form.

- a. 600Volt - wiring test
- b. grounding system test

4. Quality Assurance

In each standard referred to herein, consider the advisory provisions to be mandatory, as though the word “shall” has been substituted for “should” wherever it appears. Interpret reference in these standards to “authority having jurisdiction,” or words of similar meaning, to mean Engineer.

7.5.2 MATERIALS AND EQUIPMENT REQUIREMENTS

Materials, equipment, and devices shall, as minimum, meet requirements of UL, where UL standards are established for those items, and requirements of NFPA 70. All items shall be new.

7.5.2.1 CONDUIT AND FITTINGS

- 1. Rigid Steel Conduit (RSC): Hot dip galvanized: ANSI C80.1.
- 2. Flexible Metal Conduit: UL 1.
 - a. Liquid Tight Flexible Metal Conduit (Steel): UL 360.
- 3. Rigid Plastic Conduit: PVC schedule 40 in accordance with UL 651.
- 4. Fittings for Metal Conduit, and Flexible Metal Conduit: UL 514B.
Ferrous fittings shall be hot dip galvanized in accordance with UL 514.
 - a. Fittings for RSC: Shall be threaded-type. Split couplings are not acceptable.
 - b. Fittings for Rigid Nonmetallic Conduit: NEMA TC3.

7.5.2.2 OUTLET BOXES AND COVERS

UL 514, hot dip galvanized for ferrous metal.

7.5.2.3 CABINETS, JUNCTION BOXES, AND PULL BOXES (WITH VOLUME GREATER THAN 100 CUBIC INCHES)

UL 50, hot dip.

7.5.2.4 WIRES AND CABLES

Wires and cables shall meet applicable requirements of PEC, NFPA 70 and UL for types of insulation, jackets, and conductors specified or indicated. Wires and cables manufactured more than 6 months prior to date of delivery to site shall not be used.

1. Conductors: Conductor 3.5mm^2 and smaller shall be solid, 5.5 mm^2 and larger shall be stranded. All conductors indicated shall be copper.

- a. Equipment Manufacturer Requirements:

If manufacturer's equipment requires copper conductors at the terminations or requires copper conductors to be provided between components of equipment, provide copper conductors or splices, splice boxes, and other work required to satisfy manufacturer's requirements.

- b. Minimum Conductor Sizes:

Minimum size for branch circuits shall be 3.5 mm^2 .

2. Color Coding

For 240V, 60Hz, 1 ϕ , 2 wire

Phase A	-	Black
Phase B	-	Red
Grounding	-	Green

For 480/277 volt, 3 phase

Phase A	-	brown
Phase B	-	orange
Phase C	-	yellow
Grounding	-	Green

3. Insulation:

Unless specified for indicated otherwise or required by PEC and NFPA 70, power and lighting wires shall be 600volt, Type THHN or THW.

4. Bonding Conductors:

ASTM B1, solid bare copper wire for sizes 8.0 mm^2 and smaller diameter; ASTM B8, Class B, stranded bare copper wire for sizes 14 mm^2 and larger diameter.

7.5.2.5 SPLICES AND TERMINATION COMPONENTS

UL 486A as applicable, for wire connectors and UL 510 for insulating tapes. Connectors for 5.5 mm² and smaller diameter wires shall be insulated, pressure-type in accordance with UL 486A or UL 486C (twist-on splicing connector).

- a) Provide solderless terminal lugs on stranded conductors.

7.5.2.6 DEVICE PLATES

Provide UL listed, one-piece device plates for outlets and fittings to suit the devices installed. For metal outlets and fittings, plates on unfinished walls and on fittings shall be of zinc-coated sheet steel or cast metal having round or bevelled edges. Plates on finished walls shall be urea or phenolic, minimum 2.5mm wall thickness. Plates shall be same color as receptacle or toggle switch with which they are mounted. Screws shall be machine-type with countersunk heads in color to match finish of plate. Use of sectional-type device plates will not be permitted. Plates installed in wet locations shall be gasketed and UL listed for "wet locations."

7.5.2.7 SWITCHES

1. Toggle Switches:

Totally enclosed with bodies of thermosetting plastic and mounting strap. Wiring terminal shall be screw-type, side-wired. Switches shall be rated quiet-type AC only, 250 volts, with current rating and number of poles indicated.

2. Receptacles

UL 498 and NEMA WD 1, heavy duty, grounding type. Ratings and configurations shall be as indicated. Wiring terminals shall be screw-type, side-wired. Connect grounding pole to mounting strap.

7.5.2.8 SPECIAL PURPOSE RECEPTACLES:

Receptacles serving as indicated are special purpose. Provide ratings as indicated. Furnish one matching plug with each receptacle.

7.5.2.9 PANELBOARDS

UL 67 and UL 50. Panelboards for use as service disconnecting means shall additionally conform to UL 869. Panelboards shall be circuit breaker-equipped. Design shall be such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining clearances as

required by UL. Where “space only” is indicated, make provisions for future installation of breaker sized as indicated. Panelboard locks shall be keyed same. Directories shall be typed to indicate load served by each circuit and mounted in holder behind transparent protective covering.

1. Panelboard Buses:

All buses shall be copper support bus bars on bases independent of circuit breakers. Main buses and back pans shall be designed so that breakers may be changed without machining, drilling, or lapping. Provide separate ground bus per UL 67 for connecting grounding conductors; bond to steel cabinet.

2. Circuit Breakers:

Ambient-compensated thermal magnetic-type solid state-type with interrupting capacity of 10,000 amperes symmetrical minimum. Breaker terminal shall be UL listed as suitable for type of conductor provided. Plug-in circuit breakers are unacceptable.

a. Multi-pole Breakers

Provide common trip-type multi-pole breakers with single operating handle. Breaker design shall be such that an overload in one pole automatically causes all poles to open.

7.5.2.10 ENCLOSED CIRCUIT BREAKERS

UL 489. Individual moulded case circuit breakers with voltage and continuous current ratings, number of poles, overload trip setting, and short circuit interrupting rating as indicated. Enclosure type as indicated.

7.5.2.11 REEFER VAN OUTLET

1. The refrigerated van power center shall be to service various container van of different origin or countries including Japan, USA, Australia and other European countries.
2. Socket outlet for 250 volts shall be capable of handling current up to 60 amperes, 3 phase. Socket outlet shall be R-24604B-60 or R6-W0602B-60 series I or approved equal.
3. Connectors shall be capable of servicing van socket and plug with ease and simple operation. If, required, socket adaptor shall be type P-24604 P-4 and C-W4332B-3h and C-W4501B-A or approved equal.

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4. Plug shall be capable of insertion with the socket outlet in smooth operation. Mechanical interlock, switch and circuit breaker shall be provided for safety operation of reefer van outlets. Plug shall be type P-W4604 P-A or approved equal.
 5. The socket outlet for 250 volts, 3 phase shall be Series 1 and shall meet the requirements of ISO for the container industry for both 250V and 460 volts, 3 phase.
 6. For 460 volts, socket outlet shall be Series II, 32 amperes, 3 phase (C.E.E., ISO). This device shall be in accordance with C.E.E. standards, IEC as well as ISO. Voltage configuration shall be capable for 380 to 440 VAC.
 7. The socket outlet shall have circuit breaker or switch and C.E.E. 3h contact position. This device shall be non-interchangeable type and keyway shall have 3 o'clock position. The socket outlet type shall be R-W4332B-3h and R7-W0302B-3h and P-W4333p-3h or approved equal.
 8. Connector shall be of smooth operation with type no. C-24332B-3h, C-W4315B-A and P-208295 or approved equal.
 9. Plug shall be of type, P-W4333p-3h, P-W4392P-A and P-207627-P.
 10. All the above devices shall be mechanical interlocked that could not be closed unless the plug is fully inserted.

7.5.2.12 GROUNDING AND BONDING EQUIPMENT

UL 467. Ground rods shall be copper-clad steel, with minimum diameter of 20mm and minimum length of 3 meters.

7.5.2.13 NAMEPLATES

Provide as specified in Section 7.1 "Electrical General Requirements."

7.5.3 EXECUTION

7.5.3.1 INSTALLATION

Electrical installation shall conform to requirements of PEC, NFPA 70 and to requirements specified herein.

1. Underground Service:

Underground service conductors and associated conduit shall be continuous from service entrance equipment to outdoor power system connection.

2. Wiring Methods:

Provide insulated conductors installed in conduits, except where specifically indicated or specified otherwise or required by PEC and NFPA 70 to be installed otherwise. Provide insulated, green equipment grounding conductor in feeder and branch circuits, including lighting circuits. Provide insulated, green colored conductor for grounding conductors installed in conduits or raceways.

- a. Service Entrance Conduit: Rigid Steel Conduit (RSC), conduit underground: PVC schedule 40. The underground portion shall be encased as indicated.
- b. Underground Conduit (other than service entrance) PVC where non-metallic conduit is used, shall be converted to plastic – coated rigid steel conduit before rising through floor slab; plastic coating shall extended at least 152mm above floor.
- c. Conduit in Floor Slabs: RSC

3. Conduit Installation:

Unless indicated otherwise, conceal conduit within finished walls, ceilings, and floors. Keep conduit a minimum of 150mm away from parallel runs of flues and steam or hot water pipes. Install conduit parallel with or at right angles to ceilings, walls, and structural members where located above accessible ceilings and where conduit will be visible after completion of project. Run conduits in crawl space under slab as if exposed.

- a. Where conduits rise through floor slabs, curved portion of bends shall not be visible above finish slab.
- b. Conduit Support:

Support conduit by pipe straps, wall brackets, hangers, or ceiling trapeze. Fasten by wood screws to wood; by toggle bolts on hollow masonry units; by concrete inserts or expansion bolts on concrete or brick; and by machine screws, welded studs, or spring tension clamps on steelwork. Threaded C-clamps may be used on rigid steel conduit only. Do not weld conduits or pipe straps to steel structures. Load applied to fasteners shall not exceed one-fourth proof test load. Fasteners attached to concrete ceilings shall be vibration resistant and shock resistant. Holes cut to depth of more than 40mm in reinforced concrete beams or to depth of more than 20mm in concrete joints shall not cut main reinforcing bars. Fill unused holes. In partitions of light steel construction, use sheet metal screws. In suspended-ceiling construction, run

conduit above ceiling. Do not support conduit by ceiling support system. Spring-steel fasteners may be used for lighting branch circuit conduit supports in suspended ceilings in dry locations.

- c. Make changes in direction of runs with symmetrical bends or cast-metal fittings. Make field-made bends and offsets with hickey or conduit-bending machine. Do not install crushed or deformed conduits. Avoid trapped conduits. Prevent plaster, dirt or trash from lodging in conduits, boxes, fittings, and equipment during construction. Free clogged conduits of obstructions.
- d. Install pull wires in empty conduits in which wire is to be installed by others. Pull wire shall be plastic having minimum 91 kgs. tensile strength. Leave minimum 300mm of slack at each end of pull wire.

e. Conduit Installed in Concrete Floor Slabs:

Locate so as not to adversely affect structural strength of slabs. Install conduit within middle one-third of concrete slab. Do not stack conduits. Space conduits horizontally at a minimum of three diameters, except at cabinet locations. Curved portions of bends shall not be visible above the finish slab. Increase slab thickness as necessary to provide minimum 25 mm cover over conduits. Where embedded conduits cross expansion joints, provide suitable watertight expansion fittings and bonding jumpers. Conduit larger than 25mm trade size shall be parallel with or at right angles to main reinforcement; when at right angles to the reinforcements, the conduit shall be closed to one of the supports of the slab.

- f. Fasten conduits to sheet metal boxes and cabinets with two locknuts where required by PEC and NFPA 70, where insulated bushings are used, and where bushing cannot be brought into firm contact with the box; otherwise, use minimum single locknut and bushing. Locknuts shall have sharp edges for digging into wall of metal enclosures. Install bushings on ends of conduits, and provide insulating type where required by PEC and NFPA 70.

g. Flexible Connection:

Provide flexible connection of short length, 1.8 meters maximum for recessed and semi-recessed lighting fixtures.

4. Boxes, Outlets, and Supports:

Provide boxes in wiring or raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures. Boxes for metallic raceways shall be cast-metal, hub-type

when located in wet locations, when surface mounted on outside of exterior surfaces, when installed exposed up to 2.1 meters above interior floors and walkways, or when installed in hazardous areas. Boxes in other locations shall be sheet steel, except that aluminum boxes may be used with aluminum conduit. Each box shall have the volume required by PEC and NFPA 70 for the number of conductors enclosed in the box. Boxes for mounting lighting fixtures shall not be less than 100 mm² or octagonal, except that smaller boxes may be installed as required for fixture configurations as approved. Boxes for use in masonry-block or tile walls shall be square-cornered, tile-type, or standard boxes having square-cornered, tile-type covers. Provide gaskets for cast-metal boxes installed flush with outside of exterior surfaces. Provide separate boxes for flush or recessed fixtures when required by fixture terminal operating temperature. Fixtures shall be readily removable for access to boxes unless ceiling access panels are provided. Support boxes and pendants for surface-mounted fixtures on suspended ceilings independently of ceiling supports, or make adequate provisions for distributing load over ceiling support members. Fasten boxes and supports with wood screws on wood, with bolts and expansion shields on concrete or brick, with toggle bolts on hollow masonry units, and with machine screws or welded studs on steel. In open overhead spaces, cast boxes threaded to raceways need not separately supported except where used for fixture support; support sheet metal boxes directly from building structure or by bar hangers. Where bar hangers are used, attach bar to raceways on opposite sides of box, and support raceway with approved type fastener maximum 600mm from the box. When penetrating reinforced concrete members, avoid cutting reinforcing steel.

- a. Boxes for use with raceway systems shall be minimum 40mm deep, except where shallower boxes required by structural conditions are approved. Boxes for other than lighting fixture outlets shall be minimum 100mm², except that 100 by 50mm boxes may be used where only one raceway enters outlet.

- b. Pull Boxes:

Construct of at least minimum size required by PEC and NFPA 70 of code-gauge aluminum sheet steel except where cast-metal boxes are required in locations specified herein. Furnish boxes with screw-fastened covers. Where several feeders pass through common pull box, tag feeders to indicate clearly electrical characteristics, circuit number, and panel designation.

5. Mounting Heights:

Mount panelboards, and circuit breakers, so height of operating handle at its highest position is maximum 1.8 meters above floor. Mount

lighting switches 1.4 meters above finished floor, receptacles 300mm above finished floor and other devices. Measure mounting heights of wiring devices and outlets to center of device or outlet.

6. Conductor Identification;

Provide conductor identification within each enclosure where tap, splice, or termination is made.

7. Splices:

Make splices in accessible locations. Make splices in conductors 5.5 mm² and smaller diameter with insulated, pressure-type connector. Make splices in conductors 8.0 mm² and larger diameter with solderless connector, and cover with insulation material equivalent to conductor insulation.

8. Covers and Device Plates:

Install with edges in continuous contact with finished wall surfaces without use of mats or similar devices. Plaster fillings are not permitted. Plates shall be installed with alignment tolerance of 3mm. Use of sectional-type device plates are not permitted. Plates installed in wet locations shall be gasketed.

9. Electrical Penetrations:

Openings around electrical penetrations through fire resistance-rated walls, partitions, floors, or ceilings shall be sealed to maintain fire resistive integrity as tested per ASTM E 814.

10. Reefer Van Outlets

Installation of the reefer van outlets and other related accessories shall be in accordance with the approved Drawings accepted by the Engineer.

11. Grounding and Bonding:

In accordance with PEC and NFPA 70. Ground all exposed, non-current-carrying metallic parts of electrical equipment, metallic raceway systems, grounding conductor in metallic and non-metallic raceways, and conductor of wiring systems. Make ground connection to driven ground rods on exterior of building. Where ground fault protection is employed, ensure that connection of ground does not interfere with correct operation of fault protection.

a. Grounding Conductor:

Provide insulated, green equipment grounding conductor in feeder and branch circuits, including lighting circuits. Grounding conductor shall be separate from electrical system neutral conductor. Provide insulated, green conductor for grounding conductors installed in conduit or raceways.

b. Resistance:

Maximum resistance-to-ground of grounding system shall not exceed 25 ohms, contact the Engineer for further instructions.

7.5.3.2 FIELD QUALITY CONTROL:

Furnish test equipment and personnel and submit written copies of test results. Give the Engineer five (5) working days notice prior to each test.

1. Devices Subject to Manual Operation:

Each device subject to manual operation shall be operated at least five times, demonstrating satisfactory operation each time.

2. Test on 600Volt Wiring:

Test 600Volt wiring to verify that no short circuits or accidental grounds exist. Perform insulation resistance tests on wiring No. 6 AWG and larger diameter using instrument which applies voltage of approximately 500 volts to provide direct reading of resistance. Minimum resistance shall be 25,000 ohms.

3. Grounding System Test:

The Grounding system shall be tested to ensure continuity and resistance to ground is not excessive. Test each ground rod for resistance to ground before making connections to rod; tie grounding system together and test for resistance to ground. Make resistance measurements in dry weather, not earlier than 48 hours after rainfall. Submit written results of each test to the Engineer and indicate location of rods as well as resistance and soil conditions at the time measurements were made.

7.5.4 MEASUREMENT AND PAYMENT

1. The work under this Section shall be measured either by lengths, pieces, pairs, set and linear meters actually placed and installed as shown on the approved Drawings.

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2. All works performed and measured and as provided for in the Bill of Quantities shall be paid or at the Contract Unit Price which payment shall constitute full compensation including labor, material, tools, equipment and incidentals necessary to complete this Section.

7.6 INTERIOR LIGHTING

7.6.1 GENERAL

7.6.1.1 GENERAL REQUIREMENTS

Section 7.1, "Electrical General Requirements," applies to this section, with the additions and modifications specified herein.

7.6.1.2 DESCRIPTION OF WORK

The work includes providing lighting fixtures for interior use, including accessories mounted on the exterior surfaces of buildings. Materials not normally furnished by manufacturers of these devices are specified in Section 7.5, "Interior Wiring Systems."

7.6.1.3 SUBMITTALS

Data, shop drawings showing mounting heights, and reports shall employ the terminology, classifications, and methods prescribed by the IES Lighting Handbook, as applicable, for the lighting system specified.

1. Manufacturer's Data:

- a. Lighting fixtures, including lamps and ballasts

7.6.2 MATERIAL REQUIREMENTS

7.6.2.1 FLUORESCENT LIGHTING FIXTURES

UL 1570 except lighting fixtures for damp and wet locations shall conform to UL 57.

1. Fluorescent Lamps:

Provide the number, type and wattage indicated.

2. Fluorescent Ballasts:

UL 935, ANSI C82.1, and shall be labeled Certified Ballast Manufacturers (CBM) certified by Electrical Testing Laboratories (ETL). Ballasts shall be high power factor type and shall be designed to

operate on the voltage system to which they are connected. Ballasts shall be Class P and shall have sound rating "A". Fixtures and ballasts shall be designed and constructed to limit the ballast case temperature to 90 degrees Celsius (C) when installed in an ambient temperature of 40 degrees C.

7.6.2.2 COMPACT FLUORESCENT FIXTURES

Compact fluorescent fixtures shall be manufactured specifically for compact fluorescent lamps with ballasts integral to the fixture. Providing assemblies designed to retrofit incandescent fixtures is prohibited except when specifically indicated for renovation of existing fixtures. Fixtures shall use lamps as indicated.

7.6.2.3 RECESS AND FLUSH-MOUNTED FIXTURES

Provide types that can be relamped from the bottom. Trim for the exposed surface of flush-mounted fixtures shall be as indicated.

7.6.2.4 SUSPENDED FIXTURES

Provide hangers capable of supporting twice the combined weight of the adjoining fixtures. Provide with swivel hangers to ensure a plumb installation. Hangers shall be cadmium-plated steel with swivel-ball tapped for the conduit size indicated. Hangers shall allow fixtures to swing within an angle of 20 degrees. Brace pendants 1.2 meters or longer to limit swinging. Single-unit suspended fluorescent fixtures shall have twin-stem hangers. Multiple-unit or continuous row fluorescent fixtures shall have a tubing or stem for wiring at one point and a tubing or rod suspension provided for each unit length of chassis, including one at each end. Rods shall be a minimum 5mm diameter.

7.6.2.5 POWER HOOK FIXTURE HANGERS

Provide UL listed assembly including through-wired power hook housing, interlocking plug and receptacle, power cord, and fixture support loop. Power hook housing shall be cast aluminum having two 20mm threaded hubs. Fixture support loop shall be cast aluminum with provisions for accepting 20mm threaded fixture stems. Power cord shall include 400mm of 3-conductor No. 16 Type SO cord.

7.6.3 EXECUTION

7.6.3.1 INSTALLATION

Set lighting fixtures plumb, square, and level with ceiling and walls, in alignment with adjacent lighting fixtures, and secure in accordance with manufacturer's directions and approved shop drawings. The installation

shall meet with the requirements of PEC and NFPA 70. Mounting heights specified or indicated shall be to bottom of fixture for ceiling-mounted fixtures and to center of fixture for wall-mounted fixtures. Obtain approval of the exact mounting for lighting fixtures on the job before installation commence and, where applicable, after coordinating with the type, style, and pattern of the ceiling being installed. Recessed and semi-recessed fixtures may be supported from suspended ceiling support system ceiling tees if the ceiling system support rods or wires are provided at a minimum of four rods or wires per fixture and located not more than 150 mm from each corner of each fixture. Do not support fixtures by ceiling acoustical panels. Where fixtures of size less than the ceiling grid are indicated to be centered in the acoustical panel, support such fixtures independently or with at least two 20mm metal channels spanning, and secured to, the ceiling tees. Provide rods or wires for lighting fixture supports under this section of the specifications. Additionally, for recessed fixtures, provide support clips securely fastened to ceiling grid members, a minimum of one at or near each corner of each fixture.

7.6.3.2 GROUNDING

Ground non-current-carrying parts of equipment as specified in Section 7.5, "Interior Wiring Systems." Where the copper grounding conductor is connected to a metal other than copper, provide specially treated or lined connectors suitable for this purpose.

7.6.3.3 FIELD TESTS

The Contractor will provide electric power required for field tests.

1. Operating Test:

Upon completion of the installation, conduct an operating test to show that the equipment operate in accordance with the requirements of this section.

2. Insulation Resistance Test:

Perform as specified in Section 7.5, "Interior Wiring Systems", both before and after connection of fixtures and equipment.

3. Ground Resistance Tests:

Perform as specified in Section 7.5, "Interior Wiring System."

7.6.4 MEASUREMENT AND PAYMENT

1. The quantity of interior lighting system to be measured and paid for shall be the number of sets of each lighting fixtures installed including supports and accessories complete as a system and certified by the Engineer for full payment.
2. Payment shall constitute full compensation for all labor, materials, tools and equipment and all necessary test and incidental work needed for the successful operation of all lighting fixtures.

7.7 EXTERIOR LIGHTING

7.7.1 GENERAL

Section 7.1, "Electrical General Requirements," applies to this section, with the additions and modifications specified herein.

7.7.1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

1. American Association of State Highway and Transportation Officials (AASHTO)

AASHTO LTS-3 (2006) Structural Supports for Highway Signs, Luminaires and Traffic Signals
2. American National Standards Institute (ANSI)

ANSI C82.4 (1992) Ballasts for High-Intensity-Discharge and Low-Pressure Sodium Lamps (Multiple-Supply Type)

ANSI C136.14 (2004) Roadway Lighting Equipment - Enclosed Side-Mounted Luminaires for Horizontal-Burning High-Intensity-Discharge Lamps
3. American Society for Testing and Materials (ASTM)

ASTM A123/A123M (2002) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

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| ASTM A153/A153M | (2005) Zinc Coating (Hot-Dip) on Iron and Steel Hardware - AASHTO No.: M232 |
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4. Illuminating Engineering Society of North America (IES)
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| IES <small>LHBK</small> | (1993) Lighting Handbook, Reference and Application |
|-------------------------|---|
5. Institute of Electrical and Electronics Engineers, Inc. (IEEE)
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|-----------------------------|---|
| IEEE C2 | (2007; Errata 2007) National Electrical Safety Code (ANSI/IEEE) |
| IEEE C136.3 | (2005) Roadway Lighting Equipment - Luminaire Attachments |
| IEEE <small>C136.10</small> | (1996) Roadway Lighting Equipment - Locking-Type Photocontrol Devices and Mating Receptacles - Physical and Electrical Interchangeability and Testing |
6. National Electrical Manufacturers Association (NEMA)
- | | |
|----------------------------|---|
| NEMA <small>C78.41</small> | (2001) Guidelines for Low-Pressure Sodium Lamps |
| NEMA C78.42 | (2007) Electric Lamps - Guidelines for High-Pressure Sodium Lamps |
| NEMA ICS 2 | (2000; Errata 2002; R2005; Errata 2006) Industrial Control and Systems Controllers, Contactors and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC |
| NEMA <small>ICS 6</small> | (1993; R2006) Industrial Control and Systems Enclosures |
7. National Fire Protection Association (NFPA)
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|-----------------------|---|
| NFPA 70 | (2007) National Electrical Code |
| 8.1.1.8 | Underwriters Laboratories Inc. (UL) |
| UL <small>773</small> | (1995; R 2002) Plug-In, Locking Type Photocontrols for Use with Area Lighting |
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UL 773A (1995; R 2003) Non-industrial Photoelectric Switches for Lighting Control

UL 1029 (1994; R 2001) High-Intensity-Discharge Lamp Ballasts

8. Institute of Integrated Electrical Engineer (IIEE)

PEC (2002) Philippine Electrical Code

9. Philippine National Standard (PNS)

BS (2002) Bureau of Standard

7.7.1.2 DEFINITIONS

7.7.1.2.1 AVERAGE LIFE

Time after which 50 percent will have failed and 50 percent will have survived under normal conditions.

7.7.1.2.2 GROUNDLINE SECTION

That portion between 300 mm above and 600 mm below the groundline.

7.7.1.3 SUBMITTALS

Submit the following.

1. Shop Drawings
 - a. Luminaire drawings
 - b. Poles
2. Product Data
 - a. Luminaires
 - b. Lamps
 - c. Ballasts
 - d. Lighting contactor
 - e. Photocell switch
 - f. Steel poles
 - g. Brackets

3. Samples

a. Luminaires

Submit one sample of each luminaire type, complete with lamp and ballast.

4. Test Reports

a. Test Data for luminaires

7.7.1.4 QUALITY ASSURANCE

7.7.1.4.1 DRAWING REQUIREMENTS

1. Luminaire Drawings

Include dimensions, effective projected area (EPA), accessories, and installation and construction details. Photometric data, including zonal lumen data, average and minimum ratio, aiming diagram, and computerized candlepower distribution data shall accompany shop drawings.

2. Poles

Include dimensions, wind load determined in accordance with AASHTO LTS-3, pole deflection, pole class, and other applicable information.

7.7.1.4.2 TEST DATA FOR LUMINAIRES

1. Distribution data according to IES classification type as defined in IES LHBK.
2. Computerized horizontal illumination levels in lux at ground level, taken every 3000 mm. Include average maintained lux level and maximum and minimum ratio.

7.7.1.5 DELIVERY, STORAGE, AND HANDLING

7.7.1.5.1 STEEL POLES

Do not store poles on ground. Support poles so they are at least 305 mm above ground level and growing vegetation. Do not remove factory-applied pole wrappings until just before installing pole.

7.7.2 MATERIAL REQUIREMENTS

7.7.2.1 PRODUCT COORDINATION

Products and materials not considered to be lighting equipment or lighting fixture accessories are specified in Section 7.4, "Underground Electrical Works".

7.7.2.2 LUMINAIRES

ANSI C136.14 or UL 1572. Provide luminaires as indicated. Provide luminaires complete with lamps of number, type, and wattage indicated. Details, shapes, and dimensions are indicative of the general type desired, but are not intended to restrict selection to luminaires of a particular manufacturer. Luminaires of similar designs, light distribution and brightness characteristics, and of equal finish and quality will be acceptable as approved.

7.7.2.2.1 LAMPS: PROVIDE THE TYPE AND WATTAGE AS INDICATED.

1. Ballasts for High Intensity Discharge (HID) Luminaires

UL 1029 and ANSI C82.4, and shall be constant wattage autotransformer (CWA) or regulator, high power-factor type. Provide single-lamp ballasts which shall have a minimum starting temperature of minus 30°C. Ballasts shall be:

- a. Designed to operate on voltage system to which they are connected.
- b. Constructed so that open circuit operation will not reduce the average life.

HPS ballasts shall have a solid-state igniter/starter with an average life in the pulsing mode of 3500 hours at the intended ambient temperature. Igniter case temperature shall not exceed 90°C.

2. Floodlight Fixtures

Floodlight fixture is in heavy duty weather resistant, a die cast aluminum housing with hinged, removable and gasketed front housing and captive screws for relamping access, integral ballast, optical assembly with provisions for vertically or horizontally mounted lamp, an adjustable aiming stops and built -in rifle sight for daytime aiming, ballast shall be mounted on the back housing and shall be prewired to the lamp socket, terminal board and ignitor or equivalent.

HPI-T 1000W lamp are single ended metal halide lamps consisting of a quartz discharge tube , containing high pressure mercury and a mixture of metal halides, which is housed in a hard glass outer envelope , fitted with a standard screw base. They offer a unique combination of a natural white colour appearance, and high luminous efficacy both initially and through their long lives, giving many years of reliable operation, and making them an ideal lamp choice for many applications. The high luminous efficacy reduces the number of luminaires needed, minimizing installation and energy cost, while excellent lumen maintenance and lamp life ensures high maintained illuminance levels and minimal maintenance costs. The colour points is on the black body locus giving a natural white light colour appearance. This combined with good colour rendering makes it easy to distinguish colours and ensures a pleasant ambience and user comfort.

7.7.2.3 LIGHTING CONTACTOR

NEMA ICS 2, electrically held contactor. Contacts shall be rated 240 volts, 20 amperes, and 2 poles. Coils shall be rated 240 volts. Provide in NEMA 3R enclosure conforming to NEMA ICS 6. Contactor shall have silver alloy double-break contacts and shall require no arcing contacts. Provide contactor with hand-off-automatic selector switch. Contactor shall be hermetically sealed.

7.7.2.4 PHOTOCELL SWITCH

UL 773 or UL 773A, hermetically sealed cadmium-sulfide or silicon diode type cell rated 240 volts ac, 60 Hz with single pole double-throw (spdt) contacts for mechanically held contactors rated 1000 watts. Switch shall turn on at or below 30 lux and off at 30 to 100 lux. A time delay shall prevent accidental switching from transient light sources. Provide a directional lens in front of the cell to prevent fixed light sources from creating a turnoff condition.

7.7.2.5 POLES

Provide poles designed for wind loading of [175] km/hr determined in accordance with AASHTO LTS-3 while supporting luminaires having effective projected areas indicated. Poles shall be anchor-base type designed for use with underground supply conductors. Poles, shall have oval-shaped handhole having a minimum clear opening of 65 by 130 mm. Handhole cover shall be secured by stainless steel captive screws.

7.7.2.5.1 STEEL POLES

AASHTO LTS-3. Provide steel poles having minimum 11-gage steel with minimum yield/strength of 331 MPa and hot-dipped galvanized in accordance with ASTM A123/A123M factory finish. Provide a pole

grounding connection designed to prevent electrolysis when used with copper ground wire. Base covers for steel poles shall be structural quality hot-rolled carbon steel plate having a minimum yield of 248 MPa.

7.7.2.6 POLE FOUNDATIONS

Anchor bolts shall be steel rod having a minimum yield strength of 344.5 MPa; the top 305 mm of the rod shall be galvanized in accordance with ASTM A153/A153M.

7.7.2.7 HIGH MAST TOWER

The high mast tower shall be transported by the contractor to the erection sites at his expenses and responsibility and shall be handled with care to avoid bending or damaged to the galvanizing. Materials on which galvanizing have been damage shall be re-dipped unless in the opinion of the Engineer the damage is local and can be repaired by painting with at least two (2) coats of zinc paint. The repair shall be made by and at the expense of the contractor. The number of floodlight fixtures pre-required as shown in the plan.

Detail connection of high mast tower as shown in the plan. Anchor bolts to be stainless steel or galvanized steel and designed and provided by the high mast tower manufacturer to ensure that the high mast tower and anchor bolts assembly capacity meets all the stresses composed of wind, luminaires weight and live load of maintenance personnel.

Protective coating for the high mast tower as be as follows:

1. Galvanizing Preparation

All mild steel parts exposed to weather shall be hot-dipped galvanized after fabrication as shown in the approved plan or directed by the Engineer in accordance with the requirements if JIS H88641. Prior to galvanizing, the surface shall be cleaned of dirt, weld splatter, grease, slag, oil, paint or other deleterious matters. The steel surfaces shall be chemically descaled and cleaned with abrasive blast or other suitable method as approved by the Engineer.

2. Coating

The zinc coating shall consist of uniform layer of commercially pure zinc free from abrasions, cracks, blisters, chemical spots or other imperfections, and shall adhere firmly to the surface of the steel. *The weight of the zinc coating per square meter of actual surface shall not be less than 550 grams.* Any surface damaged subsequent to galvanizing shall be given two coats of approved zinc paint.

3. Painting of Galvanize Steel Work

Hot-dipped galvanized high mast tower are to be treated at the works with an appropriate zinc chromate two packs etch primer followed by one coat of non-etch zinc chromate primer and one coat of micaceous iron oxide paint before shipment. On site damage to the coating is to be repaired and a final coat of micaceous iron oxide is to be applied after erection, generally in accordance with the specifications for shot blasted steel.

Manufacturer must submit a warranty for the corrosion resistant cladding material against manufacturing defects for a period of one (1) year from the date of original purchase.

7.7.3 EXECUTION

7.7.3.1 INSTALLATION OF POLES

IEEE C2, NFPA 70, PEC and to the requirements specified herein.

7.7.3.1.1 STEEL

Provide pole foundations with galvanized steel anchor bolts, threaded at the top end and bent 1.57 rad at the bottom end. Provide galvanized nuts, washers, and ornamental covers for anchor bolts. Concrete for anchor bases, polyvinyl chloride (PVC) conduit ells, and ground rods shall be as specified in Section 7.4, "Underground Electrical Works." Thoroughly compact backfill with compacting arranged to prevent pressure between conductor, jacket, or sheath and the end of conduit ell. Adjust poles as necessary to provide a permanent vertical position with the bracket arm in proper position for luminaire location.

7.7.3.1.2 POLE SETTING

Depth shall be as indicated.

7.7.3.1.3 PHOTOCELL SWITCH AIMING

Aim switch according to manufacturer's recommendations.

7.7.3.2 INSTALLATION OF HIGH MAST TOWER (METHOD OF ERECTION)

The Contractor shall use standard and accepted practice and methods of erecting the high mast tower depending upon their location. The high mast tower shall be erected by the Contractor in accordance with the structure list and the erection diagrams prepared by the high mast tower manufacturer.

The high mast tower may be erected by assembling in sections on the ground and hoisting successive sections in place, or they may be build-up in place individual members at the option of the Contractor. If erected by assembling in sections, not less than fifty percent (50%) of all bolting in place shall be done on each section before starting another section. All bolts shall be drawn up tight but not to such a degree as to endanger the strength of the bolt. All nuts shall be locked in place. All bolts ends below three (3) meters above ground should be flattened to prevent the nut from being taken out from the bolt. Only wrenches approved by the Engineer shall be used on the work, and the use of any wrench that may deform the nut or cut or flake the galvanizing shall not be permitted.

A reasonable amount of drifting shall be allowed in assembling but reaming for correction of mismatched holes due to shop errors shall be permitted. If any shop error in the steel is discovered, the Contractor shall notify the Engineer, who will decide whether the errors may be corrected in the field or the members returned to the manufacturer for correction or replacement. Galvanized damaged during the corrections of shop errors shall be repaired in accordance with the plans/ specifications.

Final inspection of the high mast tower shall be made by the Engineer who shall make and report all loose bolts and other errors in erection, and shall make sure all bolts are in place and are tightened properly and that all nuts are locked properly.

The high mast tower shall be erected so that any portion of the high mast tower shall be in correct position relative to the high mast tower vertical center line, which shall not deviate from any plumb by more than 0.2% of height in either the transverse or longitudinal direction.

Construction of reinforced concrete high mast tower foundation and handhole shall be in accordance with all the details in the plan.

Excavations / backfilling required before /after installation of high mast tower and concrete pedestal post shall conform to the provisions of Earthwork and Concrete Construction.

Concrete Pedestal Post shall be reinforced concrete with appropriate weatherproof fittings as constructed as shown in the approved plan. Reinforced concrete materials shall conform to the requirements of concrete. Concrete shall be of 210kg/cm² compressive strength.

Metering: the local utility company shall be responsible for the supply and installation of metering equipment, and its accessories, but it is part of the contractor responsibility and expense to coordinate with them on this regard.

7.7.3.3 GROUNDING

Ground noncurrent-carrying parts of equipment including metal poles, luminaires, mounting arms, brackets, and metallic enclosures as specified in Section 7.4, "Underground Electrical Works." Where copper grounding conductor is connected to a metal other than copper, provide specially treated or lined connectors suitable for this purpose.

7.7.3.4 FIELD QUALITY CONTROL

Upon completion of installation, conduct an operating test to show that the equipment operates in accordance with the requirements

7.7.4 MEASUREMENT AND PAYMENT

7.7.4.1 CONDUCTOR WIRE

The quantity of conductor wire installed to be measured and paid for shall be in linear meters installed complete including splicing and other appurtenant items and incidentals and certified by the Engineer for full payment.

7.7.4.2 CONDUITS

The quantity of conduits shall be measured and paid in linear meter of each size and type of conduit materials installed complete including jointing, bends, fittings, locknut bushing, supports, adaptor, coupling and all other incidentals and appurtenances. It shall be certified by the Engineer for full payment.

7.7.4.3 CONCRETE ENCASEMENT

The quantity of concrete encasement for conduits shall be measured and paid in cubic meter of concrete placed and accepted by the Engineer. Payment shall be full compensation for all labor, material and equipment and other incidental necessary to complete the work. Earthwork shall be included in the unit cost of concrete encasement.

7.7.4.4 POLES

The quantity to be measured and paid for poles in the perimeter, parking area and roadway floodlight shall be by the number of sets of poles which include the steel mast, reinforced concrete foundation and accessories installed complete and certified by the Engineer for full payment.

7.7.4.5 LIGHTING FIXTURES FOR AREA, ROADWAY AND FLOOD LIGHTING

The quantity of lighting fixtures to be measured and paid for shall be in the number of sets of each type of lighting fixtures, panels and accessories supplied and installed complete, operational and certified for full payment by the Engineer.

7.7.4.6 PERIMETER AND PARKING AREA LIGHTING

The perimeter lighting shall be measured and paid for by the number of sets of lighting fixtures supplied and installed which include the pipe extension, and accessories installed complete, operational and certified by the Engineer for full payment.

7.8 GROUNDING SYSTEM AND LIGHTNING PROTECTION

7.8.1 PART 1 – GENERAL

7.8.1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

1. American National Standards Institute (ANSI)

ANSI C135.30	(1988) Zinc-Coated Ferrous Ground Rods for Overhead or Underground Line Construction
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2. Institute Of Electrical And Electronics Engineers (IEEE)

IEEE Std 81	(1983) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Potentials of a Ground System
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3. National Fire Protection Association (NFPA)

NFPA 70	(2007) National Electrical Code
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NFPA 780	(2007) Lightning Protection Code
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4. Underwriters Laboratories (UL)

UL Elec Const Dir	(2007) Electrical Construction Materials Directory
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UL 96	(2005) Lightning Protection Components
UL 96A	(2007) Installation Requirements for Lightning Protection Systems
UL 467	(2007) Grounding and Bonding Equipment
5. Institute of Integrated Electrical Engineer (IIEE)	
PEC	(2002) Philippine Electrical Code
6. Philippine National Standard (PNS)	
BS	(2002) Bureau of Standard

7.8.1.2 RELATED REQUIREMENTS

Section 7.1, "Electrical General Requirements," applies to this section with additions and modifications specified herein.

1. System Requirements

Materials shall consist of standard products of a manufacturer regularly engaged in production of lightning protection systems and shall be manufacturer's latest UL approved design. Lightning protection system shall conform to PEC, NFPA 70, NFPA 780, UL 96 and UL 96A.

7.8.1.3 SUBMITTALS

1. Shop Drawings

Overall lightning protection system

Each **major** component

2. Test Reports

Grounding system test

Lightning protection system inspection

3. Certificates

UL listing or label

7.8.1.4 QUALITY ASSURANCE

In each standard referred to herein, consider the advisory provisions to be mandatory, as though the word "shall" has been substituted for "should" wherever it appears.

1. Installation Drawings

- a. Submit installation shop drawing for the overall lightning protection system. Drawings shall include physical layout of the equipment, mounting details, relationship to other parts of the work, and wiring diagram.
- b. Submit detail drawings for each major component to include manufacturer's descriptive and technical literature, catalog cuts, and installation instructions.

2. UL Listing or Label

Submit proof of compliance. Label of or listing in UL Elec Const Dir is acceptable evidence. In lieu of label or listing, submit written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that items have been tested and conform to requirements and testing methods of Underwriters Laboratories.

7.8.1.5 SITE CONDITIONS

Contractor will become familiar with details of the work, verify dimensions in the field, and advise the Engineer of discrepancies before performing work. Deviations from contract drawings will not be made without prior approval of the Engineer.

7.8.2 MATERIAL REQUIREMENTS

7.8.2.1 MATERIALS

Do not use a combination of materials that forms an electrolytic couple of such nature that corrosion is accelerated in presence of moisture unless moisture is permanently excluded from the junction of such metals. Where unusual conditions exist which would cause corrosion of conductors, provide conductors with protective coatings or oversize conductors. Where mechanical hazard is involved, increase conductor size to compensate for hazard or protect conductors by covering them with or tubing made of nonmagnetic material.

1. Main and Bonding Conductors

NFPA 780 and UL 96

2. Copper

Provide copper conductors on nonmetallic stacks that do not weigh less than 144.83 kg per 300 meters, and provide cable such that the size of any strand in the cable is not less than 2 mm².

7.8.2.2 COMPONENTS

1. Air Terminals

Provide terminals in accordance with UL 96. Support air terminals by suitable brace, with guides, not less than one-half the height of the terminal.

2. Ground Rods

Provide ground rods made of copper-clad steel conforming UL 467. Provide ground rods that are not less than 20 mm in diameter and 3000 mm in length. Do not mix ground rods of copper-clad steel, stainless steel, galvanized ferrous, or solid copper on the job.

3. Connections and Terminations

Provide connectors for splicing conductors that conform to UL 96, class as applicable. Conductor connections can be made by clamps or welds (including exothermic). Provide style and size connectors required for the installation.

4. Connector Fittings

Provide connector fittings for "end-to-end", "Tee", or "Y" splices that conform to NFPA 780.

5. Lightning Protection Components

Provide bonding plates, air terminal supports, clips, and fasteners that conform to UL 96 classes as applicable.

7.8.3 EXECUTION

7.8.3.1 INTEGRAL SYSTEM

Lightning protection system consists of air terminals, down conductors, ground connections, grounding electrodes and ground loop conductor. Electrically interconnect lightning protection system to form the shortest distance to ground. Do not use non-conducting parts of the structure as part of the building's lightning protection system. Conductors are required to be in protective sleeves.

1. Air Terminals

Air terminal design and support conforming to NFPA 780. Rigidly connect terminals to, and make electrically continuous with, down conductors by means of pressure connectors or crimped joints of T-shaped malleable metal. Provide pressure connector or crimped joint with a dowel or threaded fitting to connect ground rod conductor with air terminal. Set air terminals at ends of structures not more than 610 mm from ends of ridges. Where nonmetallic spires, is present, mount air terminals to the side. In addition, where spires project more than 3050 mm above the building, continue conductor from air terminal to nearest down conductor securely connect thereto.

2. Down Conductors

Make down conductors electrically continuous from air terminals to grounding electrodes. Equally and symmetrically spaced down conductors about the perimeter of the structure. Protect conductors where necessary, to prevent physical damage or displacement to the conductor.

a. Ground Connections

Securely connect conductor forming continuations of down conductors from structure to grounding electrode in a manner to ensure electrical continuity between the two. Provide clamp type connections or welds (including exothermic) for continuation. Attach down conductor to ground rods by welding including exothermic, brazing, or clamping. Provide clamps suitable for direct burial. Protect ground connection from mechanical injury. In making ground connections, take advantage of all permanently moist places where practicable, although avoid such places when area is wet with waste water that contains chemical substances, especially those corrosive to metal.

b. Grounding Electrodes

Provide grounding electrode for down conductor. Extend driven ground rods into the existing undisturbed earth for a distance of not less 3050 mm. Set ground rods less than 610 mm nor more than 3050 mm, from the structure. After the completed installation, measure the total resistance to ground using the fall-of-potential method described in IEEE Std 81. Maximum resistance of a driven ground rod shall be 10 ohms, under normally dry conditions. Make connections between ground conductors and grounds or electrically continuous.

7.8.3.2 FIELD QUALITY CONTROL

1. Grounding System Test

Test the grounding system to ensure continuity and that resistance to ground is not in excess of 10 ohms. Test the ground rod for resistance to ground before making connections to the rod. Tie the grounding system together and test for resistance to ground. Make resistance measurements in dry weather, not earlier than 48 hours after rainfall. Include in the written report: locations of ground rods, resistance, and soil conditions at the time that measurements were made. Submit results of each test to the Engineer.

2. Lightning Protection System Inspection

Make visual inspections to verify that there are no loose connections which may result in high resistance joints, and that conductors and system components are securely fastened to their mounting surfaces and are protected against accidental mechanical displacement.

7.8.4 MEASUREMENT AND PAYMENT

Quantity for grounding rod to be measured and paid shall be in number of ground rod supplied, installed, tested and certified for full payment by the Engineer.

Quantity for grounding wire to be measured and paid for shall be in linear meter of wire supplied, installed, tested and certified for full payment by the Engineer.

Payment stated above shall be full compensation for all labor, materials, equipment, tests and reports and all incidental works and accessories necessary to make the system operation.