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TECHNICAL SPECIFICATION

"One (1) Lot Supply, Installation and Commissioning of New Individualized Inverter Air-conditioning Units and its Electrical Requirements including the Decommissioning of Existing Central Air-conditioning Equipment and its Accessories" with Approved Budget for the Contract of P10.4M

DEVELOPMENT ACADEMY OF THE PHILIPPINES

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MECHANICAL WORKS
SPLIT PACKAGE AIR-CONDITIONING SYSTEM

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

The Section “Mechanical General Requirements" with the addition and modifications specified herein, applies.

1.2 SCOPE OF WORK

Supply and installation of DX split type, INVERTER units complete with refrigerant piping, controls, power wiring and all other required accessories.

1.3 Refrigerant Piping, Fittings and Accessories

Refrigerant piping assembly as used in this section includes pipes, flanges, bolting, gaskets, valves, relief devices, fittings, and the pressure containing parts of other piping components. It also includes hangers and supports and other equipment items necessary to prevent overstressing the pressure containing parts.

a. Piping

ANSI 15 and ANSI B31.5. Compatible with fluids for which they are being used and capable of withstanding the pressures and temperatures of the service that they are handling.

b. Tubing

Refrigerant piping shall be seamless copper tubing, hard drawn, type L, ASTM B88. Tubing used for refrigerant service shall be cleaned, sealed, capped or plugged prior to being shipped from the manufacturer's plant. Fittings for copper tubing shall be wrought copper or bronze, brazing or solder joint type ANSI B16.18 or ANSI B16.22. Copper flared type tubing may be made only in annealed copper tubing ASTM B280 and in nominal sizes smaller than one-inch only for connection to equipment and no larger than 1-3/8 inches diameter for other connections.

c. Corrosion Prevention

Unless specified otherwise, equipment fabricated from ferrous metals that do not have a zinc coating shall be treated for prevention of rust with a factory coating or paint system that will withstand 125 hours in a salt-spray fog test except that equipment located outdoors shall be tested for 500 hours. The salt spray fog test shall use a 20 percent sodium chloride solution. Immediately after completion of the test, the coating shall show no signs of blistering, wrinkling or cracking, no loss of adhesion, and the specimen shall show no signs of rust creepage beyond 1/8 inch on either side of the scratch mark. The film thickness of the factory coating or paint system applied on the equipment, shall be not less than film thickness used on the test specimen.

d. Safety Standards

1. Design, Manufacture and Installation of Mechanical Refrigeration Equipment: ASHRAE Safety Code for Mechanical Refrigeration.

2. Machinery Guards: Fully guard drive mechanisms, or other moving parts. Provide guards fabricated of steel and expanded metal, rigidly mounted, and readily removed without disassembly.

PART 2 - PRODUCTS

2.1 AIR-CONDITIONING SYSTEMS – SPAC INVERTER, 4-WAY CEILING CASSETTE.

2.1.1 General

The air-conditioning systems shall be designed, constructed, and rating tested in accordance with ARI Standard 210 for air-conditioning equipment of capacities below 135,000 Btu's per hour and ARI Standard 300 for equipment with capacities of 135,000 Btu's per hour and greater. Units shall be ARI certified. Units with capacities below 135,000 Btu's per hour shall be listed in the ARI Directory of Certified Unitary Air-Conditioners.

2.1.2 Performance Rating

Cooling capacity of unit shall meet the sensible heat requirements and total requirements indicated. In selecting unit size, make true allowance for "sensible to total heat ratio" to satisfy required sensible cooling capacity. Submittals shall include catalog selection data which accounts for sensible to total heat ratio, entering air-conditions at evaporator, and condenser air-conditions.

2.1.3 Air-Conditioners, Split Type

The air-conditioning system shall consist of WALL mounted type evaporator-blower unit and remote air-cooled condensing unit. The separate assemblies shall be designed to be used together and ratings shall be based on the use of the matched assemblies. Submit data to demonstrate that the units will produce the capacity requirement specified or indicated on the drawings.

2.1.4 Evaporator Fan

Fans shall be as specified in Section "Air Ventilation Equipment".

2.1.5 Compressors

Provide hermetic, semi-hermetic rotary, inverter type provided with all the minimum standard equipment and accessories listed therein. Compressor speed for compressors above 20 tons shall not exceed 1750 rpm. Provide compressors with automatic capacity reduction of at least 50 percent for units over 10 tons. Compressors shall start unloaded. Provide each compressor with devices to protect the compressor from short-cycling

when shut-down by safety controls. Provide a pump-down cycle of the non-recycling start type for each compressor 20 tons and over. Provide compressors with vibration isolators. Compressor motor shall be suitable for electric power characteristics as indicated. Motor shall conform to NEMA NG-1. Motor starters shall conform to NEMA ICS. Motors shall be constant speed, squirrel-cage induction, open type or hermetically sealed, low-starting current, high-torque type, and shall be furnished with reduced voltage or and magnetic across-the-line type motor starter with weather-resistant enclosures.

2.1.6 Coils

a. Fan Coil Unit Cooling Coils

Cooling Coils shall conform to ARI 410. Direct-expansion coils shall be fin-and-tube type constructed of seamless copper or aluminum tubes and copper or aluminum fins mechanically bonded or soldered or helically wound to tubes. Casing and tube support sheets shall be not lighter than 16-gage (0.0635-inch nominal thickness) galvanized steel, formed to provide structural strength. Suction header shall be seamless copper tubing or seamless or resistance welded steel tube with copper connection. Supply header shall consist of a distributor to distribute the refrigerant liquid through seamless copper tubing, equally to all the circuit in the coil. Tubes shall be circuited to insure minimum pressure drop and maximum heat transfer. Circulating shall permit refrigerant flew from liquid inlet to suction outlet without causing oil staging or restricting refrigerant flow in coil. Rack coil shall be tested at the factory under water at not less than 300 psi air pressure and shall be suitable for 200 psi working pressure. Each coil shall be completely dehydrated and scaled at the factory upon completion of pressure tests. Coil shall be mounted for counterflow service.

b. The air-cooled condenser coil shall be extended-surface fin-and-tube type with seamless copper or aluminum construction. Aluminum alloy conforming to ASTM B210, alloy 1100, shall be used for the tubes, and aluminum alloy conforming to chemical requirements of ASTM B209, alloy 7072, shall be used for fins and sheets. Fins shall be soldered or mechanically bonded to tubes and installed in a metal casing. Coils shall be air tested under water for leakage. After testing, dry coils for remote type units to remove free moisture, and cap to prevent entrance of foreign matter. Evacuate and seal coils at the factory.

2.1.7 Filter Boxes

Provide filter boxes with either hanged access doors or removable panels. Filter boxes shall have racks for filters arranged for angle pattern. Filters shall be of type indicated and shall conform to paragraph hereinafter entitled, "Filters".

2.1.8 Mixing Boxes

Mixing boxes shall be of physical size to match the basic unit and include equal sized flanged openings, each sized to handle full air flow. Arrangement of openings shall be as indicated. Provide openings with dampers of opposed blade type. All damper shafts shall be connected together by one continuous linkage bar. Arrange dampers for manual operation so that when one starts to close from its opened position, the other starts to open from its closed position.

2.1.9 Controls

a. Condenser Controls

Provide load pressure control to insure condensing temperature for proper system operation at all ambient temperatures down to 40 degrees F.

b. Condenser Start-up Control

Provide condenser with a start-up control package which permits start-up compressor regardless of low ambient temperatures. Package shall temporarily bypass system low pressure-start to permit start-up whenever minimum ambient temperature is below design evaporator coil suction temperature.

2.1.10 Refrigerant Circuits

Entire refrigerant circuit shall be dehydrated, purged, and charged with refrigerant and oil at factory. Factory oil charge shall be the full amount required for operation.

2.1.11 Corrosion Protection

Units shall be factory corrosion protected in accordance with paragraph entitled, Corrosion Prevention.

2.2 CLEANING, PAINTING AND IDENTIFICATION

Cleaning, painting and identification of piping shall be as specified under appropriate section of these Specifications.

2.3 IDENTIFICATION TAGS AND PLATES

Provide equipment, thermometers, valves, and controllers with tags numbered and stamped for their use. Plates and tags shall be of brass or suitable non-ferrous material, securely mounted or attached. Minimum letter and numeral size shall be 1/8 inch.

PART 3 - EXECUTION

3.1 INSTALLATION

Application and installation practices for unitary air-conditioning systems shall conform to the requirements of an acceptable industry standard for installation of unitary systems.

3.1.1 General

Install equipment and components in a manner to insure proper and sequential operation of the equipment and its controls. Installation of equipment not covered herein or in manufacturer's instructions shall be installed as recommended by manufacturer's representative. Provide proper foundations for mounting of equipment, accessories, appurtenances, piping and controls including, but not limited to, supported vibration isolators, stands, guides, anchors, clamps, and brackets. Foundations for equipment shall conform to equipment manufacturer's recommendation, unless otherwise shown in the drawings. Set anchor bolts and sleeves accurately using properly constructed templates.

Anchor bolts shall be of adequate length and provided with welded-on plates on the head end embedded in the concrete. Level equipment bases, using jacks or steel wedges, and neatly grouted-in with a non-shrinking type of grouting mortar. Locate equipment so that working space is available for all necessary servicing such as shaft removal, disassembling compressor cylinders and pistons, replacing or adjusting drives, motors, or shaft seals, access to water heads and valves of shell and tube equipment, tube cleaning or replacement, access to automatic controls, refrigerant charging, lubrication, oil draining and working clearance under overhead lines. Provide electric isolation between dissimilar metals for the purpose of minimizing galvanic corrosion.

3.1.2 4-Way Ceiling Cassette Air-Conditioning System

Install system as indicated, in accordance with the requirements of ASHRAE 15-76 and as recommended in the manufacturer's installation and operational instructions.

3.1.3 Electrical Work

Electric motor driven equipment specified herein shall be provided complete with motors, motor starters, and controls. Electrical equipment and wiring shall be in accordance with Building Code. Motor starters shall be provided complete with properly sized thermal overload protection and other appurtenances necessary for the motor control wiring required for controls and devices but not indicated.

3.1.4 Piping

a. Piping Sleeves

Pipe sleeves shall be as Galvanized Iron, Schedule 20.

b. Provide refrigerant driers, sight glass liquid indicators, moisture indicators, and strainers in refrigerant piping for remote installations when not furnished by the manufacturer as part of the equipment.

c. Locate strainers close to equipment they are to protect. Provide a strainer in the common refrigerant liquid supply to two or more thermal valves in parallel when each thermal valve has a built-in strainer. Install strainers with screen down and in direction of flow as indicated on strainers body.

d. Solenoid valves shall be installed in horizontal lines with stem vertical and with flow in direction indicated on the valve. If not incorporated as internal part of the valve, provide strainers upstream of the solenoid valve. Provide service valves upstream of the solenoid valve, upstream of the strainer, and down stream of the solenoid valve. Remove the internal parts of the solenoid valve when brazing the valve.

3.1.5. Auxiliary Drain Pans, Drain Connections, and Drain Lines

Provide auxiliary drain pans under all drain pans of the units located above finished ceilings or over mechanical or electrical equipment where condensate overflow over unit drain pan may cause damage to ceilings, piping, and equipment below. Provide drain lines for all drain and auxiliary drain pans. Trap the drain from bottom pan of air-conditioning units to insure complete pan drainage. Drain lines shall be full size of

opening.

3.1.6 Air Filters

Provide access panels for all concealed valves, controls, dampers, and other fittings requiring inspection and maintenance.

3.1.7 Inspection Plates and Test Holes

Inspection plates and test holes where required in casings for air balance measurements shall conform to SMACMA High Pressure Low Velocity Duct Construction Standards. Test holes shall be a factory-fabricated, air-tight, non-corrosive test hole with screw cap and gasket. Extend cap through insulation.

3.1.8 Flashing and Pitch Pockets

Provide flashing and pitch pockets for equipment support and roof penetrations and flashing where piping or ductwork passes through exterior walls.

3.2 FIELD TESTS AND INSPECTIONS

3.2.1 Tests

All tests shall be performed and materials and equipment required for test shall be furnished by the Contractor. Tests after installation and prior to acceptance shall be performed in the presence of a representative of the Owner and subject to his approval. Equipment and material certified as having been successfully tested by the manufacturer in accordance with referenced specifications and standards will not require retesting before installation. Equipment and materials not tested at the place of manufacturer will be tested before or after installation, as applicable, where necessary to determine compliance with referenced specifications and standards.

a. Leak Testing

Upon completion of installation of the air-conditioning equipment, test all factory as well as field refrigerant piping with an electronic-type leak detector to acquire a leak tight refrigerant systems. If leaks are detected at the time of installation or during the guarantee period, remove the entire refrigerant charge from the system, correct the leaks and retest the system.

b. Evacuation, Dehydration, and Charging

After system is found to be without leaks, evacuate the system using a reliable gage and a vacuum pump capable of pulling a vacuum of at least 1 mm lig absolute. Evacuate system in strict compliance with the triple-evacuation and blotter method or in strict accordance with equipment manufacturer's printed instructions. System leak testing, evacuation, dehydration, and charging with refrigerant shall comply with the requirement contained in an acceptable industry standard.

c. Start-Up and Operation Tests

The air-conditioning system and its components shall be started and initially placed under operation and checked to see that it is functioning correctly. Adjust safety and automatic control instruments as necessary to place them in proper operation and sequence. The operational test shall be not less than 8 hours.

d. Performance Tests

Upon completion of evacuation, charging, start-up, final leak testing, and proper adjustment of controls, the system shall be performance tested to demonstrate that it complies with the performance and capacity requirements of the specifications and plans. Test the system for not less than 8 hours, during which time hourly readings shall be recorded. At the end of the test period, the readings shall be averaged and the average shall be considered to be the system performance.

e. Sound Tests, Air-conditioner- Split Type

Sound pressure level measurements shall be conducted on units designated by the Owner. Calculate sound power levels by ASHRAE Systems Handbook and Product Directory. Submit test results and calculations.

- End of Section

SECTION 16011

ELECTRICAL GENERAL REQUIREMENTS

PART 1 – GENERAL

1.1 APPLICATION:

This section applies of Division 16, “Electrical”, of this project except as specified otherwise in each individual section.

1.2 SCOPE OF WORK:

The work shall include supply and installation of equipment, materials and all other items necessary to complete the following:

a. Exterior Lighting
b. Grounding System
c. Testing and Commissioning of Electrical Works

1.3 CODES, INSPECTION, PERMITS AND FEES:

All works under this contract shall be installed in accordance with the latest requirements of the Philippine National Building Code, Philippine Electric Code (PEC), Regulation of local Power Company and Telephone Company.

1.3.1 PERMITS AND FEES: All construction permits and fees required for this works shall be obtained by and at the expense of the Contractor. The contractor shall furnish the Engineers and the Owner final certificates of inspection and approval from the proper government authorities after the completion of the work. The contractor shall prepare all shop or working drawings, as-built plans, and all other paperwork required by the approving authorities.

1.3.2 APPROVAL OF PLANS: Approval from authorities of all plans for construction shall be secured by the contractor.

1.4 SUBMITTALS:

Obtain approval before procurement, fabrication, or delivery of items to the job site. Partial submittals will not be acceptable and will be returned without review. Submittals shall include he manufacturer’s name, trade name, place of manufacturer, catalog model or number, nameplate data, size, layout dimensions, capacity, project specification and paragraph reference, applicable industry, and technical society publication references, and other information necessary to establish contract compliance of each item to be furnished. Substitutions for materials, devices and equipment other than those specified shall be accepted only when specified brand names are not available.

1.4.1 SHOP DRAWINGS: Shop drawing shall meet the following requirements. Drawing shall be a minimum of 215 mm by 280 mm in size, except as specified otherwise. Drawing shall include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, accessories , and other items that must be shown to assure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. If equipment is disapproved, revise drawings to show acceptable equipment and resubmit.

1.4.2 MANUFACTURER'S DATA: Submittals for each manufacture items shall be current manufacturer's descriptive literature of cataloged products, equipment drawings, diagrams, performance and characteristic curves, and catalog cuts.

1.4.3 PUBLICATION COMPLIANCE: Where equipment or materials are specified to conform to industry and technical society publications of organizations such as American National Standards 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 through the word "shall" had been substituted for "should" wherever it appears. In lie of the label or listing, submit a certificate from an approved independent testing organization, adequately equipped and competent to perform such services, stating that the item has been tested in accordance with the referenced publications", or" equal or exceed the service and performance of the specified materials". Certifications shall simply state that the item conforms to the requirements specified. Certificates shall be printed on the manufacturer's letterhead and shall be signed by the manufacturer's official authorized to sign certificates of compliance.

1.5 RECORD DRAWINGS:

The contractor shall, during the progress of the work, keep a record of all deviations of the actual installation from the contract drawings.

1.5.1 ELECTRONIC COPIES: The Engineer will furnish the contractor at cost a complete set of electronic copies of drawings, or may Contractor may prepare his own, on which he shall indicate all changes and revisions. Electronic files and prints of these indicating such changes and revisions, shall be submitted to Engineer.

1.5.2 AS-BUILT DRAWINGS: Upon completion of the work, contractor shall submit two (2) copies of the as-built drawing, indicating the work as actually and finally installed, including new information not originally shown in contract drawings, to the Engineer for approval as to conformance with the design concepts and compliance with pertinent code provisions. After such approval, the contractor shall submit the as-built drawings electronic files and originals and one (1) set of prints to the Owner. Approval of the as-built drawings by the Project Manager shall be a requirement for final acceptance of the completed works and for final payment.

1.6 OPERATION AND MAINTENANCE MANUAL:

Submit as required for systems and equipments indicated in the technical sections. Furnished three copies, bound in the hardback binders or an approved equivalent. Furnished one complete manual prior to the performance of systems or equipment test, and furnish the remaining manuals prior to contract completion. Inscribed the following identification on the cover: the words "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 subcontractor installing the system or equipment. Include a 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 drawing folded in. the manual shall include:

a. Internal and interconnecting wiring and control diagrams with data to explain detailed operation and control of the system or equipment
b. A control sequence describing startup, operation, and shutdown

c. Description of the function of each principal item of equipment
d. Installation and maintenance instructions
e. Safety precautions
f. Diagram and illustrations
g. Testing method
h. Performance data
i. Parts list. The list shall indicate sources of supply, indicate sources of supply, recommended spare parts, and name of servicing organization
j. Appendix: List qualified permanent servicing organizations for support of the equipment, including addresses and certified qualifications

1.7 POSTED OPERATING INSTRUCTIONS :

Furnish approved operating instructions for the system and equipment indicating instructions for system and equipment indicated in the technical sections for use by operation and maintenance personnel. The operating instruction shall include wiring 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. Post instruction as directed. Attach or post operating instructions adjacent to each principal system and equipment including startup, proper adjacent to each principal system and equipment including startup, proper adjustment, operating, lubrication, shutdown, safety precautions, procedure in the event of equipment failure, and other items of instruction as recommended by the manufacturer of each system or equipment.

1.8 DELIVERY AND STORAGE:

Handle, store, and protect equipment and materials in accordance with the manufacturer's recommendations. Replace damaged or detective items with new items.

1.9 CATALOGED PRODUCTS/SERVICE AVAILABILITY:

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

1.10 MANUFACTURER'S RECOMMENDATIONS:

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

1.11 ELECTRICAL REQUIREMENTS:

Provide Electrical Lighting Layout under Section 16520, “Exterior Lighting”.

1.12 GUARANTEE:

The contractor shall guarantee that the Electrical Works are free from defective workmanship and materials and will remain so for a period of one year from date of acceptance of the work. Any defects appearing within the said period shall be remedied by the contractor at his own expense.

1.12.1 The Contractor shall indemnify and save harmless the Owner and the Engineers from and against all liability for injuries to persons or damage to property occasioned by any act or omissions of the contractor or any of his Sub-contractors, including any and all expenses, legal or otherwise which may be incurred by the Owner of the Engineers, in the defense of any claim, action or suit.

PART 2 – PRODUCTS

2.1 NAMEPLATES: Provide laminated plastic nameplates for each enclosure, switch, and device. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 3 mm thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the black core. Minimum size of nameplates shall be 50 mm by 150 mm. Lettering shall be a minimum of 25 mm high normal block style.

2.2 EQUIPMENT AND MATERIAL: Equipment and the materials should be based on acceptable brands or manufacturers as indicated below. Any substitution or use of equivalent brands other than those listed shall be subject to the approval of the Engineers. The list of the acceptable brands or manufacturers indicates compliance of the equipment and the materials listed to the project specifications. Final approval and selection of specific equipment and materials shall comply with paragraph 1.3 of this section.

PART 3 – EXECUTION

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.

3.2 PAINTING OF EQUIPMENT:

3.2.1 Factory Applied: Electrical equipment shall have factory applied painting system which shall, as a minimum, meet the requirements of NEMA ICS6 corrosion-resistance test. Baked enamel paint or powder-coat finish on epoxy primer is also acceptable.

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

-- End of Section --

SECTION 16130
RACEWAYS, CABINETS, BOXES AND FITTINGS

PART 1 - GENERAL

1.1 DESCRIPTION

This item shall consist of the supply and construction of the complete raceways consisting of electrical conduits; conduit boxes such as junction boxes, pull boxes, utility boxes, octagonal and square boxes; conduit fittings and other materials such as couplings, locknuts, bushings and other electrical materials to complete the conduit roughing-in work for the project.

PART 2 - PRODUCTS

2.1 MATERIAL REQUIREMENTS

All materials shall be brand new and shall be of the Approved Type, meeting all the requirements of the *Philippine Electrical Code* and bearing the Philippine Standard Agency (PSA) mark.

A. Conduits are classified as per the following:

1. Intermediate Metal Conduit - Zinc coated mild steel tubing, hot dipped galvanized for exposed installations.

2. Flexible Metal Conduit - For Drop Connections on Fixtures and Motors subject to vibrations

3. Rigid Non-Metallic Conduit - UPVC schedule 40 for underground and concealed on ceilings, walls and floors.

B. Cabinets and boxes shall be PEC grade galvanized formed steel sheet with corrosion resistant screws. Cabinets and boxes exposed to weather or wet locations shall be NEMA 3R as indicated. Boxes installed indoors shall be NEMA 1.

1. Light outlet box concealed on ceiling shall be 100 mm square x 78 or 55 mm deep as required with plaster rings. Cast metal box shall be used on surface or exposed conduit runs.

2. Wiring devices outlet boxes shall be 100 mm x 50 mm x 78 mm or 55 mm deep.

PART 3 - EXECUTION

3.1 CONSTRUCTION REQUIREMENTS

A. Underground installation
Underground installation shall be concrete encased under paved areas (and reinforced under roads subject to traffic conditions). Underground conduits entering areas below grade shall be arranged to drain water that may enter the conduit system. Where possible, conduits shall pitch away from building to exterior hand holes. Conduit entries through building walls below grade shall be made watertight by means of manufactured fittings. Fittings shall provide sleeve through wall having neoprene ring gasket that can be compressed for positive seal between entering conduit and fitting body.

B. Exposed conduit
Exposed conduit shall run parallel or perpendicular to walls or ceiling and shall be kept as inconspicuous as possible. Conduits shall be substantially supported by pipe straps, or suitable clamps or pipe hangers attached to structural members or wall supports.

C. Conduit connections
Connections to pull boxes, safety switches, panels, etc. shall be made by double steel locknuts. The conduit system including boxes shall form a continuously grounding system.

D. Conversion of PVC and IMC conduits
Conversion of PVC and IMC conduits shall be made through the use of adapter concealed on grade, floor or ceiling.

E. Conduit on structural slab
Conduits on structural slab shall be placed between upper or lower layers of reinforcing steel and shall be spaced at least 200 mm apart. Conduit shall have at least 30 mm of concrete all around.

F. Junction boxes
Junction boxes shall be provided where necessary to terminate or tap multiple circuit runs and where required to comply with PEC.

G. Pull boxes
Pull boxes shall be installed where required for offsets to facilitate installation of conductors or where shown on plans.

H. Boxes
Boxes shall be supported independently of conduits. Splices shall not be made in conduit bodies.

END OF SECTION

SECTION 16140
WIRING DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION

This item shall consist of the supply and installation of wires and wiring devices comprising of electric wires and cables, wall switches, convenience receptacles, heavy duty receptacles and other devices shown on the Plans but not mentioned in these Specifications.

PART 2 - PRODUCTS

2.1 MATERIAL REQUIREMENTS

A. Wall switches

Wall switches shall be NEMA WD1, heavy duty AC only, general use, snap type, ivory plastic with rating 250V AC, 10 or 15 amps. Complete with matching plate cover.

B. Receptacles

Receptacles shall be NEMA WD1, heavy duty general use receptacle, ivory plastic, grounding type complete with matching plate cover, with rating 250V AC 10 or 15 Amps and 20 Amps for Air con units.

PART 3 - EXECUTION

3.1 CONSTRUCTION REQUIREMENTS

Install devices flush and level to finished wall and floor. Install wall switches 1.3716 meters above finish floor while receptacle outlets will be 0.3048 meter above finish floor or 0.150 meter above counter or 1.3716 meters for toilet hand dryer and convenience outlet. For Air con units and other equipment, field verify equipment location.

END OF SECTION

SECTION 16149
LOW VOLTAGE SWITCHGEAR

PART 1 - GENERAL

1.1 REQUIREMENTS:

A. These specifications cover complete low voltage switchgear. All equipment shall be designed, assembled and tested in conformity with the single line diagram and the layout shown on the drawings.

B. The equipment shall consist of the following sections: Main Compartment, Branch feeders compartment, bus bar section and instrumentation.

1.2 SUBMITTALS:

A. Shop Drawings:

Submit shop drawings for substations indicating, but not limited to the following:

1. Overall dimension, front view, and sectional view.
2. Bus arrangement including dimension and ampere ratings of all bus bars.
3. Type and spacing of bus and cable supports.
4. Maximum short-circuit bracing.
5. Circuit breaker type, interrupting rating, trip setting.
6. Ratings and sizes of lugs, impedance taps and fans.
7. Elementary diagrams and wiring diagrams with terminals identified and indicating the internal wiring for each item of equipment.
8. Manufacturer’s data for all components and accessories including labels.
9. Routine test and design tests.
10. Installation Shop Drawings.
11. Equipment base construction details including foundation-loading weights.
12. Metering equipment, connections, and mounting details.
13. Cable terminal devices and supports.

B. Operation and Maintenance Manuals.

C. Complete protective relay coordination study and settings.

D. Test reports.

PART 2 - PRODUCTS

A. This section shall consist of metal enclosed switchboard assembly rated 600 volts, AC and arranged for service on a 480 and 230 volts, 3-phase, 3 wire, with ground bus.

B. Construction:

1. The low voltage distribution section shall consist of completely enclosed, self-supporting vertical structures bolted together to form one sheet metal enclosure. It shall be provided with front and rear channels. The ends, top and rear shall be covered with removable screw-on-steel plates not less than 12 gauge. Switchboard shall include all protective devices and equipment as listed with necessary interconnection, instrumentation and control wiring, terminal blocks, and mechanical type solderless connectors for terminals.

2. Protective devices shall have individual drawings or compartment, and necessary bus connection straps. Devices shall be modular-sized and so arranged as to be individually removable and readily interchangeable. Each device shall be provided with cardholder and card for identifications.

3. Bus structure shall be arranged to permit future extension. It shall be mounted on insulator supports of high impact, non-tracking, high quality insulation material and adequately braced to withstand the mechanical forces exerted during short circuit conditions up to 100,000 amperes RMS symmetric short circuit at 400 volts. Bus bars shall be silver plated copper, ratings as shown on the drawings. Branch circuit bushing shall connect directly to the bus structure. All bushings shall be arranged so as not to obstruct straight in wiring to the protective devices. All bus work shall consist of sufficient copper to limit temperature to 40^{o}C ambient temperature.

4. Small wiring necessary fuse blocks and terminal blocks within each vertical structure shall be furnished as needed.

5. All hardware shall have suitable protective finish.

6. Metal surfaces shall be chemically cleaned and treated. Chemical treatment shall provide a bond between paint and metal surfaces and help prevent entrance of moisture and formation of rust under the paint film.

   The vertical structure shall be finished in ASA No. 49 medium-light-gray, the hinged doors over the protective devices on the front in ASA No. 61 light gray.

   Switchboard shall be completely assembled and wired at the factory. Rigid inspection before and after assembly shall be made to assure correctness of design and workmanship. All groups of control wires leaving equipment shall be provided with terminal blocks with suitable numbering strips.

7. Switchboard supports of anchoring and for providing proper alignment will be furnished and installed on the floor or pad by others.

8. A ground bus shall be furnished secured to each vertical structure and shall extend the entire length of the switchboard.

9. All switchboard-outgoing feeders shall be top and bottom exit. Provide feeder cross brace supports as directed.

10. Engraved metal nameplates shall be provided for each device. The letters or numerals on the nameplates shall be a minimum of 25mm in height, with light colored, enameled characters on a dark background. The legend on the strips shall be so composed as to

clearly indicate the name of the feeder and/or panelboard and/or equipment served by protective devices, etc.

C. Circuit Breaker:

1. The main and feeder breakers shall be air or molded case, manually operated, each with direct acting inverse time characteristics and instantaneous over current devices. Feeder breakers shall be fixed mounting type.

2. All feeder breakers shall be air circuit breaker or molded case manually operated.

3. All feeder breakers shall be provided with adjustable continuous ampere setting, adjustable long time delay setting, adjustable short time delay pick-up, adjustable instantaneous pick-up and adjustable ground fault pick-up.

4. All circuit breaker shall be 3-pole unless noted otherwise on plans, rated 100,000 A RMS symmetrical minimum interrupting rating, at 400 volts with trip ratings as shown on the one-line diagrams.

2.1 METERING:

1. All equipment shall be equipped with an ac ammeter, and ammeter transfer switch, an ac voltmeter, a voltmeter transfer switch, a watt-hour meter with demand register and power factor meter. All meters shall be switchboard type.

2. AC Ammeter:

   Transformer rated, 5-ampere input, for use with a 5 A current transformer secondary ratio, scale range as required, 60 Hz.

3. AC Voltmeter:

   Transformer rated, 120 volt, input for use with a 230V-120 volt potential transformer ratio, 0 to 600-volt scale range, and 60 Hz.

4. Watt-hour Meter:

   Shall be 3-phase, 3-wire system, 2 stators, and 120V potential coil, 60 Hz with 15 minutes integrating interval demand register.

5. Power Factor Meter:

   Transformer rated, 5 amperes, 120V input, 0.5 lag to 0.5 leading scale range.

6. Rating of instrument transformers shall be as required by instruments application.

PART 3 - EXECUTION

3.1 GENERAL:

A. All equipment and auxiliaries shall be delivered to the project site.

B. Installation of all supplied equipment shall be supervised by the Manufacturer's Qualified Representative, who shall be personally present at all times while the equipment are being installed and tested.

END OF SECTION

SECTION 16301
UNDERGROUND ELECTRICAL WORK

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS:

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

1.2 SUBMITTALS:

Submit the following information for approval:

Catalog Data and/ or Shop Drawing:
Conduit
Cable lubricants

PART 2 - MATERIALS

2.1 MATERIALS AND EQUIPMENT:

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

2.1.1 CONDUITS:

a. Rigid Steel Conduit (UL6) or Intermediate Metal Conduit (UL 1242): Hotdip galvanizes, treaded type.
b. Rigid Plastic Conduit: NEMA TC2, Type EPC-PVC

2.1.2 FITTINGS AND OUTLET BOXES:

Metal Fittings and Outlet Boxes: UL 514 A & B. Fittings and outlet boxes for use with steel and plastic conduit, rigid or flexible shall be cast-metal with gasketed closures.

2.1.3 TAPE:

UL 510. Plastic insulation tape shall be capable of performing in the continuous temperature environment of 80 degrees C.

2.1.4 POWER WIRE AND CABLES:

Wire and Cable Conductor Sizes: Conductors shall be copper. Provide conductor identification within each enclose where a tap, splice or a termination is made.

2.1.5 600 VOLT WIRES AND CABLES:

Conductors sizes are indicated by area in square mm for copper conductors. Use 3.5 square mm minimum sized conductors, unless otherwise noted

2.1.6 600 VOLT WIRE CONNECTOR AND TERMINALS:

Wire Connectors and Terminals for use with Copper Conductors: UI 486 A.

2.1.7 PULL WIRE:

No. 14 hot-dip galvanized steel or plastic rope having a minimum tensile strength of 200 pounds in each empty duct. Leave a minimum of 600 mm slack at each end of the pull wires.

PART 3 – EXECUTION

3.1 INSTALLATION

Underground cable installation shall conform to the IEC, ANSI C2 and NFPA 70

3.1.1 CONCRETE;

Concrete for electrical requirements shall be at least 20.68 MPa concrete with one-inch maximum aggregate.

3.1.2 UNDERGROUND DUCT WITH CONCRETE ENCASEMENT:

Construct underground duct lines of individual conduits encased in concrete. Conduit shall be schedule EPC-40.Do not mix the kind of conduit used in any one duct bank. Ducts size shall be as indicated. The concrete encasement surrounding the bank shall be rectangular in cross-section and shall provide at least 75 mm of concrete cover for ducts. Separate conduits by a minimum concrete thickness of 50 mm, except separate light and power conduits for control signal, and telephone conduits by a minimum concrete thickness of 75 mm.

3.1.2.1 The Top Concrete envelope shall not be less than 457 mm below grade except that under roads and pavement it shall be not less than 610 mm below grade.

3.1.2.2 Duct lines shall have continuous slope downward towards manholes and handholes and away from buildings with a pitch of not less than 1 mm in 400 mm. except at conduit risers, accomplish charges in direction of runs exceeding a total of 10 degrees, either vertical or horizontal, by long sweep bends having a minimum of curvature of 7.62 m. sweep bends may be made up of one or more curved or straight sections combinations thereof. Manufactured bends shall have a minimum radius of 457 mm for use with conduits of less than 80 mm in diameter and larger.

3.1.2.3 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 rors and layers so as to provides a duct line having the minimum stregth. 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 is clear of all particles of earth, sand, and gravel; then immediately install conduit plugs.

3.1.3 CABLE PULLING:

Thoroughly swab out duct lines to remove foreign materials before pulling of cables. Pull cable downgrade with the fee-in point at the handhole of the highest elevation.

3.1.3.1 Cable Pulling tensions shall not exceed the maximum pulling tension recommended by the cable manufacturer.

3.1.3.2 Secondary Cable Runs in Nonmetallic Duct Conduit: Include an insulated copper equipment grounding conductor sized and required by the rating of the overcurrent device supplying the phase conductors, in nonmetallic conduit, for secondary cable runs, 600 volts and less.

3.1.4 CABLE TERMINATING: Protect terminations of insulated power and lighting cables from accidental contact, deterioration of coverings and moisture by the use of terminating devices and materials.

Splice for 600 Volts Class Cables: Splice in underground systems only in accessible locations such as handholes using a compression type connector on the conductor and insulate suitable for continuous submersion in water.

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

Grounding other metal enclosures of electrical and electricity operated equipment 10 ohms

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

3.1.5.1 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 before stated for the particular equipment being grounded.

3.1.5.2 Make grounding connections which are buried or otherwise normally inaccessible, and excepting specifically those connections for which access for periodic testing is required by exothermite type process or ground clamps. Make thermit wells strictly in accordance with the weld manufacturer’s written recommendation.Welds which have “puffed up” or which show convex surfaces indicating improper cleaning are not acceptable. No mechanical connector is required at thermal weldments.

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

3.1.5.4 Grounding Conductor shall be bare soft-drawn copper wire 14 square mm minimum unless otherwise indicated or specified.

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

3.1.5.6 Provide all empty conduit with a 2.0 mm (No. 14 AWG) zinc coated steel wire or a plastic rope having a breaking strength of at least 200 lbs. leave 610 mm of spare at each test.

3.2 FIELD TESTS

As an exception to requirements that may be stated elsewhere in the contract, the Engineer shall be given 3 working days notice prior to each test.

3.2.1 GROUND RODS: Test ground rods for ground resistance value before any wire is connected. Use a portable ground testing merger to test each ground or group of grounds. The instrument shall be equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground electrode under test. Provide one copy of the megger manufacturer's directions for use of the ground megger indicating the method to be used.

3.2.2 DISTRIBUTION CONDUCTOR 600 VOLTS CLASS: Test 600 Volts class conductors to verify that no short circuits or accidental ground exist. Make tests using an instrument which applies a voltage of approximately 500 volts to provide a direct reading in resistance shall be 250,000 ohms.

END OF SECTION

SECTION 16402
INTERIOR WIRING SYSTEMS

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS: Section 16011, "Electrical General Requirements," applies to this section with additions and modifications specified herein. In each of the standards referred to herein, consider the advisory provisions to be mandatory, as though word "shall" had been substituted for "should" wherever it appears. Interpret reference in these standards to the "authority having jurisdiction," or words of similar meaning, to mean the engineers. Underground Service: Underground primary service conduits shall be continuous from the service entrance pole to the pad mounted transformer.

1.2 SUBMITTALS

1.2.1 Manufacturer's Data:

a. Receptacles
b. Circuit Breakers
c. Switches
d. Conduit and Fitting (each type)
e. Ground rods
f. Device plates
g. Insulated conductors
h. Outlet and junction boxes

1.2.2 Shop Drawings:

a. Panelboards
b. Wireways
c. Pullboxes

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT, GENERAL: All materials, equipment, and devices shall, as a minimum, meet the requirements of the PEC. All items shall be new unless specified or indicated otherwise.

2.2 CONDUIT AND FITTINGS:

2.2.1 Rigid Steel Conduit or Intermediate Metal Conduit: Zinc coated steel only, Pusan , Matshushita or approved equal.

2.2.2 Rigid Non-Metallic Conduit : PVC Schedule 40

2.2.3 Electrical Metallic Tubing (EMT): ANSI C80.3

2.2.4 Flexible Metal Conduit:

a. Liquid-Tight Flexible Metal Conduit (Steel)

2.2.5 Fittings for Metal Conduit, and Flexible Metal Conduit: All ferrous fittings shall be cadmium – or zinc- coated.

2.2.5.1 Fittings for rigid or intermediate conduit shall be threaded type. Split couplings are not acceptable.

2.3 OUTLET BOXES AND COVERS: Zinc-coated ferrous metal.

2.4 CABINETS, JUNCTION BOXES, AND PULL BOXES (WITH VOLUME GREATER THAN 100 MCUBIC INCHES): Hot dip zinc-coated, sheet steel.

2.5 WIRES AND CABLES: Wires and cables shall meet the applicable requirements of the PEC and UL for the type of insulation, jacket, and conductor specified or indicated.

2.5.1 Conductors: Conductors 1.5 mm dia. and smaller shall be solid, and those larger shall be stranded. All Conductors shall be copper.

2.5.1.1 Equipment Manufacturer Requirements: Where Contractor provides equipment whose manufacturer requires copper conductors at the termination, or requires that only copper conductors be provided between components of equipment, it shall be the Contractor's responsibility to provide copper conductors or all necessary splices, splice boxes and other work required to satisfy manufacturer's requirements.

2.5.1.2 Minimum Conductor Sizes: Minimum size for branch circuits shall 2.0 m dia.; for Class 1 remote-control and signal circuits, 2.0 sq. mm. and for Class 2 low energy remote-control and signal circuits, 1.25 sq. mm.

2.5.2 Color Coding: Provide for all feeder, branch, control, and signaling circuit conductors. Color shall be green for grounding conductors, and white for neutrals, excepts where neutrals of more than one system are installed in same raceway or box, the other neutral shall be white with a colored (not green) stripe. The color of the undergrounded conductors in different voltage system shall be as follows:

400/230 Volts, 3-phase -	Phase A – black
	Phase B – red
	Phase C – blue
	Neutral - Yellow
	Ground - Green

2.5.3 Insulation: Unless specified or indicated otherwise or required to be otherwise by PEC, all power and lighting wires shall be 600-volt, Type THHN, except that grounding wire may be Type TW; remote-control and signal circuits shall be Type THHN.

2.5.4 Bonding Conductors: ASTM B 1,solid bare copper wire for size 2.6 mm dia. And smaller; ASTM B 8, Class B, stranded bare copper wire for sizes 8.0 mm sq. and larger.

2.6 SPLICES AND TERMINATION COMPONENTS: UL 486A, as applicable for wire connectors, and UL 510 for insulating tapes. Connectors for wires 2.6 mm dia. and smaller shall be insulated pressure-type, twist-on-splicing connector. Provide Soderless terminal lugs on stranded conductors.

2.7 DEVICE PLATES: Provide one-piece device plates for outlets and fittings to suit the devices installed. Plate on unfinished walls and fittings shall be of zinc-coated sheet steel or cast metal having round or beveled edges. Plates on finished walls shall be satin finish stainless steel, minimum 0.75 mm thick. Screws shall be machine type with countersunk head in a color to match the finish of the plate. Plates installed in wet locations shall be gasketed. Telephone outlet shall be modular jack with six (6) position, four contracts and matching cover plate.

2.8 SWITCHES

2.8.1 Toggle Switches: Totally enclosed with bodies of thermosetting plastic and a mounting strap. Wiring terminals shall be of the screw, slide wired. Switches shall be rated quiet-type ac only 220 volts, with the current rating and number of poles indicated.

2.8.2 Disconnect Switches: NEMA KSI, Switches serving as motor-disconnect means shall be horsepower rated.

2.9 RECEPTACLES: NEMA WD1, grounding type. Ratings and configurations shall be as indicated. Bodies shall be of thermosetting plastic supported on a metal mounting strap. Wiring terminals shall be of the screw type, side wired. Connect grounding pole to the mounting strap.

2.9.1 Weatherproof Receptacles: Provide in a cast metal box with a gasketed, weatherproof, cast-metal cover plate and a gasketed cap over each receptacle opening. The cap(s) shall be provided with a spring-hinged flap. Receptacle shall be UL approved for use in "wet locations"

2.9.2 Ground-Fault Circuit Interrupter (GFCI) Receptacles: UL 943 Duplex for mounting in standard outlet box. Device shall be capable of detecting current leak of 6 milliamperes or greater and tripping per requirements of UL943 for Class A GFCI devices.

2.9.3 Special Purpose Receptacles: Receptacles serving water heater, etc. are considered special purpose for this project. Provide in ratings indicated.
Furnish one matching plug with each receptacle.

2.10 PANELBOARDS: Panelboards shall be circuit breaker equipped. Design shall be such that any individual breaker can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as a means of obtaining clearances as required by UL. Where "space only" is indicated, make provisions for the installation of a breaker sized as indicated. All panelboard locks included in the project shall be keyed alike. Directories shall be typed to indicate load serve by each circuit and mounted in a holder behind protective covering. Enclosure shall be 2.0 mm thick (Ga.14)

2.10.1 Panelboard Buses: Support copper bus bars on bases independent of the circuit breakers. Main buses and back pans shall be designed so that breakers may be changed without machining, drilling, or tapping. Provide a separate ground bus as indicated, marked with a green stripe along its front and bonded to the steel cabinet for connecting grounding conductors.

2.10.2 Circuit Breakers:Bolt–on, thermal magnetic type with interrupting capacity as indicated. Breaker terminals shall be UL listed as suitable for the type of conductor provided. Plug–in circuit breakers are not acceptable.

a. Multipole Breakers: Provide internal common-trip type with a single operating handle. Breaker design shall be such that an overload in one pole automatically causes all poles to open. Maintain phase sequence throughout each panel so that any three adjacent breaker pole are connected to Phase A, B, and C, respectively. Single pole circuit breakers provide with external tripping handles for multipole circuit breaker are not acceptable.

2.11 TELEPHONE SYSTEM: Provide a system of conduits and terminal boxes, outlets and junction boxes, and other accessories. Provide pull wires in empty conduits. The complete

system shall be ready for use by others who will provide wires/cables and install equipment and outlets.

2.11.1 Outlet Boxes for Telephone System: Standard type, as specified hereinbefore. Mount flush in finished walls at the height indicated.

2.11.2 Cover Plates: Standard telephone type of the finish specified for receptacle and switch cover plates.

2.11.3 Conduit Sizing: Unless otherwise indicated, conduit for single outlets shall be a minimum of 20 mm electrical trade size and for multiple outlets as shown on drawings. Size conduits for telephone risers to telephone cabinets, junction boxes, distribution centers, and telephone services as indicated.

2.12 GROUNDING AND BONDING EQUIPMENT: Ground rods shall be copper – encased steel, with a diameter of 20 mm dia and total length as indicated.

PART 3 - EXECUTION

3.1 INSTALLATION:

3.1.1 General Requirements: Electrical installations shall conform to the requirements of the PEC and to requirements specified herein.

3.1.2 Wiring Methods: Wiring method shall be insulated conductors installed in conduit, except where specifically indicated or specified otherwise, or required by the PEC to be installed otherwise. An insulated equipment grounding conductor shall be provided in all feeder and branch circuits, including lighting circuits. Provide insulated, green-colored conductor for grounding conductors installed in conduit or raceways.

3.1.2.1 Conduit in Floor Slabs: Rigid steel or Intermediate Metal Conduit.

3.1.2.2 Nonmetallic Conduit: Do not use above ground floor slab except where specifically indicated or specified for special situation or systems.

3.1.3 Conduit Installation: Unless indicated otherwise, conceal conduit within finished walls, ceilings, and floors. Keep conduit at least 150 mm away from parallel runs of flues and stream 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. Conduits in crawl space under slab shall be run as if exposed.

3.1.3.1 Where conduits rise through floor slabs, the curved portion of bends shall not be visible above the finish slab.

3.1.3.2 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; by machine screws, welded threaded studs, or spring-tension clamps on steel work. Do not weld conduits or pipe straps to steel structures. The load applied to fasteners attached to concrete ceiling shall be vibration and shock

resistant. Holes cut to a depth of more than 38 mm in reinforced concrete beams or to a depth or more than 20 mm in reinforced concrete beams or to a depth of more than 20 mm in concrete joints shall not cut the main reinforcing bars. Fill holes that are not used. In partitions of light steel construction, run conduit above the ceiling and fasten only lighting system branch circuit conduits to the ceiling supports. Spring steel fasteners may be used for lighting branch circuit conduit supports in suspended ceiling in dry locations.

3.1.3.3 Make changes in direction of runs with symmetrical bends or cast-metal fittings. Make field-make bends and offsets with a hickey or conduit-bending machine. Do not install crushed or deformed conduits. Avoid trapped conduits. Prevent plaster, dirt or trash from lodging in conduit, boxes fittings, and equipment during construction. Free clogged conduits of all obstructions.

3.1.3.4 Install pull wires in empty conduits in which wire is to be installed by others. The pull wire shall be 2.0 sq. mm. zinc-coated steel or plastic having not less than 90 kg. Tensile strength. Leave not less than 300 mm of slack at each end of the pull wire.

3.1.3.5 Telephone and Signal System Conduits: Install in accordance with the previous requirements for conduit and with the additional requirement that no length of run shall exceed 45 m for trade sizes 50 mm and smaller and shall not contain more than two 90-degree bends or the equivalent. Provide pull or junction boxes where necessary to comply with these requirements. Inside radii of bends in conduits 25 mm trade size and larger shall not be less than two (2) times the nominal diameter. Terminate conduit in terminal cabinet with two locknuts and a plastic bushing.

3.1.3.6 Conduit Installed in Concrete Floor Slabs: Locate so as not adversely affect the structural strength of the slabs. Install conduit within the middle one-third of the concrete slab. Do not stack conduits. Space conduits horizontally not closer than 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 a minimum 25 mm be run parallel with or at right angles to the main reinforcement; when at right angles to the reinforcement, the conduit shall be close to one of the support of the slab.

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

3.1.3.8 Stub-Ups: Provide conduits stubbed up through concrete floor for connection to free-standing equipment with an adjustable top or coupling threaded inside for plugs, set flush with the finished floor. Extend conductors to equipment in rigid steel, except that flexible metal conduit may be used 150 mm above the floor. Where no equivalent connections are made, install screwdriver-operated threaded flush plugs in conduit end.

3.1.3.9 Flexible connections of short length (maximum of 1.8 m) shall be provided for recessed and semi-recessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for motors. Liquid-tight flexible conduit shall be used in wet locations. A separate ground conductor shall be provided across flexible connections.

3.1.4 Boxes, Outlets, and Supports: Provide boxes in the wiring or raceway systems wherever required for pulling of wires, making connections, and mounting of devices of fixtures. Boxes for metallic raceways shall be of the cast-metal hub type when located in normally wet locations, when surface mounted on outside of exterior surfaces, when installed exposed up to 2.10 m above interior floors and walkways. Boxes on other location shall be sheet steel. Each box shall have the volume required by the PEC for the number of conductors enclosed in the box. Boxes for mounting lighting fixtures shall be not less than 100 mm square, except that smaller boxes may installed as required by the 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 boxes installed flush with the outside of exterior surfaces. Provide separate boxes for flush or recessed fixtures when required by the fixture terminal operating temperature; fixtures shall be readily removable for access to the boxes unless ceiling access panels are provided. Support boxes and pendants for surface-mounted fixtures on suspended ceilings independently of the ceiling supports or make adequate provisions for distributing the load over the ceiling support members in an approved manner. Fasten boxes and supports with bolts and expansion shield on concrete or brick, with toggle bolts on hollow masonry units, and with machine screws or welded studs on steel works. Threaded studs driven in by charge and provided with lock washers and nuts or nail-type nylon anchors may be used in lieu of wood screws, expansion shield or machine screws. In open overhead spaces, cast boxes threaded to raceways need not be separately supported except where used for fixture support; support sheet metal boxes directly from the building structure or by bar hangers. Where bar hangers are not used, attach the bar to raceways on opposite sides of the box and support the raceways with an approved type fasteners not more than 600 mm from the box. When penetrating reinforced-concrete members, avoid cutting any reinforcing steel.

3.1.4.1 Boxes for use with raceways systems shall not be less than 55 mm deep, except where shallower boxes required by structural conditions are approved. Boxes for other than lighting-fixture outlets shall not be less than 100 mm square, except that 100 mm x 50 mm boxes may be used where only one raceway enters the outlet. Telephone outlets shall be a minimum of 100 mm x 55 mm deep.

3.1.4.2 Pull boxes: Construct of not less than the minimum size required by the PEC of code-gage galvanized sheet steel, except where cast- metal boxes are required in locations specified above. Furnish boxes with screw fastened covers. Where several feeders pass through a common pullbox, tag the feeders to indicate clearly the electrical characteristics, circuit number and panel designation.

3.1.5 Mounting Heights: Mount panelboards, circuit breakers, and disconnecting switches so that the height of the operating handle at its highest position will not exceed 1.8 m from the floor. Mounting lighting switches, receptacles and other devices as indicated. Measure mounting heights of wiring devices and outlets to the center of device or outlet.

3.1.6 Conductor Identification: Provide conductor identification within each enclosure where a tap, splice, or termination is made. For conductors 14 mm sq. and smaller, color coding shall be by factory-applied plastic-coated, self-sticking markers, colored nylon cable ties and plates, or heat-shrink type sleeves. Identify control circuit terminations.

3.1.7 Splices: Make splices in accessible locations. Make splices in conductors 2.6 mm dia. and smaller with an insulated pressure type connector. Make splices in conductors 8

sq. mm and larger with a solderless connector and cover with an insulation material equivalent to the conductor insulation.

3.1.8 Covers and Device Plates: Install with all four edges in continuous contact with finished wall surfaces without the use of mats or similar devices. Plaster fillings will not be permitted. Plates shall be installed with an alignment tolerance of 2 mm. The use of sectional type device plates will not be permitted. Plates installed in wet locations shall be gasketed.

3.1.9 Grounding and Bonding: In accordance with the PEC, Ground all exposed non-current-carrying metallic part of electrical equipment, metallic raceways systems, and neutral conductors of wiring systems. Make ground connection to driven ground rods as shown on drawings.

3.1.9.1 Grounding Conductor: Provide an insulated, green-colored equipment grounding conductor in all feeder and branch circuits. This conductor shall be separate from the electrical system neutral conductor.

3.1.9.2 Resistance: The maximum resistance to ground of the grounding system shall not exceed 25 ohms under normally dry conditions.

3.2 FIELD TESTS: The contractor shall provide all test equipment and personnel and submit written copies of all tests results. As an exception to requirements that may be stated elsewhere in the contract, the Engineer shall be given 5 working days notice prior to each test.

3.2.1 Device Subject to Manual Operation: Each device subject to manual operation shall be operated at least five times, demonstrating satisfactory operation each time.

3.2.2 Test on 600-Volt Wiring: Test all 600-volt wiring to verify that no circuits or accidental grounds exist. Perform insulation resistance test on all wiring using an instrument which applies a voltage of approximately 500 volts to provide a direct reading of resistance; minimum resistance shall be 250,000 ohms.

3.2.3 Grounding System Test: Test the grounding system to assure continuity and that the resistance to ground is not excessive. Test each ground rod for resistance to ground before making any connections to the rod; then tie entire grounding system together and test for resistance to ground. Make resistance measurements in normally dry weather, not less than 48 hours after rainfall. Submit written results of each test to the Engineer and indicate the locations of the rods as well as the resistance and soil conditions at the time the measurement were made.

END OF SECTION

SECTION 16450
GROUNDING

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Power system grounding.
B. Electrical equipment and raceway grounding and bonding.
C. Isolated equipment grounding.
D. High-performance grounding system for computers and process equipment.

1.2 RELATED WORK

A. This Section shall be used in conjunction with the following other specifications and related Contract Documents to establish the total requirements for grounding:

1. Section 16010 – Basic Electrical Requirements
2. Section 16120 – Wire and Cable
3. Section 16972 – Startup Testing and Commissioning of Electrical Equipment.

CAUTION! Use of this Section without including all of the above-listed items will result in omission of basic requirements.

B. In the event of conflict regarding grounding requirements between this Section and any other section, the provisions of this Section shall govern.

1.3 SYSTEM DESCRIPTION

A. Ground the electrical service system neutral at service entrance equipment to grounding electrodes (do not use piping).

B. Ground each separately derived system neutral to specific purpose grounding grid plate at the nearest column electrode or grounding grid pigtail.

C. Bond together system neutrals, service equipment enclosures, exposed noncurrent carrying metal parts of electrical equipment, metal raceway systems, grounding conductor in raceways and cables, receptacle ground connectors, and plumbing systems.

D. Provide separate isolated, insulated equipment grounding conductor bonded to grounding counterpoise system only at service or separately derived source where required for reduction of electrical noise.

1.4 SUBMITTALS

A. Provide the following in addition to the standard requirements: Indicate layout of ground ring, location of system grounding electrode connections, and routing of grounding electrode conductor.

PART 2 - PRODUCTS

2.1 GROUND RODS

A. Copper-clad steel, 20mm diameter, 3.00 meters long and 25mm diameter, 3.00 meters

long driven full length into the earth.

2.2 GROUND CONDUCTORS

A. Provide grounding conductors of the size shown and the type specified in Section 16402, Interior Wiring System.

2.3 GROUND CONNECTIONS

A. Below Grade: Exothermic-welded type connectors by Cadweld, Thermoweld.

B. Above Grade or in Manholes: Compression type connectors by T&B, Burndy, or Anderson.

C. When making bolted connection to aluminum or galvanized structures, apply a corrosion-inhibitor such as Penetrox A to all contact surfaces between cable, connector, and surface of structure.

2.4 GROUND CONDUCTOR FOR GROUNDING GRID AND ASSOCIATED CONNECTIONS

A. $100mm^2$, $60mm^2$ and $50mm^2$ Bare Copper Wire, 7 stranded

2.5 GROUND BRAID

A. Acceptable Manufacturers:

1. Phelp Dodge
2. American Wire
3. Belden

B. Grounding Braid: constructed from flat 98-percent conductivity tinned copper grounding braid.

PART 2 - EXECUTION

3.1 GENERAL

A. Where grounding conductors are shown, bond the wires to metallic enclosures at each end and to all intermediate metallic enclosures. Connect grounding conductors to all grounding bushings on raceways. Where any equipment contains a ground bus, extend and connect grounding conductors to that bus. Connect the enclosure of the equipment containing the ground bus to that bus. Run grounding conductors inside conduits enclosing the power conductors.

3.2 INSTALLATION

A. Grounding conductors shall not be spliced except in junction or outlet boxes.

B. Provide a separate, insulated equipment grounding conductor in all circuits. Terminate each end on a grounding lug, bus, or bushing and to all intermediate metallic enclosures.

C. Connect grounding conductors to motors 10 hp and above or circuits 20A or above by

a solderless terminal and a 7.94mm minimum bolt tapped to motor frame or equipment housing. Connect to smaller motors or equipment by fastening the terminal to a connection box. Connect junction boxes to the equipment grounding system with grounding clips mounted directly on the box or with 9.52mm machine screws. Completely remove all paint, dirt, or other surface coverings at grounding conductor connection points so good metal-to-metal contact is made.

D. Connect grounding electrode conductors to metal water pipe using a suitable ground clamp. Make connections to flanged piping at street side of flange. Provide bonding jumper around water meter.

E. Supplementary Grounding Electrode: use driven ground rod on exterior of building. Install ground rod in suitable recessed well; fill with gravel after connection is made.

F. Separately Derived Source:
   1. Transformers, UPS systems, power conditioners, inverters or other power supplies are separately derived sources.
   2. Standby or emergency ac generators are separately derived sources if the neutral is bonded to the generator frame and if there is no direct connection of the generator neutral conductor to the service neutral conductor.
   3. Ground separately derived sources to the service ground and to closest additional electrode as described in this Section.

G. Provide one No. 6 AWG bare copper conductor from facility grounding grid to each communication / data backboard.

H. Bare Grounding Conductors Below Grade:
   1. Minimum 76.2 cm below the soil or as shown on Drawings.
   2. Not in contact with gravel fill or concrete unless making transition from connections above the slab to conductors below grade.
   3. Neatly trained around foundations and footings.

I. Ground Resistance: Maximum 1 ohm at 60Hz as measured by Three-point Fall-of-Potential test.

J. Ground shields of any shielded power cable at each termination as recommended by the manufacturer. Ground shields of any control cables in accordance with the details shown.

K. Ground metal sheathing and any exposed metal vertical structural elements of buildings. Ground metal fences enclosing electrical equipment. Bond any metal equipment platforms which support electrical equipment to the equipment ground. Provide good electrical contact between metal frames and railings supporting push-button stations, receptacles, instrument cabinets, etc., and raceways carrying circuits to these devices.

L. Grounding Connections:
   1. Connect grounding conductors to ground rods at the upper end of the rod with the end of the rod and the connection point below finished grade.
   2. Connect sections of outdoor ground mats (counterpoise) for substations or other equipment below grade. Connect other grounding conductors generally in an accessible manner.
   3. In manholes, install ground rods with ends 100 to 150 mm above the floor with connections of grounding conductors fully visible and accessible.
   4. Do not use thermite welds in manholes.
   5. In medium-voltage manholes, apply compression connectors using hydraulic-type tool similar to Burndy Model Y-35. Kearney-type screw connections

shall not be used.

6. When making thermite welds, wire brush or file the point of contact to a bare metal surface. Use thermite welding cartridges and molds in accordance with the manufacturer's recommendations. After welds have been made and cooled, brush slag from the weld area and thoroughly clean the joint. For compression connectors, use homogeneous copper, anticorrosion, surface treatment compound at connectors in accordance with connector manufacturer's recommendations. Use connectors of proper size for conductors and ground rods specified. Use connector manufacturer's compression tool. Notify the Inspector prior to backfilling any ground connections.

M. Bond fab raised floor stringer system to building grounding system per attached details. Length-to-width ratio of installed ground braid shall not exceed 5:1.

3.3 FIELD QUALITY CONTROL

A. Inspect grounding and bonding system conductors and connections for lightness and proper installation.

B. Test all ground fault interrupter (GFI) receptacles, alarm systems, and circuit breakers for proper connection and operation with methods and instruments prescribed by the manufacturer.

C. Test grounding system in accordance with the requirements of Section 16972, Start up Testing and Commissioning of Electrical Equipment.

END OF SECTION

SECTION 16470
PANELBOARDS

PART 1 - GENERAL

1.5 WORK INCLUDED

A. Distribution panelboards.
B. Branch circuit panelboards.

1.6 RELATED WORK

A. This Section shall be used in conjunction with the following other specifications and related Contract Documents to establish the total requirements for panelboards:

1. Section 16011 – Electrical General Requirements
2. Section 16402 – Interior Wiring System

B. In the event of conflict regarding grounding requirements between this Section and any other section, the provisions of this Section shall govern.

1.7 SUBMITTALS

A. Provide the following in addition to the standard requirements with the Bid:
1. Electrical characteristics of circuit breakers, including voltage, frame size, trip rating, short-circuit rating in rms symmetrical amperes, and time-current curves.
2. Panelboard electrical ratings, including short-circuit rating.

PART 2 - PRODUCTS

2.6 ACCEPTABLE MANUFACTURERS – DISTRIBUTION PANELBOARDS

A. General Electric Company (Spectra Series).

B. Cutler Hammer.

C. Square D.

D. Westinghouse

E. Siemens

2.7 DISTRIBUTION PANELBOARDS

A. Panelboards: NEMA PB 1; circuit breaker type.

B. Enclosure: NEMA PB 1; size as shown on the Drawings.

C. Provide cabinet front with door-in-door (picture frame) construction. Finish in manufacturer's standard gray enamel.

D. Provide panelbooards with copper phase bus, ratings as shown on the Drawings. Provide aluminum ground bus in all panelboards.

E. Where indicated, provide neutral bus bar of the same material as the phase bus bars

and a continuous current rating 200 percent of the phase bus bars. Provide at least one terminal screw for each branch circuit.

F. Minimum Short-Circuit Rating: as shown on the Drawings.

G. Molded-Case Circuit Breaker: NEMA AB 1; circuit breakers with integral thermal and instantaneous magnetic trip in each pole. Handle shall be pad-lockable in OFF position. All circuit breakers shall be fully rated.

H. Factory-Installed Nameplates: temporary tape labels.

I. Field-Installed Nameplates: laminated plastic with engraved letters on each unit (furnished by installing subcontractor).

2.8 ACCEPTABLE MANUFACTURERS – BRANCH CIRCUIT PANELBOARDS

A. General Electric (A Series).

B. Cutler Hammer

C. Westinghouse

D. Square D

E. Siemens

2.9 BRANCH CIRCUIT PANELBOARDS

A. Lighting and Appliance Branch Circuit Panelboards: NEMA PB1; circuit breaker type.

B. Enclosure: NEMA PB1; as shown on the Drawings.

C. Cabinet Size: as shown on the Drawings.

D. Provide cabinet front with door-in-door, hinged-to-box construction with flush inner door lock and screwed-on outer door. Finish in manufacturer's standard gray enamel.

E. Provide panelboards with copper phase bus, ratings as scheduled on Drawings. Provide extruded aluminum ground bus with main lug in all panelboards.

F. Provide extruded aluminum neutral bus with a minimum continuous current rating of 100 percent of the phase bus bars, except where 200 percent neutral bus is specified. Provide at least one terminal screw for each branch circuit.

G. Where more than one neutral bus is provided in the same panelboard, the neutral buses shall be connected together at the factory with continuous current rating of the connector equal to the neutral bus rating.

H. Minimum Short-Circuit Rating: 10,000 amps rms symmetrical unless otherwise shown on the panel schedules.

I. Molded-Case Circuit Breakers: NEMA AB 1; bolt-on type thermal magnetic trip circuit breakers, with common trip handle for all poles. Provide circuit breakers UL listed as Type SWD for lighting circuits. Provide UL Class A ground fault interrupter circuit breakers where shown on the Drawings. Provide circuit breakers UL listed as Type HACR for air-conditioning equipment branch circuits. All circuit breakers shall

be fully rated.

J. Provide lock-off devices for each panelboard. Device shall be capable of accepting a single padlock.

K. Terminations: Provide all hardware required to accommodate the type of connectors specified in Section 16402 – Interior Wiring System

L. Factory-Installed Nameplates: temporary tape labels.

M. Field-Installed Nameplates: laminated plastic with engraved letters on each unit.

N. Provide standard circuit inventory holders.

O. Refer to panel schedules attached to this Section for specific requirements.

P. Provide isolated ground bus where indicated.

PART 3 - EXECUTION

3.4 PROTECTION DURING CONSTRUCTION

A. Store all products specified in this Section in a dry location. Following installation, protect products from the effects of moisture, corrosion, and physical damage during construction.

3.5 BRANCH CIRCUIT AND DISTRIBUTION PANELBOARDS

A. Mount panelboards securely where indicate, plumb, in-line, and square with walls. Unless otherwise, mount panelboard with top of its cabinet approximately 1.98 meters above the floor. Provide a typewritten circuit directory with transparent plastic cover inside each panelboard.

B. Directories: Provide typewritten circuit directory on the inside face of each panel.

3.6 GROUND BUS INSTALLATION

A. Install ground bus in accessible location.

3.7 NAMEPLATES

A. Provide laminated plastic nameplates with engraved letters per the requirements of Section 16402 (3.16) Identification.

END OF SECTION

SECTION 16950

TESTING AND COMMISSIONING OF ELECTRICAL SERVICES

PART 1 GENERAL

1.1 SCOPE OF WORK

A. Provide any materials, equipment and labor required, and make such tests as specified in the various Electrical Power and Lighting Systems, Standby Power Generator System and Communication system as specified herein, and as otherwise deemed necessary to show proper execution of the work in the presence of the Architect/Engineer.

B. Any deficiencies discovered as result of such tests shall be corrected without additional cost to the Owner.

C. After the installation is completed and properly adjusted, operating tests shall be conducted. The various equipment and systems shall be demonstrated to operate in accordance with the requirements of the Contract Documents. Test shall be performed in the presence of the Architect/Engineer. Provide electric power, instruments and personnel necessary for performing the various tests.

D. Procedures and tests outlined below are to be considered as in addition to normal visual and mechanical inspections which must be carried out prior to balancing equipment in service.

E. Procedures and test outline below are to be considered as in addition to tests called for under other sections of the electrical specifications.

F. Perform the following tests in the presence of the Architect/Engineer:

1. Voltage test shall be made at the last outlet on each circuit. If drop in potential is excessive, correct the condition and re-test the relevant circuit.

2. All cables, after being pulled in place and before being connected, shall be tested by Megger test to determine that conductor insulation resistance is not less than that recommended by cable manufacturer. Four copies of all test shall be furnished to the Architect. All cable failing insulation test shall be removed, replaced and re-tested.

3. All equipment shall pass similar tests and entire system tested after all final connections have been made.

4. All motors shall be tested under load with ammeter readings taken in each phase, and the RPM of motors recorded at the time. All motors shall be tested for correct direction of rotation.

1.2 TESTING, SPECIAL REQUIREMENTS

A. The following relevant tests shall be conducted at the factory and witnessed by the Architect or his representative for all custom built, electrical plant and equipment such as Main Low Voltage Switchgear Transformers. Automatic Transfer Switches, and Diesel Generator Sets:

1. Earthing facilities
2. Installation resistance
3. Phasing and wiring check

4. Operational checks of all circuit breakers, isolators, starters and switches.
5. Check major component type and sizes.

B. The contractor shall take every precaution possible to assure the proper functioning of equipment or systems, and shall adhere to the following procedures.

1. Electrical equipment delivered to job-site during construction shall be protected in such a way that prevent dirt, dust, water or any other foreign materials from entering or contaminating the working parts. This protection shall also be provided after installation as long as construction operations continue.

2. Before any equipment or system is energized, the following procedures and tests should be followed and/or performed.

a. Clean all dirt, dust and moisture from equipment.
b. Check for loose bus and cable connections.
c. Check for missing insulation in equipment and on conductors.
d. Check for any modifications, alternations, or the use of unapproved parts in the assembly of the equipment against the approved submittals.
e. Ascertain that all circuit breaker short interrupting ratings are adequate.
f. The equipment room or area should be free of moisture accumulations
g. Check conductors run in multiple to ensure that they are properly phased.
h. Conduct a ”megger” test of all equipment and wiring (the use of battery operated test lights and bells is not acceptable for this test).

C. For maximum safety on feeder of 200 amperes and greater, it is recommended that a low amperage test fuse (15 amperes or less be used and the circuit be energized without load to ensure the safe interruption of the circuit if a fault exists. Under no circumstances shall a wire or open link be use a substitute for approved enclosed fuse.

D. Ascertain that all equipment is rated for the available fault current.

1.3 SUBMITTALS

A. Provide a detailed short circuit and coordination study of the electrical system including the incoming Meralco supply and 34.5 KV Switchgear, Bus Duct and feeder Cables to Sub-Switchboards and Distribution Boards and Standby Power System.

B. The study result shall be submitted for review in the following form:

1. For the short circuit study, five (5) bound copies of the time current curves, together with a tabulation of relay identification, location and recommended settings. A commentary covering the basis for selection of settings, and suggestions for improvement of coordination and protection shall be included where applicable.

C. A short circuit study and protective device coordination study shall be performed as described herein.

D. A short circuit study shall determine the maximum duty that the system protective devices, transformers, and interconnections will be subjected to in event of three phase and/or line- to- ground fault conditions. The fault study shall also provide the basic information required for determining protective relay settings.

1. The study be a tabulation of symmetrical RMS short circuit values for both interrupting duty and momentary duty. Resistance and reactance components of total impedance to the point of fault, the X/R ratios and voltages one two busses remote from the fault shall be given. All values shall be printed in per unit form or kilo

amperes. A fault shall be assumed at each of the bus locations, and the total duty on the bus, as well as the individual contributions from each connected branch shall be indicated.

2. In addition to the above, the study shall include a lists of all branch and source impedances. Branch and bus identification numbers shall be pre-assigned and identified on a accompanying system diagram.

3. Individual switching operations shall be performed during the course of the study to stimulate opening or closing of the circuit or the addition of generation or other short circuit sources as applicable.

E. The coordination study shall include the necessary calculations and logic decisions to select, or to check the selection of power circuit breaker ratings, phase and ground over-current relay characteristics and settings, and the ratios of associated instrument transformers. The objective of the study is to provide the optimum protective and coordination performance or these devices.

1. The coordination study shall cover utility service cable, all high voltage classes of equipment (34.5KV) and including the 380 Volt transformer mains, feeders and motor control centre.

2. The coordination study may be performed manually or by digital computer or combination of the two procedures.

F. The results of the study shall be presented graphically on time-current coordination curves. These curves to illustrate the selected trip characteristics of the protective devices in series to the fault location, and show the degree of protection attained from transformers, motor, etc. as selective tripping obtained from the backup protective devices.

G. The results of the study shall also be presented as data tabulations under the following heading where applicable:

1. Short circuit data:
   a. Current values for maximum and minimum fault conditions for close-in and line-end fault locations for each protective device.
   b. A comparative tabulation of the calculated short circuit duties versus the ratings of the applied circuit breakers and fuses. If the study reveals problem areas or inadequacies of protective device, the report shall include recommendations for corrective steps to be taken.

2. Devices identification and Settings:
   a. A listing of relay types and available taps, current transformer ratios, breaker types, fuses ratings and the location of each device in the system.
   b. The recommended tap and time dial setting, and the instantaneous pickup setting is to be given for each over current relay and setting for each breaker.
   c. A critique of the applied devices shall be included with comments pertaining to the suitability of the selected types, ranges and CT ratios, etc.

3. Device Operation Check:
   a. For faults at each bus location, the operation time in second shall be listed for each relay at the fault bus one and two buses away from the fault bus.

H. The contractor shall obtain the following data where applicable form the switchgear manufacturer, utility company and/or other Sub-contractor to enable him to proceed with the short circuit and coordination study. (data to be obtained unless otherwise noted from contract document send/or manufacturer furnished equipment for the project).

1. Single line interconnection diagram.

2. Short circuit contribution from power company source and X/R ratio of this contribution.

3. Impedance, voltage ratio, MVA rating and method of neutral earthing of power transformers.

4. The ratings of all induction motors. Rating of motors should include full load amperes, voltage, speed and sub-transient reactance.

5. Type voltage rating, size and number of conductors, type of conduits, shielding, and lengths of all interconnecting cable.

6. Identification of circuit breakers and power fuses to include manufacturer and type, voltage rating, interrupting and momentary short circuit ratings, and rated interrupting time.

7. Indication of which tie breakers or switches are normally closed or cannot be closed for certain reasons.

8. The ratio of the instrument transformers energizing each relay.

9. The type designation, range of adjustments, style or catalogue number and the manufacturer of each protection relay. The existing settings on each relay should be included if applicable.

1.4 SAFETY AND PRECAUTIONS

A. Safety practices shall included but are not limited to the following requirements:

1. Local Authority and Insurance Company's Standards/Requirements.
2. Applicable national and Local Safety operating procedures.
3. Owner's safety practices

B. All tests shall be performed with apparatus de-energized except where otherwise specially required herein.

C. Power circuits shall have conductors shortened to earth by a hot line earthing device approved for the purpose.

D. In all cases, work shall not proceed until it has been determined that it is safe to do so.

E. The Contractor shall have available, sufficient protective barriers and warming signs to conduct specified tests safety.

PART 2 - PRODUCTS

(NOT APPLICABLE)

PART 3 - TESTING, ADJUSTING AND VERIFICATION

3.1 TESTING, ADJUSTING AND VERIFICATION

A. Provide necessary material, labor and miscellaneous services for temporary feeders, provision of jumpers and connections, and handling equipment during the testing, adjusting and verification procedure.

B. Confirm that all protective device schemes function properly. Conduct circuit breaker trip test. Apply correct voltage and current to protective device.

C. Provide cross wattmeter readings equivalent or any differential and or directional relay schemes. Verify metering schemes.

D. During the testing and verification procedure, conduct spot checks on selected protective devices with representative of the Owner and/or Engineering to adjust and to re-test prospective devices to that final settings will result in performance in accordance with approved issue of respective coordination curve.

E. Witness tests shall occur in locations to be determined once manufacturers have been agreed with the successful electrical sub-contract tenderer.

F. Provide factory witness testing to suit delivery schedule of manufacturers. Provide hourly rates etc. to re-witness equipment if initial tests fails.

G. Provide all submission and final report as previously specified.

H. The final report and study shall include assurance for the following items:

1. That the protective devices on the main low voltage equipment its coordinate with the Utility Company protective devices.

2. That the protective devices within the parameters of the study conform to the results of the study.

3. That the equipment has been tested and performs as per the settings of approved coordination curves.

4. That the “as left” condition of the protective device correspond to the record documents.

   Complete studies and reports shall be submitted simultaneously to the Engineer as well as part of the requirement of the Project record document.

3.2 BUILDING DISTRIBUTION SYSTEM

A. Before energizing any portion of the electrical systems perform megger tests on all feeders. Result to conform to the applicable Codes and Standards to the satisfaction of the authorized inspection authority and to the Electrical Engineer.

B. Upon completion of the building and immediately prior to final inspection and takeover check the load balance on all feeders at distribution centers, motor control and panelboards. Tests to be carried out by turning on all possible loads in the building and checking load current balance. If load ambulance exceeds 10%, reconnect circuit to balance load.

C. Make voltage checks throughout building after building is in operation for sixty (60) days and at this time. If directed by the Electrical Engineer, adjust transformer tap settings.

Readings taken at this time to be logged, tabulated and any adjustments made to be suitably logged and incorporated in the Operating and Maintenance Manuals.

D. All protective devices to be tested and calibrated on site prior to energizing, to ensure proper operation as calculated on coordination studies provided by equipment suppliers. Testing and calibration to consist of verification of published curves and setting of devices at specified settings. Complete report to be submitted to the Electrical Engineer within seven (7) days of completion of testing.

3.3 SYSTEM

The following systems and equipment are to be tested, inspected and certified.

A. Wire and Cable (600 Volts and Below):

1. Inspect all splices and terminations and make mechanically and electrically tight transformer tap settings. Readings taken at this time to be logged, tabulated and any adjustments made to be suitable logged and incorporated in the Operating and Maintenance Manuals.

2. Perform standard 500 volt insulation test with “megger” tester for all conductors. Test shall show insulation resistance in excess of minimum values required by Codes. Submit certification to the Architect/Engineer.

B. Motor controllers:

1. Submit with certification in tabular form a complete listing of all motors on the project for which motor controller have been provided. Include on this listing, the nameplate full load amperes of each motor and the size overload heaters installation each motor controller.

C. Motors:

1. Test all motors under load and confirm that motor rotation is correct.

D. Engine Generator and Automatic Transfer Switches.

1. Factory testing:
   a. Prior to shipment of each engine-generator set from the factory, a certified load test shall be performed and the results submitted to the Architect/Engineer for approval before shipment of the unit. The test shall conform the proper operation of all alarms and shut down circuits.

   b. The test shall also demonstrate compliance with the set performance criteria as specified herein.

   c. Testing shall be performed as follows:
      c.1 In a period of five (5) hours with a loading of 25, 50, 75,100 and 110 percent of rated load. Step loading procedures shall be utilized (i.e. 25 % first hour, 50% second hour, etc).
      c.2 Shock load of 100% of rated output, step loading is unacceptable. Maintain 100 load for 1 hour.

2. Field testing:

   a. After completion of the installation, the Contractor shall arrange with the engineer for a load test of each control switchgear and related automatic transfer

switches. The generator shall be required to start- up and accept full load within 10 seconds. The unit shall continue to operate for not less than four (4) hours at 100% rated load. The test shall also include demonstrating that all alarms, signals, shut down devices, lift recall, etc., are functioning properly. The Contractor shall be responsible for securing all temporary load-banks, etc. required for the tests.

b. The contractor shall supply all fuel for the testing. Upon acceptance by the Architect/Engineer the day tank and main fuel oil tank shall be filled to capacity after testing.

E. HV Switchgear, Substation, Low Voltage Switchboards.

1. At the completion of the work equipment shall be field tested in the presence of the Engineer in accordance with applicable standards. Tests shall be conducted under the close supervision of the service organization of the manufacturer.

2. Test shall include the following:
   a. Operation of each disconnecting means under load.
   b. Operation of all metering equipment.
   c. Operation of all alarm devices.
   d. Operation of forced air cooling system.
   e. Operation of all key interlocks.

3. The manufacturer shall observe all cable bracing both incoming and outgoing and certify that same in provided in accordance with the manufacturers' recommendations.

4. The earth leakage systems shall be set at the level specified by the switchboard supplier.

5. As work shall be retorqued in accordance with manufacturer's recommendations. Submit certification of same.

F. Lighting Protection System

1. Provide testing for the system as per applicable codes and standards attach a certified label at the origin of the electrical installations as required by this standard.

G. Earthing

1. Upon completion of the electrical earthing system for the contractor shall test the earthing system for stray currents, earths, shorts, etc. these tests shall be performed with approved instruments.

H. Auxiliary Systems

1. Refer to the auxiliary system sections the details of testing.

3.4 COMMISSIONING

A. The contractor shall be responsible for the coordination of all the previously described elements which comprise the whole installation.

B. In addition, the Contactor shall carry out final settings and adjustments and commissioning of the whole installation up to including the incoming circuit breakers of

the main low voltage switchboards in accordance with the manufacturer's recommendations and recognized practice.

C. details of proposed commissioning procedures shall accompany the Contractor's proposal Submission.

END OF SECTION