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SECTION 16050

ELECTRICAL WORK GENERAL

PART 1 GENERAL

1.01 DESCRIPTION

- A. Install electric power, lighting and grounding systems, including the installation and wiring of miscellaneous instruments and devices.
- B. Furnish temporary circuits, over current devices, conduit and wiring, and other equipment required during change-over from existing to proposed electric system.

1.02 QUALITY ASSURANCE

- A. Install electrical work in conformance with latest rules and requirements of National Fire Protection Association Standard No. 70 (National Electric Code) and with requirements of the U.S. Virgin Islands Electric Power Company.

1.03 SUBMITTALS

- A. Shop Drawings and Data: Include manufacturer's drawings, bills of material, panel and equipment layouts, catalog data, wiring diagrams and other documentary or descriptive information as required for each assembly submitted in one package insofar as possible.
 - 1. Bills of material: Include a numbered list of all components, with manufacturer's name; catalog number, rating, and other identification. Place item number or similar identification on all other drawings where item appears.
 - 2. Where additions and modifications are made to existing equipment, provide drawings which include both retained existing equipment and new work.
 - 3. Mark shop drawings and data submitted showing only items applicable to specific contract.
 - 4. Make early submission of certain drawings where dimensions of equipment, location of conduit, entrances, etc., are important to facilitate construction.
 - 5. Include one-line diagrams, schematic diagrams and wiring diagrams. Submit only completed drawings showing all local and remote devices associated with each item. Submit one complete package of shop drawings as far as possible. Partial submittals may be returned with but action.
 - 6. Submit list of type and make of conduit, fittings, wires, cables, switches, fixtures, receptacles, pushbuttons, sleeves and inserts, etc.

7. Submit for installation, operation and maintenance of equipment, and parts list. Specifically mark standard publications forming a part of this contract. Cross out, blank out, or otherwise delete any non-applicable items.
8. Install nameplates on all devices or pieces of equipment for which use or identification not readily apparent, such as, starters, relays, contactors, pushbuttons, indicating lights, and switches. Ensure position of nameplates readable after equipment installation.
9. Submit samples of wires and cables.
10. As soon as possible after award of contract, submit all information and data on wires, cables, and other non delivery items proposed. Early submission for review and early ordering are required to avoid delays in completion of work.

1.04 INTERFERENCE AND ERRONEOUS LOCATIONS

- A. Locations of electrical equipment, devices, outlets and similar items, as indicated, are approximate only. Exact locations determined or accepted during construction.
- B. Verify, in field, all data and final locations of work, done under other sections of specifications, required for placing of electrical work.
- C. In case of interference with other work or erroneous location with respect to equipment or structures, furnish all labor and materials necessary to complete work.

1.05 APPROVAL AND MARKING EQUIPMENT

- A. Insure, that devices and materials are listed and/or labeled by Underwriters Laboratories, Inc. wherever standards have been established by that agency.

Where Underwriters Laboratories listing is not available for equipment, submit certified test reports of adequately equipped, recognized, independent testing laboratory, approved by the local inspecting authority, indicating that equipment is in conformance with local code requirements or any other applicable requirements. In lieu of independent tests test reports, written approval of equipment by local electrical inspecting authority will be acceptable.

- B. Clearly mark equipment, devices and material with name or trademark of manufacturer and rating in volts and amperes and other pertinent information on a nameplate.

1.06 ELECTRIC SERVICE

- A. Earth and rock excavation, backfill, concrete masonry, concrete reinforcement, and construction joints required for electrical work: Conform to requirements specified under applicable sections of specifications.

1.07 POWER SYSTEM STUDY

- A. Obtain from manufacturer of substation a complete system protection coordination study of electrical distribution system with curves of each protective device indicated on common drawing, to verify proper selectivity and protection for all parts of system obtained. Include all calculations, selected equipment and devices, and recommended settings.

1.08 INCOMING SERVICE

- A. The power company will install connections to transformer primary.
- B. Contractor to furnish and install transformer substation, primary cable and conduit, secondary cable and conduit, stress cones, concrete pads, etc.
- C. Furnish and install all necessary conduit and wire to service pole, extend conduit up pole for distance of 10 feet, and leave sufficient length of conductors to reach power company's overhead conductors. Connections at pole made by the power company. Perform work at service pole in accordance with power company's requirements.
- D. Perform work at transformer substation in accordance with power company's requirements and in manner approved by power company.

PART 2 PRODUCTS

2.01 METERING EQUIPMENT

- A. Obtain from power company drilling templates, dimensions, and mounting arrangements for metering transformers.
- B. Ensure that metering equipment installation is in accordance with requirements of power company by submitting drawings, sketches, catalog information and other appropriate material for power company approval.

2.02 CONDUCTORS

- A. Unless otherwise indicated all conductors shall be copper.
- B. All building conductors shall be THWN/THHN-600V. Insulation
- C. Up to #10-AWG use solid conductors, all larger sizes shall be stranded conductors.
- D. Conductors Sizing

All conductors shall be #12-AWG except when otherwise indicated in the drawings or as indicated below for 20 AMPS switch conductors sizing.

All 20 AMPS, 120 volts circuit runs shall be as follows for the indicated length of circuit run:

<i>Length of Circuit Runs</i>	<i>Conductors Size</i>
Up to 100'	#12 - AWG
From 101' up to 200'	#10 - AWG
From 201' up to 300'	#8 - AWG
From 301' up to 400'	#6 - AWG

All 20 AMPS, 277 volts circuit runs shall be as follows for the indicated length of circuit run:

<i>Length of Circuit Runs</i>	<i>Conductors Size</i>
Up to 200'	#12 - AWG
From 201' up to 350'	#10 - AWG
From 350' up to 500'	#8 - AWG

- E. Provide a ground conductors in all the conduits.
- F. Provide a #12-AWG green jumper between the receptacle grounding screw and the outlet box grounding screw.
- G. Provide a #12-AWG THHN/THWN first wire in all empty conduits.

2.03 CONDUITS

- A. Unless otherwise indicated all conduits shall be 3/4" in diameter minimum.
- B. Unless otherwise indicated in the drawings the following conduit work shall apply:
 - 1. All conduits installed underground shall be PVC SCH. 40.
 - 2. All conduits installed embedded in floor slabs which are in direct contact with the earth, shall be PVC SCH. 40.
 - 3. All conduits installed embedded in walls, ceiling slabs and in floor slabs which are not in direct contact with the earth shall be EMT.
 - 4. All conduits installed in the area between hung ceilings and ceiling slabs or metal decks shall be EMT.
 - 5. All conduits installed exposed in indoor areas shall be EMT.
 - 6. All conduits installed exposed in outdoor areas shall be PVC COATED HEAVY WALL RIGID GALV. STEEL.

7. Final connections to all motors and electrical equipment shall be done with liquidtight flexible steel conduit.
- C. All underground conduit couplings shall be watertight.
- D. Provide an expansion joint coupling of the required type and size whenever a conduit crosses an expansion joint.
- E. Provide plastic conduit dividers in all underground conduits runs. Maximum distance between dividers to be 4'-0".

2.04 WIRING DEVICES

- A. Unless otherwise indicated, all wiring devices shall be white colored with 302 stainless steel cover plates, except the weatherproof of outlets which shall have their standard gray cover plates.
- B. When two or more wiring devices are shown together in adjacent positions and at the same height, they shall be installed in a multiple gang outlet box of the proper size so that only one raised cover plate of the required type and size are used. 120V and 277V outlets must be installed on separate boxes.
- C. All dimmers shall be of the slide type.
- D. All wiring devices to be specification grade.

2.05 PANELBOARDS

- A. All panelboards and load centers shall be provided with a factory installed ground bus for connecting to ground all the ground wires or cables entering or leaving the panelboard. The ground bus shall be similar in size and characteristics to the neutral bus. All panelboard shall have a monoflat front and key lock.
- B. When two or more panelboards or cabinets are shown together in adjacent locations, the top of all panelboards or cabinets shall be aligned with the top of the biggest one so that all the tops are at exactly the same height from the finished floor.
- C. Contractor must make sure that the entire electrical system has ground continuity.

2.06 TELEPHONE CABINETS

- A. Telephone terminals cabinet shall be approved equal to Columbia metal, type "PF" with the door hinges, lock and 3/4" plywood backboard cover at the bottom of the cabinet.

PART 3 EXECUTION

3.01 GENERAL

- A. All the electrical installation shall be done in a neat and workmanlike manner, according to the last edition of the national electrical code, the U.S. Virgin Islands Electric Power Company latest standard and the U.S. Virgin Islands Telecommunications Company latest practices.

- B. The Contractor shall visit the job site and become acquainted with the existing field conditions. It shall be the direct responsibility of the Contractor to bring promptly to the attention of the engineer any discrepancies between the existing field conditions and those that were used for design purposes. This shall be done before the Contractor submits his bid, so that the engineer can render a decision on the matter before the bids are received. The submittal of the bid by the Contractor will be held as proof that the Contractor understand thoroughly and completely the Scope of Work involved, has familiarized himself with the existing field conditions, and has included in his bid all the items necessary to perform the electrical work. No allowance will be permitted on this matter after the bids are received.
- C. Unless otherwise indicated all outlets shall be flush mounted and shall have their own independent outlet boxes. Minimum size of outlet box to be 4" square and 1 1/2" deep. Exact size of outlet box shall be determined according to the maximum number of conductors in the box per N.E.C. Article 70-Section 6.
- D. All indicated heights are from center of box to finished floor.
- E. Contractor shall balance all loads.
- F. Route of conduits shown in the layout is schematic and intended only to indicate interconnections between outlets. Exact conduit routing shall be determined at the job site to conform with the structural conditions and shall be subject to the final approval of the architect/engineer.
- G. In conduit runs, the numbers of arrows designate the number of circuits in the conduit (one pole in the panelboard per each circuit). The number of lines designate the number of conductors in the conduit, the longer line being a neutral conductor and "1" being the ground conductor.
- H. CI in lighting outlet, C1 indicates the circuit number, L1 indicates the luminary L1____ type from the luminary schedule and 1 indicates the switch controlling unit. C3____ in receptacle outlet, C3 indicates the circuit number.
- I. It shall be the responsibility of the Contractor to verify the voltage characteristics as the site with the utility company at the time of installation before ordering any primary equipment.
- J. All the self-standing and surface mounted electrical equipment as well as the luminaries shall all be braced for seismic shock according to the seismic restraint manual guidelines for mechanical systems. The same applies to all the conduit work. The details and installation methods in said manual shall be modified as required to fit the electrical installation of the project.,
- K. For final location of mechanical and medical equipment see corresponding mechanical and architectural drawings. Contractor to relocate electrical rough-in accordingly at no additional cost to Owner.
- L. All pedant mounted luminaries shall be installed using stems, 2 stems per each 4' luminary. Stems shall be painted of the color required by the Architect.

- M. Normal power and emergency power switch must be installed in separate conduit runs.

3.02 REMOVAL AND RELOCATION OF MATERIAL AND EQUIPMENT

- A. Carefully dismantle and salvage electrical equipment, switches, fixtures, conduits, cables, wiring, etc. as necessary to carry out proposed changes. Rehabilitate and relocate items of equipment as required and as indicated or specified.
- B. Deliver material and equipment not indicated for reuse to Owner for his disposal.

3.03 PROTECTION OF ELECTRICAL EQUIPMENT

Protect electrical equipment from the weather, especially from water dripping or splashing upon it, at all times during shipment, storage; and construction. Do not store equipment outdoors. Where equipment is installed or stored in moist areas, such as unheated buildings, etc., provide acceptable means to prevent moisture damage, such as uniformly distributed source of heat to prevent condensation. Protective means, as acceptable by Engineer.

3.04 DEFECTIVE OF DAMAGED EQUIPMENT

Thoroughly dry out equipment or material subjected to possible water damage, and put through special dielectric test as directed, without additional compensation.

END OF SECTION 16050

SECTION 16110

ELECTRICAL RACEWAY SYSTEMS

PART 1 GENERAL

1.01 DESCRIPTION

- A. Furnish and install complete raceway systems, with all accessories, fittings, boxes, etc., as indicated and specified.
- B. All raceway runs are shown diagrammatically to outline general routing of raceway. Avoid interfering with pipes, ducts, structural members, or other equipment. Deviations in accordance with Engineer, after acceptance, and without additional compensation.

1.02 REFERENCE STANDARDS

- A. NEC: National Electrical Code: National Fire Protection Association, 470 Atlantic Avenue, Boston, MA.
- B. UL: Underwriters' Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL 60062, USA.
- C. ANSI: American National Standards Institute, Inc., 1430 Broadway, NY , N.Y. 10018 USA.
- D. NEMA: National Electrical Manufacturers Association, 2102 L Street, Northwest, Washington, D.C.

1.03 SUBMITTALS

- A. Submit shop drawings and manufacturer's product data in accordance with requirements of General Specifications.

PART 2 PRODUCTS

2.01 MANUFACTURER'S COMPLIANCE

- A. Manufacturers acceptance contingent upon products' compliance with specifications.
- B. Rigid Metal Conduit:
 - 1. Triangle Conduit & Cable Company, 6900 Jersey Avenue, New Brunswick, NJ 08903, USA.
 - 2. Republic Steel Corporation. 144: 1-T Republic Building, Cleveland, OH 44101, USA.
 - 3. Robroy Industries, River Road, Verona, PA 15147, USA.

C. Polyvinylchloride (PVC) Conduit:

1. Triangle Conduit & Cable Company, New Brunswick, NJ, USA.
2. Republic Steel Corporation, Cleveland, OH, U.S.A.
3. Carlon Inc., Cleveland, OH USA.

D. Flexible Conduit:

1. American Flexible Conduit Company, P.O. Box A -2094, New Bedford, MA 02741, USA.
2. Anaconda Metal Hose, Brass Division, 700 South Main Street, Waterbury, CT 06723, USA.
3. International Metal Hose Company, Goodrich Road & Sullivan Avenue, Bellevue, OH 44811, USA.

2.01 MATERIALS AND COMPONENTS

A. Rigid Metal Conduit:

1. Furnish galvanized rigid metal conduit with a coupling on one end and thread protector on other.
2. Hot-dip galvanize rigid steel conduit over entire length, including threads. Conduit conforming to ANSI Standard C80.1-1966.

B. Flexible-Metal Conduit:

1. Match flexible-metal conduit, fittings, size, and material to rigid conduit to which it is connected, unless otherwise indicated.
2. Liquid-tight flexible-metal conduit consists of flexible, corrosion-resistant metal conduit, with watertight synthetic jacket extruded over the conduit and a continuous copper ground under the jacket. Where ground is not included as in sizes greater than 1-1/4". IPS furnish separate external ground wire. Liquid-tight flexible-metal conduit conforming to UL Standard 360.

C. Polyvinylchloride (PVC) Conduit:

1. Furnish PVC conduit, EPC-40-PVC, for direct burial or exposed in extra severe conditions conforming to industry NEMA Standard TC 2-1975 and UL listed for indicated application.
2. Furnish PVC conduit, EPC-40-PVC, for normal exposed conditions in ductwork, or for use in all corrosive atmospheres specifically chlorine, conforming to industry NEMA Standard TC 2-1975 and UL listed for the indicated application.

D. Polyvinylchloride-Coated Rigid Steel Conduit:

1. Polyvinylchloride-coated (PVC-coated), rigid steel conduit shall be hot-dipped galvanized rigid steel conduit, as specified hereinbefore, with a polyvinylchloride jacket not less than 40 mils thick, bonded to the conduit. The adhesive strength of the bonding shall be equal to or greater than the tensile strength of the coating. Couplings and fittings for this conduit shall include an integral, bonded overlapping pressure-sealing sleeve of the same insulation thickness. The sleeves shall extend one pipe-diameter or 2" (whichever is less) beyond the end of the coupling. When coupled together, the sleeve of the coupling shall make a watertight fit with the plastic jacket on the conduit.

E. Boxes:

1. Furnish standard, sheet-metal, outlet and junction boxes constructed of code-gauge" galvanized sheet steel. Size each box as required by the NEC.
2. Furnish boxes containing fixture studs for hanging fixtures. Furnish concrete-tight boxes for installation in concrete. Do not use shallow boxes unless building construction is such that it is impossible to use standard-depth boxes.
3. Outlet boxes and fittings for hazardous locations conforming to ANSI -Standard C33.27 for class, group, and division indicated.
4. All cast-iron boxes shall be manufactured by O.Z. Electrical MFG. Co., Brooklyn, NY; Appleton Electric Co., Chicago, IL; Crouse-Hinds Co., Syracuse, NY; or be an acceptable equivalent product.
5. All cast-aluminum boxes shall be manufactured by Crouse-Hinds Co., Syracuse, NY; Killark Electric Manufacturing Co., St. Louis, MO; Adalet MFG. Co., Cleveland, OH; or be an acceptable equivalent product.
6. Boxes and covers for use with polyvinylchloride coated steel conduit shall be galvanized cast boxes as above, with a polyvinylchloride factory-applied coating over the galvanizing. The coating shall have a 40-mil thickness and the boxes shall have hubs with extruded sleeves extending beyond the hub in the same manner as specified for conduit couplings. Cover screws shall be stainless steel.
7. Cast boxes shall be provided with cast covers and watertight gaskets. Cover screws shall be stainless steel or high brass for iron boxes, and stainless steel for aluminum boxes.
8. Polyvinylchloride boxes shall be used with polyvinylchloride conduit. The size of each box shall not be less than that which is required by the National Electrical Code. Boxes shall be manufactured by Carlon, Cleveland, OH; Crouse-Hinds Co., Syracuse, NY; Raco, Inc., South Bend, IN; or be an acceptable equivalent product.

9. Pull boxes used below motor control centers shall be constructed of angle or channel frames, and sheet metal with weld joints. All welds shall be ground smooth. Neoprene gaskets shall be provided for complete sealing. Covers longer than 40" shall be sectionalized to facilitate handling. Sectionalized covers shall be gasketed where covers meet, using angle iron or channel cross members at the joint. Sheet metal shall be not less than No.12 gage galvanized sheet steel. Interior angles and supports shall be made of galvanized steel, or shall have a corrosion-resistant phosphate coating and primer. Each box shall be provided with a grounding lug for connection to the nearest ground bus. The ground lug shall have the current capacity required by the National Electrical Code for the largest feeder entering the equipment.

F. Fittings:

1. Furnish cast-iron fittings of malleable iron or a mixture of gray iron and cast steel. Conduit fittings shall conform to ANSI Standard C80.4.
2. Supply fittings for electrical metallic tubing with UL Label. Do not use "sock" or "drive-on" fittings. Use fittings of set screw, compression, or permanent indentation types, which are galvanized and made of steel or malleable iron. Where indicated, use fittings which are watertight, with a sealing compression ring.
3. Furnish suitable expansion fittings where conduits cross expansion joints. Equip these fittings with grounding straps, clamps, and copper bonding jumpers.
4. Terminate ends of all floor conduits installed for future use with couplings and readily removable plugs set flush with finished floor surface. Cap spare wall conduits at wall where they enter building.
5. Equip ends of all conduits with suitable conduit fittings. Fit conduit terminating at motor control center or power distribution equipment, or in box above or below, with grounding type bushings, or solidly ground by locknuts or other acceptable fittings. Connect each grounding bushing to ground bus by a bare or green-covered copper wire. Do not use ground wire or smaller than 12 awg. Install sizes larger than 12 gauge as required by NEC. Where conduits terminate in unprotected areas or where bonding is required over expansion joint, flexible conduit or equivalent; ground wire smaller than No. 6 Awg. copper.
6. Terminate conduits entering gasketed sheet-metal boxes or gasketed sheet-metal equipment enclosures with gasketed hubs.
7. Terminate conduits entering non-gasketed sheet-metal boxes or enclosures with double locknuts and insulated bushings, or with acceptable equivalent.

PART 3 EXECUTION

3.01 INSTALLATION OF FITTINGS

- A. Install expansion fittings wherever conduits cross structural expansion joints. Keep the fittings in line with conduit, and install with regard to temperature so that full working range of expansion is available.
- B. Do not install fittings to replace elbows and pull boxes, unless space or other problems make use of fittings necessary. Use oversize fittings whenever large cable is installed, in order to maintain proper bending radius.

3.02 INSTALLATION OF RACEWAYS

- A. Install exposed raceways parallel or at right angles to walls and ceiling beams. Make all changes in directions as far as possible, with approved bends, elbows, and pull boxes. Space parallel runs uniformly throughout. Secure in place by approved hangers and approved fasteners. Effectively ground by connection to properly grounded enclosures, bonding, or other approved means, to obtain permanent low resistance path to ground throughout installation. Ensure that raceway sections in single run and in parallel runs are of same type and finish.
- B. Support raceways concealed above suspended ceilings from slab above ceiling in same manner as exposed raceways. Do not support raceways from ceiling supports.
- C. Use cast-in-place inserts in concrete to support all runs, unless otherwise permitted. Use stainless steel sleeve type concrete anchors for installing boxes, conduit supports, etc. Furnish stainless steel nut, bolts, washers, etc. used with concrete anchors.
- D. Use bolts or machine screws on steel work. Support conduits by hangers or pipe straps spaced according to NEC, but in no case more than 10 feet on centers.
- E. Use galvanized supports for galvanized conduit.
- F. Install conduits in slabs as close to middle of concrete slabs as practicable without disturbing reinforcement. Do not use conduit with outside diameter exceeding one-third of slab thickness. Do not place conduits closer than three diameters on centers, except at cabinet locations where slab thickness is increased as permitted by Engineer.
- G. Where conduits are concealed in bottom floor slab, place in concrete slab and not in fill below slab. Do not install aluminum conduit in concrete slab.
- H. Use sleeves passing through exterior walls and slabs which are wall entrance seals of watertight construction. Furnish watertight seal between slab and sleeve, and between sleeve and conduit and cable. Use wall-entrance seals of malleable iron with watertight sealing gland which may be tightened any time after installation.

- I. Do not use dissimilar metals in conjunction with each other. Use suitable insulation between adjoining surfaces so as to eliminate direct contact and any resultant electrolysis. Maintain electrical continuity of system. Use bituminous impregnated felt, heavy bituminous coatings, nonmetallic separators or washers, or other acceptable materials as insulation.
- J. Install fittings to match raceway being used.

3.03 BENDS

- A. Make all bends carefully to prevent distortion of circular cross section. Field bend conduit to have an inside radius of not less than nine diameters.
- B. Where bends of less than nine diameters are necessary, use standard factory elbows. Size conduit to permit cable-bending radius within the factory elbow of at least eight times cable diameter.
- C. Use concentric bends in parallel runs. Allow no conduit to have more than two 90 degree bends or equivalent thereof between pulling points.

3.04 CUTTING, THREADING AND CONNECTING

- A. Make all field cuts in raceways squarely, file cut ends, and remove burrs, and chamfer inside edge with conduit reamer. Install insulating bushing on each end of conduit or tubing, unless connector is designed to prevent contact with cut end. Make all connections mechanically strong and tight, and with acceptable connectors. Permit no running threads. Where surface coating is damaged or removed by cutting, threading or reaming restore to original condition.

3.05 CONDUIT CLEANING

- A. Clean all conduit carefully before and after installation, ream ends free of burrs, and free inside surfaces from all imperfections likely to injure cable.
- B. After installation of each complete new conduit run, snake the run with band to which is attached an acceptable tube cleaner with acceptable cylindrical mandrel of a diameter not less than, 85 percent of nominal diameter of conduit. Remove and replace all conduit through which mandrel will not pass.
- C. Use a steel band and mandrel to clean steel conduit.
- D. After cleaning, protect ends of all conduit with standard caps to prevent entrance of water, concrete, debris, or other foreign substance.

3.06 CONDUIT DRAINAGE

- A. As far as practicable, pitch conduit to drain to outlet boxes, or install so as to avoid trapping moisture. Where dips are unavoidable in exposed conduits, install fitting with

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suitable drain hole at low point.

3.07 INSTALLATION OF BOXES

- A. Install sheet metal boxes only in dry, accessible location. Do not install below grade, in outside concrete or masonry walls or in floor slabs subject to moisture. Sheet metal boxes cannot be used where vapor-tight fixtures are required for surface mounting of wall switches and receptacles or for any outdoor use.
- B. Install boxes in conformity with all requirements of NEC. Install boxes designed for type of construction involved. Support boxes in same manner as required for conduit. Size boxes to provide bending radius for wire or cable of at least eight times diameter or in accordance with NEC, whichever is larger.
- C. Center all outlets in panels, or spaces and adjust to structural finish. Where specific locations are not indicated, locate outlets with respect to equipment served.
- D. Place all outlet boxes, junction boxes, pull boxes, etc., in accessible locations when they are installed above or behind plastered ceilings, furred spaces, or suspended ceilings. Install access panels of suitable size. Mark all access panels for all boxes so panels can be readily located in future. Mark, using metal tabs or plastic buttons which cannot mark ceilings or walls, appropriate for type of construction being used.
- E. Assemble cast-metal boxes with threaded conduit hubs in such manner that conduit connections and gasketed covers are watertight. Close all unused threaded openings with pipe plugs and compound.
- F. Provide cast boxes with cast covers and watertight gaskets. Install cover screws of stainless steel or high brass for iron boxes, and stainless steel for aluminum boxes.

3.08 MOTOR AND EQUIPMENT CONNECTIONS

- A. At all motors and other electrically operated equipment to which conduit connections are required install complete connection between end of conduit and terminal box of motor or other equipment.
- B. Terminate conduits extending up through floors in locations permitting direct connection to motors.
- C. Make connections with flexible metal conduit.
- D. Install flexible metal conduit, fittings, and accessories in accordance with requirements of NEC. Use flexible metal conduit only for connections to motors, or to other equipment subject to vibration or adjustment. Make each connection with at least one quarter bend so that no vibration can be transmitted beyond flexible connection. Install visible bonding wire across flexible connection larger than 1-1/4-in. IPS size bonding wire in accordance with NEC; but in no case smaller than 6 awg. stranded.
- E. Install liquid-tight flexible metal conduit, mechanically strong and watertight, and located to reduce possibility of damage to exterior coating. Use connectors that screw into flexible

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conduit and provide gaskets where needed.

3.09 HAZARDOUS AREAS

- A. Install all conduits, fittings, equipment and devices within areas indicated to comply with requirements of NEC for Hazardous Locations, Class, Division, and Group as indicated.
- B. In such hazardous locations, seal conduits terminating at boxes enclosing circuit-opening equipment at entrance to enclosure with approved, compound-filled, commercial, sealing fittings to prevent passage of explosive or combustible gases through conduits.
- C. Seal all conduits leading from or entering such hazardous locations at points of exit or entrance.
- D. Install conduit connections with at least five threads tightly engaged, and made up with suitable thread compound.

END OF SECTION 16110

SECTION 16120
ELECTRIC CONDUCTORS

PART 1 GENERAL

1.01 DESCRIPTION

- A. Furnish and install all (conductors wires and cables) necessary for complete electrical systems, as indicated and specified.

1.02 REFERENCE STANDARDS

- A. NEC: National Electrical Code: National Fire Protection Association, 470 Atlantic Avenue, Boston, MA.
- B. U.U. Underwriters Laboratories, Inc., 333 Pfingston Road, Northbrook, IL
1. U.L. 44 - Wires and Cables Rubber Insulated
 2. U.L. 83 - Wires Thermoplastic Insulated
 3. U.L. 854 - Cables, Service Entrance
- C. NEMA: National Electrical Mfg's Association, 2101 L Street, N.W. Washington, DC 20037
1. WC 3 - Rubber Insulated Wire & Cable
 2. WC 5 - Thermoplastic Insulated Wire & Cable
 3. WC 7 - Cross Linked Thermosetting Polyethylene - Insulated Wire & Cable
 4. WC 8 - Ethylene-Propylene Rubber Insulated Wire & Cable
 5. WC 30 - Color Coding of Wires & Cable

1.03 SUBMITTALS

- A. Shop drawings and manufacturer's product data in accordance with requirements of Section 01000.
- B. Two samples of each type of wire. Samples of necessary length with manufacturer's name and number or type, voltage rating, conductor size, and insulation type on each conductor sample. Color code all control, indicating and metering wiring, and lighting branch-circuit wiring.

1.04 MANUFACTURER'S COMPLIANCE

- A. Contingent upon products' compliance with specifications.
- B. 15 KV CABLE
 - 1. General Electric Company, 1260 Boston Avenue, Bridgeport, CT - Type
 - 2. Rome Cable Division of Alcoa, 1501 Alcoa Building, Pittsburgh, PA - Type XLP
 - 3. Triangle Conduit and Cable Company, Inc., PO Box 711, New Brunswick, NJ - Everene Cable
 - 4. The Anaconda Company, Wire and Cable Division, Greenwich, CT
- C. 600V, 480V, 380V, 220V, 208V, 200V, 120V, 115V cable:
 - 1. General Electric Company
 - 2. Rome Cable Division
 - 3. The Rockbestos Company, 550 Nicoll Street, New Haven, CT
- D. Control and metering wire:
 - 1. The Rockbestos Wire and Cable Company, single and multiconductor, 600V control cable.
 - 2. General Electric Company - Vulkene control cable, Type SI.
 - 3. Rome Cable Company - control cable, 600V, Type B, Size 12, 7 strand.
- E. Cable fireproofing tape:
 - 1. MAC Products, Inc., 60 Pennsylvania Avenue, Kearny, NJ
 - 2. Acceptable Equivalent.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Furnish copper conductors. Material and stranding of conductors: Conform to ASTM B 33-80 ASTM B3-80, and to ASTM B 8-77, for the appropriate class. No. 12 Awg minimum wire size unless otherwise noted.
- B. Tinned wire used with natural rubber insulation: Conforms to ASTM B 33. Uncoated, soft or annealed copper wire conforming to ASTM B3-80.

- C. 15 KV/5 KV Cables: Single-conductor, shielded, grounded cross-linked polyethylene insulated, 90 degrees C., copper conductors. The outer jacket: polyvinylchloride.
- D. Wires and cables for maximum 600 volt power circuits: Type XHHW rated RHW with cross-linked polyethylene insulation, Type RHW-75C with rubber or rubberlike insulation and neoprene jacket or ethylene propylene rubber EPR.
- E. Wires and Cables for lighting and other 120/240 volt and 120/208 volt circuits: Type THW-75C.
- F. Wires and Cables for control, indicating, metering, or alarm circuits: single and multi-conductor control cable, copper conductors, Class B or C stranding. Insulation, 600 volt polyethylene, polyvinylchloride, or E.P.R.
- G. Shielded cable for instrumentation wiring: 19 strand copper conductors, size no. 16 AWG. Insulate conductors individually with color coded polyethylene or polyvinylchloride. Twist pairs twisted with varying lay (if more than one pair) and cover with cable tape and copper or aluminum coated mylar shielding tape and tinned copper drain wire. Jacket: polyvinylchloride. Cables: rated 600 volts and 90 degrees C.

PART 3 EXECUTION

3.01 GENERAL INSTALLATION

- A. Install wiring in accordance with applicable provisions of National Electrical Code, and as indicated.
- B. Wire and cable sizes are indicated however, in no case use smaller cable sizes than required by the National Electrical Code.
- C. Unless otherwise indicated, use no conductor smaller than No. 12 AWG.
- D. Conductors for branch lighting circuits: Install conductors of sizes that greatest voltage drop between lighting panel and center of load will not exceed 3 percent at rated load.
- E. Number and sizes of wires and conduits indicated are guide only and are not necessarily correct numbers and sizes necessary for actual equipment installed. Install as many wires and conduits as required and necessary for complete electrical system, and provide adequately for the equipment actually installed.
- F. Install conductors continuous from outlet to outlet and make no splices except within outlet or junction boxes.
- G. Draw all conductors contained within single conduit at same time.
- H. Apply wire pulling compound if required to conductors being drawn through conduits. Use pulling compound, Minerallac No. 100, Y-er-Eas, Yellow 77 or acceptable equivalent.
- I. Use no cable bend with radius of less than eight times its diameter.
- J. Wires and cables installed without prior submittal review and approval are subject to

removal at no additional expense to owner.

- K. Support cables in rise conducts at intervals as required by National Electrical Code.

3.02 15 KV AND 5 KV CABLE SPLICING AND TERMINATIONS

- A. Use primary 15KV/5KV cable terminations with rating of 15,000 volts/5,000 volt. Ensure that standard withstand conforms to IEEE Std. 48 and is in compliance with specification Section 16999, Field Acceptance Tests. Use potheads, elbow connectors, clamp type connectors or termination as recommended by equipment manufacturer.
- B. Ensure that all splicing and terminating of 15 KV and 5 KV cable is in accordance with designs, materials, and instructions set forth by cable manufacturer.
- C. Wrap cables in manholes with fireproof tape which meets ASTM D626. Install tape in accordance with manufacturer's instructions.

3.03 CONDUCTOR IDENTIFICATION

- A. Label each wire at both termination points. Carry individual conductor or circuit identification throughout, with circuit numbers or other identification clearly stamped on terminal boards and printed on directory cards in distribution cabinets and panelboards.
- B. Identify each wire in junction boxes, cabinets, and terminal boxes where total number of control, indicating, and metering wires is three or more and no terminal boards is provided, including all power wire by means of plastic-coated, self-adhesive, wire marker.
- C. In cases similar to above where terminal boards are provided for the control, indicating, and metering wires, identify all wires including motor leads and other power wires too large for connection to terminal boards, by wire markers as specified above.
- D. In manholes, identify each wire by laminated plastic tag located so easily seen.

3.04 CONNECTORS, TERMINAL LUGS AND BOARDS

- A. For wiring of circuits consisting of No. 10 or No. 12 AWG solid wires, such as for lighting branch circuits, utilize self-insulated pressure type connectors for all splices or joints.
- B. Terminate all wires connected to terminal boards, terminal blocks, or to other similar terminals by means of ring and tongue, nylon self-insulated, tin-plated copper pressure terminals.
- C. Fabricated terminal boards, installed where indicated, of type 600 volts, 30 amperes, screw terminals, with white marking strips for wire identification, of the 4-, 6-, 8-12 pole type, as necessary.
- D. Clearly and permanently mark terminal strips with ink or indelible pencil. Mark each wire consistently throughout entire system, using notation of wires given on manufacturer's wiring diagrams wherever possible.

END OF SECTION 16120

SECTION 16140

WIRING DEVICES

PART 1 GENERAL

1.01 DESCRIPTION

- A. Furnish, install, field test, and place in successful operating condition, wiring devices as indicated and as specified.

1.02 REFERENCE STANDARDS

- A. NEMA: National Electrical Manufacturers Association, 2102 L Street Northwest, Washington, D.C.
- B. Federal Specifications, Superintendent of Documents, U.S. Government Printing Office Washington, D.C. 20402.
 - 1. W-S-896c(1) Switch, Toggle, Single Unit with wall plates.
 - 2. W-C-596,b(1) Plug, Electrical Connector, Receptacle, Electrical.
- C. Underwriters' Laboratories, Incorporated Standards.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Arrow-Hart, Inc., Florence, KY.
- B. Allen-Bradley Co., Milwaukee; WI.
- C. Appleton Electric Co., Chicago, IL.
- D. Bryant Electric, Div. of Westinghouse, Bridgeport, CT.
- E. Cutler Hammer, Inc., Milwaukee, WI.
- F. Crouse-Hinds Co., Syracuse, NY.
- G. Harvey Hubbell, Inc., Bridgeport, CT.
- H. Midland-Ross Corp., - Electrical Products Div., Pittsburgh, PA.
- I. Sierra Electric, Div. of Sola Basic, inc. Gardena, CA.

2.02 WALL SWITCHES

- A. Provide alternating current, general-use, snap switches, in flush device boxes or on outlet box covers, totally enclosed in composition case, with insulated mounting yoke and sidewired, binding screw type terminals. Single-pole, 2-pole, 3-way, or 4-way switches rated 20 amperes at 120/277 volts a.c.
- B. Switches for controlling lighting:
 - 1. Arrow-Hart Cat. No. 1991, 1992 or 1994
 - 2. Harvey Hubbell Cat. No. 1221, 1222, 1223 or 1224
 - 3. Bryant Electric Cat. No. 4901, 4902, 4903 or 4904
 - 4. Sierra Electric Cat. No. 5721X, 5722X, 5723X or 5724X
- C. Provide pilot lights for switches controlling lights in seldom frequented locations Consisting of either separate units or a 2-unit combination with separate switch and yoke-mounted candelabra base socket rated 75 watts, 125 volts, and fitted with a ruby lens. Provide a clear 6 or 7-watt lamp with each pilot.

2.03 WATERTIGHT SWITCHES

- A. Provide watertight switches consisting of flush mounting switches in NEMA Type 4 gasketed cast metal boxes. Switch operable through shaft in matching cast metal cover, twenty-ampere, 120/277-volt switch enclosures:
 - 1. Crouse-Hinds Type MC or MCC
 - 2. Allen-Bradley Cat. No. 600-TCX-4
 - 3. Cutler-Hammer Cat. No. 91-1 H 96

2.04 EXPLOSIONPROOF SWITCHES

- A. Provide explosion proof switches consisting of flush mounting switches in cast metal boxes meeting requirements for NEMA Type 7D enclosure approved for use in National Electric Code Class I, Group D, Div. I, atmosphere. Switch operable through shaft in matching cast metal cover. 20-ampere, 120/277-volt switch assemblies:
 - 1. Crouse-Hinds Type EFS
 - 2. Midland-Ross Type EFS
 - 3. Appleton Electric Type EFS

2.05 FLUSH RECEPTACLES

- A. Provide twenty-ampere, 125-volt flush receptacles constructed in flush device boxes, and of grounding type in composition case with insulated mounting yoke, side-wired, binding screw-type terminals.
- B. Duplex receptacles:
 - 1. Arrow-Hart Cat. No. 5739-S
 - 2. Harvey Hubbell Cat. No. 5362
 - 3. Bryant Electric Cat. No. 5362
 - 4. Sierra Electric Cat. No. 14602
- C. Single receptacles:
 - 1. Arrow-Hart Cat. No. 5361
 - 2. Harvey Hubbe 1 Cat. No. 5361
 - 3. Bryant Electric Cat. No. 5361
 - 4. Sierra Electric Cat. No. 12605

2.06 CLOCK RECEPTACLES

- A. Provide 3-wire, 15-ampere, 125-volt hanger receptacle with flush stainless steel plate for each clock:
 - 1. Arrow-Hart Cat. No. 5708
 - 2. Harvey Hubbell Cat. No. 5235
 - 3. Bryant Electric Cat. No. 2828GS
 - 4. Sierra Electric Cat. No. 2123

2.07 SPECIAL RECEPTACLES

- A. Provide weatherproof devices rated 20 ampere, 125-volt, consisting of single receptacles with spring-loaded, soft-gasketed hinged covers with stainless steel spring. Covers as follows:
 - 1. Arrow-Hart Cat. No. 4500FS
 - 2. Harvey Hubbell Cat. No. 5206
 - 3. Bryant Electric Cat. No. 4510

- B. Provide watertight, gasketed cast-metal enclosures with covers in areas subject to hose-down, meeting requirements, and either standard single or duplex type:
 - 1. Appleton Electric Cat. No. AEE3382 and AEP3361, Style 2.
 - 2. Crouse-Hinds Cat. No. ARRH3322 and APJ3385, Style 2.
 - 3. Midland-Ross Cat. No. 3313 and 3317, Type SCA.
- C. Provide receptacles with matching plug or cord cap designed to meet NEMA 4 requirements when plug, cord and receptacle are assembled.
- D. Provide explosionproof 20-ampere receptacles, of the delayed action type, preventing contact from being broken until arc has been extinguished. Receptacles with angle covers and pring-closed flaps:
 - 1. Crouse-Hinds Type CPS
 - 2. Appleton Electric Type CPS
 - 3. Midland-Ross Type EFS
- E. Furnish one explosion proof plug for each three receptacles, with minimum of one, plugs to match receptacles and from same manufacturer:
- F. Provide welding receptacles whereby plug ground contact makes contact with receptacle ground contact before current carrying contacts engage, and when withdrawing plug, ground contact remains engaged until after current carrying ground contacts disengage.

2.08 OUTLET BOXES AND ENCLOSURES

- A. Provide outlet boxes and enclosures conforming to Section 16110, Electrical Raceway Systems unless otherwise indicated.

2.09 DEVICE PLATES

- A. Provide device plates suitable for type of outlet boxes and enclosures used. Plates for flush-mounting by device manufacturer. Plates for surface-mounting boxes by either device manufacturer or box manufacturer.
- B. Provide flush device plates of high corrosion resistant, Type 302 stainless steel. Provide plates of 93,000 series thickness, not less than 0.030 in.
- C. Provide flush device plates with security (vandal proof) throughout.
- D. Provide five (5) security screws screwdrivers at end of job to Owner.

2.10 NAMEPLATES

- A. Provide nameplates or equivalent markings on switch enclosures to indicate ON and OFF positions of each switch. Do not use ON and OFF for 3-way or 4-way switches. Receptacles for special purpose shall have nameplates indicating their use, unless use is obvious. Nameplates shall otherwise conform to requirements specified under Section 16050.

PART 3 EXECUTION

3.01 CONNECTION

- A. Securely and rigidly attach wiring devices in accordance with regulating agency, and as indicated, avoiding interference with other equipment.
- B. Securely fasten nameplates using screws, bolts, or rivets and centered under or on the device, unless otherwise indicated.

3.02 GROUNDING

- A. Ground all devices.
- B. Ground switches and their metal plates through switch mounting yoke, outlet box, and raceway system.
- C. Ground flush receptacles and their metal plates through positive ground connection to outlet box and grounding system. Maintain ground to each receptacle by spring loaded grounding contact to mounting screw, or by grounding jumper, both making positive connection to outlet box and grounding system at all times.
- D. Ground explosionproof receptacles and plugs by making contact between the metal shells, and also by using a grounding pin to make contact before power contacts are made.

END OF SECTION 16140

SECTION 16160

PANELBOARDS

PART 1 GENERAL

1.01 DESCRIPTION

- A. Furnish and install panelboards including circuit breakers and cabinets complete, in conformance with the latest NEMA Standards and Federal Specifications listed below.

1.02 REFERENCE STANDARDS

- A. NEMA: National Electrical Manufacturers Association, 2101 L Street Northwest, Washington, .D.C.
 - 1. PB1-1971
 - 2. AB1-1975
- B. NEC: National Electrical Code, National Fire Protection Association, 470 Atlantic Avenue, Boston, MA.
- C. UL: Underwriter's Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL.
 - 1. UL 67- 74 (Revise 1976) - Panelboards.

PART 2 PRODUCTS

2.01 PANELBOARD MANUFACTURERS

- A. Manufacturers acceptable contingent upon products' compliance with the specifications:
 - 1. General Electric Company, 1 River, Road Schenectady, NY.
 - 2. Westinghouse Electric Corp., Distribution Equipment Division, 1945 Craig Road, St. Louis, MO.
 - 3. Square D Company, Park Ridge, IL.

2.02 PANELBOARDS

- A. Factory assembled deadfront type panelboards.
- B. Furnish panelboards complete with branch circuit breakers and a main circuit breaker of main lugs only as indicated.
- C. Furnish panelboards with full capacity separate ground bus and furnish panelboards connected to a 3-phase, 4-wire service with an insulated neutral bus.

- D. Provide panelboards with the voltage, frequency and current ratings as indicated conforming to NEMA Standard PB1, Federal Specification W-P-115A. U.L. 67, and the N.E.C.
- E. Furnish panelboards with main and neutral buses, with minimum 98 percent conductivity rectangular copper bars provided with bolted type lugs as necessary.
- F. Drill buses to fit either "A", "B" or "C" Phase connectors, and ensure that connectors are interchangeable and installed in a distributed phase sequence.
- G. Silver plate buses, connectors and terminals to a minimum thickness of 0.005-in., conforming to the requirements of Federal Spec. QQ-S-365B.
- H. Prevent Terminal Lugs from turning per NEMA standard PBI- 1971 and ensure they are suitable for the conductor material and size.
- I. Main bus-bracing for each panel board shall be for 10,000 amperes symmetrical short circuit or as otherwise indicated.

2.03 CIRCUIT BREAKERS

- A. Furnish bolt-on type branch and main circuit breakers. Furnish frame sizes, trip settings and number of poles as indicated. Circuit breakers shall have their ampere trip rating clearly marked and visible.
- B. Furnish all breakers with quick-make, quick-break, toggle mechanisms and thermal-magnetic, inverse time-limit overload and instantaneous short circuit protection on all poles, unless otherwise indicated. Automatic tripping shall be indicated by the breaker handle assuming a clearly distinctive position from the manual ON and OFF position. Furnish breaker handle that is trip-free on overloads.
- C. Do not use single pole breakers with handle ties or bails in lieu of multipole breakers.
- D. Furnish handle lock device on breakers as indicated to prevent the manual opening of the selected breakers.
- E. Furnish padlocking device on breakers as indicated to prevent the opening of indicated breakers.
- F. Ensure that voltage and interrupting rating of all breakers in a panelboard is not less than voltage and short circuit rating of the panelboard main buses, as indicated. Furnish breakers suitable to operate satisfactorily at the frequency indicated.
- G. Furnish ground fault interrupter circuit breakers for certain circuits as indicated on the drawings.
- H. Furnish single pole breakers with full module size. Do not install two pole breakers in a single module.
- I. Furnish Time-current characteristics curves and other necessary information and data for each size of breaker furnished.

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- J. Ensure that branch and main circuit breakers rated 120 and 240 volts have an interrupting rating of not less than 10,000 rms amperes, symmetrical, at rated voltage.

2.04 CABINETS

- A. Cabinets shall be NEMA 1 type, unless otherwise indicate and shall be without knockouts. Drill cabinets only for the exact conduit entrances and mounting bolts.
- B. Finish cabinet fronts, trims and surface-mounted boxes in ANSI NO. 61, light-gray enamel over a rust-inhibitive primer. Attach the fronts (exterior trims) to the boxes or interior trims, by quarter-turn, indicating trim clamps: Design cabinets for surface or flush mounting as indicated.
- C. Unless otherwise specified, construct panelboard cabinets of code-gauge galvanized, sheet steel and equip with gutters of ample size for the risers and outgoing circuits. Ensure that the cabinets do not exceed 78-in. (1980 mm) in height.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Mount all panelboards such that the height of the top operating handle does to exceed 6 ft. 6-in. (1980 mm) from the floor.
- B. Hang each door of the cabinet on semi- or fully-concealed hinges with a combination catch and lock.
- C. On cabinets 48 in. (1200 mm) high and over, install a 3 approximate middle.
- D. All Panelboard locks shall be keyed alike.

END OF SECTION 16160

SECTION 16402

UNDERGROUND DISTRIBUTION SYSTEM

PART 1 GENERAL

1.01 DESCRIPTION

- A. Furnish and install complete underground distribution system as indicated and specified.
- B. Adhere to lines, grades, elevations, and dimensions. Resolve interferences with other underground conduit, piping or equipment, either new or existing with the Engineer. Match components suitable for proper installation.
- C. Install concrete encasement of duct system where indicated. Include all necessary forms and reinforcing installation.
- D. Furnish and install manholes and handholes complete with ground rods, windows, ladders, frames, covers, end bells, and other inserts. Use reinforced concrete:

1.02 REFERENCE STANDARDS

- A. NEMA: National Electrical Manufacturers Association, 2101 L Street, Northwest, Washington, D.C.
- B. ANSI C2: National Electrical Safety Code Published by Institute of Electrical and Electronics Engineers, Inc., 345 East 47th Street, New York, NY 10017.
- C. NFPA-70: National Electric Code, Published by National Fire Protection Association, Battery March Park Quincy, MA 02269.

1.03 SUBMITTALS

- A. Submit shop drawings and manufacturers' product data in accordance with requirements of Section 01000.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Polyvinylchloride (PVC) Conduit
 - 1. Triangle Conduit & Cable Co., Inc. New Brunswick, NJ.
 - 2. Republic Steel Corp., Cleveland, OH.
 - 3. Carlon, Inc., Cleveland, OH.
- B. Rigid Steel Conduit, Galvanized
 - 1. Section 16110

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- C. Fiber, Conduit, Type I
 - 1. Ashland Chemical Co., Columbus, OH.
 - 2. Bermico Co., W. Bend, WI.
- D. Manhole Waterproofing Material,
 - 1. Heavy Duty Black, No. 46-449, by Tnemec Company, Inc., No. Kansas City, MO.
 - 2. Hi-Build Bituminous Coating, No. 35-J-10, by Mobil Chemical Company, Edison, NJ.
 - 3. Bitumastic Super Service Black, by Koppers Company, Inc., Pittsburgh, PA.
 - 4. Acceptable equivalent.
- E. Conduit Spacers: Furnish conduit spacers made of plastic to maintain spacing of 3-in. (76 mm) between conduits and 6-in. (150 mm) between power and communication conduits as indicated.
- F. Concrete: Minimum compressive strength, 3,000 psi (210 kg per square centimeter).
- G. Hot-dipped galvanized steel conduit painted with bituminous paint.

PART 3 EXECUTION

3.01 INSTALLATION OF CONDUITS

- A. Lay conduits, indicated to be direct buried in the ground, in trench on 4-in. (100 mm) bed of sand and cover with, an equivalent 4-in. (100 mm) bed of sand. Ensure that no rocks come in contact with conduit during backfilling. Dig trenches to depth and location indicated. Do not allow top of ductbank to be less than 2-ft. (0.61 m) below finished grade.
- B. Install conduit, indicated to be encased in concrete with concrete, spacers, reinforcing, etc., as specified and as indicated.
- C. Install conduit runs following routing on drawing and running in straight lines as far as possible. Where deviation from a straight line becomes necessary, install bends of sufficient radius for proper rodding and installation of cable.
- D. Accomplish changes in direction of runs exceeding total of 10 degrees, either vertical or horizontal, by long sweep bends having minimum radius of curvature of 25 ft. (7.62 m), except that manufactured bends used at ends of short runs of 100-ft. (30.48 m) or less, and then only at or close to end of run. Long sweep bends made up of one or more curved or straight sections and/or combinations thereof. Install manufactured bends with minimum radius of 36-in. (915 mm) where larger radius cannot be used.
- E. Lay duct lines to minimum slope of 4 inches (100 mm) per 100-ft. (30.48 m) and slope to manholes and handholes as indicated. Duct lines are to slope away from buildings where possible.

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- F. Prior to placing of concrete remove all dirt, sand, and any other debris from between conduits and from trench bottoms. Hold conduits in place to prevent floating or accidental movement.
- G. Stagger joints in conduits at least 6-in. (150 mm). Do not allow couplings to rest on bottom of trench. Install couplings for plastic conduit in accordance with manufacturer's recommendations.
- H. Install concrete encasements so minimum clearance of 12-in. (300 mm) from concrete to parallel pipes, lines, structures, etc., is maintained. Where ducts cross, minimum clearance of 6 inches (150 mm) will be acceptable. Do not allow the top of concrete to be less than 36-in. (915 mm) below finished grade or paving. Submit special conditions which may require lesser clearances to Engineer for approval.
- I. Where a connection is made to existing ductline, firmly bond or dowel concrete encasement to existing encasement.
- J. Do not use power-driven vibrators for spading of concrete around ducts.
- K. Roll and grade backfill, and restore surface to condition at least equal to which it was found immediately before work was begun, or as otherwise indicated.
- L. Locate duct-bank markers at ends of all duct banks except at manholes or handholes, at approximately every 2,000 ft. (61.0 m) along duct run, and at each change in direction of duct run. Place markers approximately on duct bank. Install markers 6-in. (150 mm) square or round section by 3 ft. (0.91 m) long made of Class B concrete. Imprint the letter "D" or cast it on top of the marker. Install top of duct markers flush in paved areas, protruding no more 2-in. (50 mm) above finished grade in paved areas. In finished lawns, allow marker to protrude 1/2-in. (12.7 mm).
- M. Keep conduits clean of concrete, dirt, and other substances during the course of construction. After the duct lines have been completed, pull a standard flexible mandrel not less than 12-in. (300 mm) long, having a diameter approximately 1/4-in. (6 mm) less than the inside diameter of the conduit, through each conduit, after which pull a brush with stiff bristles through each conduit to make certain that no particles of earth, sand, or gravel have been left in the line. Replace conduit runs that do not allow the passage of the mandrel at no additional cost to the Owner. Pneumatic rodding may be used to draw in the lead wire. Plug and seal spare conduits after cleaning.
- N. Where electrical ducts cross under roads, encase them in reinforced concrete.

3.02 MANHOLES AND HANDHOLES

- A. Construct manholes and handholes of Class A concrete cast in place or of precast-concrete sections, as indicated.
- B. Install manholes with cable racks, hooks, insulators, and other features, as indicated.
- C. Place a 6-in. (150 mm) crushed-stone base under each manhole and handhole.
- D. Construct cast-in-place manholes and handholes with forms, complete with centering

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cores and molds, to conform to shape, form, line, and grade required and maintain sufficiently rigid to prevent deformation under load. Make all joints leakproof and arrange horizontally or vertically. Place forms on successive units for continuous surfaces and fit to accurate alignment, assuring a smooth completed surface, free from irregularities.

- E. At convenient point close to wall, drive 3/4-in. by 10 ft. -0 long copper-clad steel ground rod into earth as indicated. Extend ground rod approximately 5-in (150 mm) above finished manhole floor. After completion of manhole, connect 6 foot (1.83 m) length of No. 4 bare copper ground wire to ground rod and coil it within manhole or handhole.
- F. Size space, and place reinforcing bars as indicated and as specified.
- G. Set manhole and handhole frames to the required grade, in full bed of concrete mortar to make watertight connection.
- H. Unless otherwise indicated, install tops of manhole and handhole covers in unpaved areas approximately 1/2-in. (13 mm) above finished grade, and in paved areas install flush with finished surface of paving.
- I. Install galvanized corrosion-resistant channel support, with continuous slot and required fittings designed for concrete encasement.
- J. Install inserts in the manholes as indicated.
- K. Install two cable pulling irons in wall opposite each duct bank entrance into manhole, one 6-in. (150 mm) above floor and one 6-in. (150 mm) below the roof of manhole. Where indicated on drawings, install additional features such as openings in manhole walls for future conduit entrances. Seal future entrance with required courses of brick.
- L. Where duct lines enter manholes, terminate conduits in end bells. Terminate steel conduit entering manholes and handholes in grounding bushing.

3.03 MANHOLE AND HANDHOLE WATERPROOFING

- A. Apply two coats of bituminous waterproofing material to exterior surfaces of manholes and handholes. Apply by brush or spray, in accordance with manufacturer's instructions. Allow time between coats to permit sufficient drying.
- B. As-Built Drawings of Underground Work: Furnish one set of marked copies of contract drawings, showing exact routing and depths of all underground conduit, duct handholes and manholes. Furnish scaled plot plans, showing principal outline of buildings and structures. Reference conduits, ducts, and manholes, and all bends deviating from straight line, dimensionally from fixed objects, or structures.

END OF SECTION 16402

SECTION 16450

GROUNDING

PART 1 GENERAL

1.01 DESCRIPTION

- A. Furnish and install a single, complete, integrated grounding system, including all conductors, raceways, and connections, specified and indicated.
- B. Include grounding of switchgear, substations, motor control centers, electric equipment enclosures, etc., outdoor substations, transformers, switch structures, etc.; ground grid systems with ground rod and water pipe connections; structural steel, and lightning protection system.
- C. Include grounding conductors completely interconnecting water supply pipe, ground rods, ground grid, substation, switchgear and motor control center ground buses, other distribution equipment, and other groundable equipment.

1.02 REQUIREMENTS OF REGULATORY AGENCIES

- A. Install complete grounding system in accordance with codes, and standards.

1.03 REFERENCE STANDARDS

- A. American National Standards Institute:
 - 1. ANSI C2.-1978 National Electrical Safety Code
- B. National Fire Protection Association, 470 Atlantic Avenue, Boston, MA:
 - 1. NFPA 70-1981 National Electric Code
 - 2. NFPA 78-1975 Lightning Protection Code

1.04 TESTS

- A. Measure ground grid resistance with earth test megohmmeter and install additional ground rods and conductors as required until resistance to interconnected ground system is 5 ohms or less. Measure ground resistance in normally dry conditions and not less than 48 hours after rainfall.

PART 2 PRODUCTS

2.01 MANUFACTURERS ACCEPTABLE

- A. Contingent upon products' compliance with the specifications.
- B. Ground rods - Copperweld Corporation, 2 Oliver Plaza, Pittsburgh, PA.

2.02 CONDUCTORS

- A. Furnish soft drawn stranded copper grounding conductors. Minimum size of unenclosed grounding conductor shall be No. 6 Awg. All conductors shall be protected if physical damage would result from exposure.
- B. Furnish bare conductors where buried in earth or where embedded in concrete.
- C. In buildings run insulated grounding conductors with green insulation only.
- D. Furnish insulated grounding conductors with insulation rated at 600 volts.
- E. Furnish grounding conductors for installation in all non-metallic raceway in addition to, and not to be considered as, the neutral wire of the system.
- F. Connect a grounding conductor between panelboard and grounding system. Where a grounding bar is furnished with panelboard, connect grounding conductor to bar.

2.03 GROUND BUS

- A. Furnish a 2-in. by 1/4-in. copper bar complete with bolted type connectors as indicated. Connect grounding conductors from equipment in area to this ground bus. Connect ground bus to grounding system. Mount ground bus on 600-V. pedestal insulators:

2.04 CONNECTIONS

- A. Make all buried and concealed ground connections by exothermic welding.
- B. Make accessible connections to structural members by exothermic welding process or by bolted connector. Connections to equipment or ground bus by acceptable bolted connectors. Furnish bolted ground connectors suitable for, and matching, grounding provisions furnished.
- C. Furnish copper, brass, or silicon bronze ground lumps for use on copper or brass pipes.
- D. Furnish ground clamps, for use on iron pipes, of galvanized or malleable iron, or of standard noncorrosive material.
- E. Furnish ground clamps for use on pipes, with rigid metal base providing good contact by proper seating on the pipe. Do not use strap type clamps.
- F. Design cable to ground rod connectors capable of being installed without having to pass over end of ground rod.
- G. Where conduits are not effectively grounded by firm contact with a grounded enclosure,

apply grounding bushings on at least one end of conduit run.

- H. Furnish copper-clad steel or galvanized steel ground rods; type, diameter and length as indicated on drawings.

PART 3 EXECUTION

3.01 INSTALLATION OF GROUNDING CONDUCTORS

- A. Install grounding conductors so not exposed to physical damage. Install connections firm and tight. Arrange conductors and connectors so no strain on connections.
- B. Run grounding conductors associated with direct burial cables in common trenches above or if indicated beside cables.
- C. Bury equipment grounding conductors 18-in. deep. Bring loops or taps up for connection to equipment or other items to be grounded.
- D. Where raceways are used to contain and protect grounding conductors, install in accordance with Electrical Raceway Systems Section.
- E. Where bare grounding conductors are contained within metallic raceways, bond ends of raceways to conductors by suitable fittings.
- F. Install loop type, low impedance, grounding system interconnecting all components so at least two grounding connections are provided for each major item of electrical equipment. Ensure that severing of any single grounding conductor in this system does not remove grounding protection on any major item.
- D. Install a separate grounding conductor from ground system to motors of 100 hp. and larger, in addition to raceway system. Ground motor ground connection to motor frame, independent of mounting bolts or sliding base. Ground motor to nearest point on grounding system unless otherwise indicated.
- E. Connect lightning arresters to ground system by suitable conductors.
- F. Connect emergency generator neutral to grounding system by a grounding conductor of size required by National Electrical Code, unless a larger size is indicated. Connect grounding conductor to generator disconnect enclosure and generator neutral on generator side of disconnect. Ground generator frame with two separate independent connections, so removal of one connection will not impair continuity of other.
- G. Ground each street lighting standard by ground rod driven near base of standard, in accordance with requirements of National Electric Safety Code. Connect ground rods to grounding conductor brought with street lighting feeder cable.
- H. Ground transformers, lightning arresters, insulators etc., installed on poles, poles and timber structures on metal structure. Run grounding conductors between poles or structure and ground rods. Protect grounding conductor by molding applied for at least 8 ft. above ground, with both molding and conductor stapled. Install ground rod where indicated, and driven until top of rod is 1 ft. below ground. Measure ground resistance of rod and if not 25 ohms or less, drive additional rods to obtain resistance of 25 ohms or less.

- I. Ground wire fences when used to enclose electrical equipment. Unless otherwise indicated, provide minimal grounding by buried outside peripheral ground loop; connections to each corner fence post and nearby ground rod; flexible connections to each gate; and at least two connections to grounding system from approximately opposite positions on fence.
- J. Also connect the ground rods to the grounding conductor run with the direct burial cable.
- K. Connect structural steel at locations indicated by an external perimeter loop of grounding conductor installed around all sides of building foundation, buried at least 18-in. (450 mm) below grade, and connect to each vertical column by loop or tap. Connect two opposite points on external loop to two different points on grounding system.
- H. Perform exothermic welding with properly sized molds in good condition.

3.02 INSTALLATION OF GROUND RODS

- A. Install ground rods in manholes in accordance with requirements specified under the Section Underground Distribution Systems. Connect each grounding conductor entering a manhole to ground rod.
- B. Install ground rods where indicated. Install the top of the rod 12-in. below the ground surface. Measure ground resistance of electric power service ground rod and if it is not 25 ohms or less, drive additional rods to obtain resistance of 25 ohms or less.
- C. Make connection to overall grounding system as indicated.
- D. Ensure that final resistance of interconnected ground system is 5 ohms, or less. Measure ground resistance in normally dry conditions, and not less than 48 hours after rainfall.

3.03 EQUIPMENT GROUNDING

- A. Ground each piece of electrical equipment by means of a grounding conductor installed in raceway feeding that piece of equipment with copper wire sized in accordance with National Electric Code. Grounding conductors installed in conduit furnished with green, 600-volt insulation.
- B. Connect transformer cases and neutrals to grounding system. Connect neutral ground connection at transformer terminal. Provide two separate, independent, diagonally opposite, connections for power transformers so removal of one connection will not impair continuity of other.
- C. Connect two separate ground connections from ground grid to ground bus of switchgear assemblies, motor control centers and all outdoor substation equipment. Ensure that each connection for item of equipment is from different section of ground grid.

3.04 COMMERCIAL GROUNDING

A. Telephone:

1. Install one No. 2 insulated ground conductor to ground bus in telephone equipment cabinet.
2. Connect one No.12 insulated ground conductor to all 68 conduits terminating at backboard.

END OF SECTION 16450

SECTION 16500

LIGHTING

PART 1 GENERAL

1.01 DESCRIPTION

- A. Furnish and install complete indoor lighting systems.

1.02 REFERENCE STANDARDS

- A. Underwriters' Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL.
- B. National Fire Protection Association, Battery March Park, Quincy, MA, 02269 NFPA 70 1981, National Electrical Code.
- C. Federal Specifications and Standards Superintendent of Documents U.S. Government Printing Office, Washington, D.C., 20402.
 - 1. W-L-101(5) Lamp, Incandescent, (Electric, large, Tungsten Filament)
 - 2. W-L-001166 Lamps, Fluorescent
 - 3. W-L-142a Lampholder, adaptor, and shadeholder, medium screw-shell, 125, 250, and 600 volts.
- D. American National Standards Institute:
 - 1. Fluorescent Lamp Ballasts, ANSI C82, 1-1972 and Supplement C82.la.
 - 2. High Intensity Discharge Lamp Reference Ballasts, ANSI C82.5-1975.
 - 3. Mercury Lamp Ballasts, (Multiple Supply Type), ANSI C82.4-1974.
 - 4. Electric Lamp Bases and Holders, Fluorescent Types, ANSI C81.20-1976.
 - 5. Electric Lamp Bases and Holders, Screw-Shell Types, ANSI C81.10-1976.

1.03 SUBMITTALS

- A. Submit manufactures installation instructions in accordance with General Specifications.
- B. Submit manufacturer's shop drawings including photometric data to show that fixtures proposed are of same type, construction and quality as those indicated. Lighting fixtures listed and labeled by Underwriters, Laboratories.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Lighting equipment as indicated or specified.

2.02 LAMPS

- A. Furnish lamps of types and wattages shown in fixture schedule.
- B. Unless otherwise indicated, furnish fluorescent lamps suitable for 12-volt operation. Type: Rapid start, standard cool white, 48-in. long, 34 watt.

2.03 BALLASTS

- A. Furnish high power factor type ballasts for fluorescent lamps. Ballasts are required to operate one, two, or four lamps as required by fixture schedule.
- B. Ballast sound rating: "A"
- C. Furnish ballasts class "p" type or equivalent protection, containing a nonrenewable, nonresetting thermal protector; designed for applicable indoor or outdoor use; conforming to UL standard 935.
- D. Furnish ballasts with certified ballasts manufacturer (CBM) label.
- E. Furnish ballasts with power factor not. less than 95 percent.
- F. Furnish constant wattage (regulator) type ballasts for mercury vapor and metal halide lamps.
- G. Ballasts: In non-air conditioned spaces, rate for operation in 40-deg. C temperature environment.
- H. Furnish mercury vapor and other H.I.D. ballasts suitable for 120-volt, 277-volt or 480-volt operation as indicated.

2.04 FIXTURES

- A. Furnish fixtures complete with lamps of wattage indicated.
- B. Furnish each fluorescent fixture with ballasts of proper type and characteristics for lamps in fixture and with voltage rating as required by circuit in which fixture is connected.

2.05 EMERGENCY LIGHTING AND EXIT LIGHTING FIXTURES

Furnish types of fixtures shown in fixture schedule.

PART 3 EXECUTION

3.01 LIGHTING FIXTURES AND LAMPS

- A. Install types and sizes indicated, complete. Deliver lamps of proper type, wattage and voltage rating to site and install in fixture prior to completion of project.
- B. Install all fixtures to comply with applicable provisions of National Electrical Code. Suspend pendant fixtures by means of suitable outlet box coverted aligners, each having flexible joint permitting unit to hang plumb. Install stems of 1/2-in. galvanized steel conduits, unless otherwise specified.
- C. Use aligners of shock absorbing type, where, indicated.
- D. Use vaportight aligners with vaportight fixtures.
- E. Install each explosion-proof pendant fixture having stem longer than 12-in. (305 mm), with explosion-proof swivel or flexible fitting permitting fixture to hang plumb. Fixtures with stems shorter than 12-in. (305 mm) aligned by level outlet box mounting, explosion-proof swivels, or other-acceptable means:
- F. Install recessed fluorescent fixtures in suspended ceiling openings in conformance with manufacturer's recommendations. Install fixtures with adjustable fittings to permit alignment with ceiling panels. install fixtures in fire-resistive type of suspended ceiling construction, equipped with fireproofing boxes constructed of materials of same fire rating as ceiling panels. Materials in conformance with UL approved building materials list.
- G. Install accessories such as straps, mounting plates, nipples or brackets necessary for proper installation.
- H. Connect emergency light fixtures to separate unswitched circuit in lighting panelboard in a lighting circuit breaker locked in closed position.

END OF SECTION 16500

SECTION 16999

FIELD ACCEPTANCE TESTS

PART 1 GENERAL

1.01 DESCRIPTION

- A. After electrical installation is complete, make tests to demonstrate that entire system is in proper working order and in accordance with drawings and specifications. Make no tests less than those outlined hereafter, unless requested in writing and approved by Program Manager. Tests are in addition to, and no substitution for, tests of individual items at manufacturer's plant. Make insulation and ground resistance tests before operating tests. Determine proper rotation of motors before permanent connections are made.
- B. Pay all costs for tests including expenses incident to retests occasioned by defects and failures of equipment to meet specifications.
 - 1. Replace wiring and equipment found defective, or failing to meet specified requirements, without charge.
 - 2. Furnish three copies of all test results to Engineer.
 - 3. Unless otherwise specified Owner will supply electric current necessary for tests.

1.02 REFERENCE STANDARDS

- A. NEMA: National Electrical Manufacturers Association, 2101L Street, Northwest, Washington, D.C.
- B. IEEE: Institute of Electrical and Electronic Engineers, 345 East 47th Street, New York, NY.

PART 2 PRODUCTS

2.01 TESTING EQUIPMENT

- A. Calibration:
 - 1. Furnish suitable electrical instruments including voltmeters, ammeters, wattmeters, tachometers and all other equipment necessary to perform tests specified. Furnish certified copies of calibration curves of these instruments which have been calibrated for specific tests.
 - 2. Make necessary openings in circuits for testing instruments and place and connect all instruments, equipment, and devices, necessary for the tests. Upon completion of tests, remove instruments and instrument connections and restore

all circuits to permanent condition.

3. Other sections of specifications require services of one or more manufacturer's representatives, to ensure that equipment supplied has been installed properly and adjusted to proper working order. Advise representative of all applicable tests in this section, so that work will be coordinated, and tests combined where feasible.

2.02 TESTING

A. Coordination:

1. Coordinate activities, and cooperate with others on project to ensure that systems are energized when required, loads applied, and other requirements of Section are carried out on timely coordinated basis.
2. Conduct tests in presence of Engineer. Notify Engineer seven calendar days or more in advance when any test to be performed, and do not start tests without Engineer's permission.

B. Preparation:

1. Make up no high and/or medium-voltage connections at service entrance, transformers, substations, motors, medium voltage motor control centers, switchgear and generator permanently until correct phase rotation of all equipment is determined.

Install and insulate these connections temporarily, if necessary, while determining proper rotation. Have permanent connections after proper rotation has been established and subsequent to completion of insulation resistance and dielectric tests.

PART 3 INSULATION

3.01 INSULATION RESISTANCE TESTS OF CIRCUITS, 600 VOLTS AND BELOW

- A. Do not subject conductors rated 600 volts and below to high potential dielectric tests. Test each complete feeder and branch circuit of 6000 volts or below with everything but power supply and power-consuming equipment, connected thereto, and have an insulation resistance, between conductors and between each conductor and ground of not less than 1,000,000 ohms, unless otherwise accepted by Engineer.
- B. Determine insulation resistance values with all switchboards, panelboards, fuseholders, switches, receptacles, and overcurrent devices in place.
- C. Use megohmmeter having output of at least 500 volts to determine insulation resistance value for 600 volt rated conductors, and a 2400 volt megohmmeter for 5 KV and 15 KV rated conductors.
- D. List each circuit and measured resistance as test data.

- E. Maintain record of all insulation resistance valued. Identify conductor, or equipment, date that value was taken and resistance value. Arrange information in suitable neat tabular form and turn to Engineer in triplicate

3.02 DIELECTRIC TESTS OF CONDUCTORS RATED 2400 VOLTS AND ABOVE

- A. After all high and/or medium-voltage conductors are installed, and before connecting and putting into service, subject to dielectric tests. Perform direct current, high-potential tests form phase to phase and from phase to ground. Make tests as specified in latest edition of the applicable IPCEA-NEMA Standard.
- B. Complete and enclose splices in conductor system being tested within all pull, junction or splice boxes before test is started, and complete all potheads and switchgear terminations. Disconnect potential transformers and all power consuming equipment or devices from circuit, if any are present.

3.03 GROUND RESISTANCE

- A. Test each ground rod in accordance with IEEE Std. 142, and submit tabulation of results. Include identification of electrode, date of reading and ground resistance value in results.
- B. Test each entire grounding system for continuity of connections and for resistance. Ensure that ground resistance of conduits, equipment cases, and supporting frames does not vary appreciably from that of system as whole and does not exceed 5 Ohms.

END OF SECTION 16999