

SPECIFICATIONS - DETAILED PROVISIONS
Section 16050 - Basic Electrical Materials and Methods

C O N T E N T S

PART 1 - GENERAL	1
1.01 SCOPE	1
1.02 RELATED SECTIONS	1
1.03 STANDARDS AND CODES	1
1.04 SUBMITTALS	3
1.05 COORDINATION OF WORK AND TRADES	4
1.06 DELIVERY, STORAGE, AND HANDLING	5
PART 2 - PRODUCTS	5
2.01 GENERAL	5
2.02 CONDUCTORS AND CABLES	6
2.03 CONDUCTOR AND CABLE CONNECTORS	9
2.04 CONDUCTOR AND CABLE MARKERS	10
2.05 METAL CONDUITS	11
2.06 NONMETALLIC CONDUITS	14
2.07 LIQUID-TIGHT FLEXIBLE METAL CONDUITS	14
2.08 CONDUIT FITTINGS	14
2.09 CONDUIT OUTLET BODIES AND OUTLET BOXES	16
2.10 EXPLOSION-PROOF CONDUIT COMPONENTS	17
2.11 DEVICE BOXES AND COVER PLATES	20
2.12 JUNCTION BOXES	22
2.13 METAL WIREWAYS	23
2.14 NON-METALLIC WIREWAY	24
2.15 METAL CABLE TRAY	25
2.16 NON-METALLIC CABLE TRAY	27
2.17 RECEPTACLES AND SWITCHES	28
2.18 PILOT DEVICES AND LOCAL CONTROL STATIONS	29
2.19 PANELBOARDS	30
2.20 OVERCURRENT PROTECTION	30
2.21 DISCONNECT SWITCHES	31
2.22 SUPPORTS	32
2.23 GROUNDING	34
2.24 MANHOLES AND PULL BOXES	35
2.25 NAMEPLATES	36
2.26 MISCELLANEOUS MATERIALS AND COMPONENTS	36

PART 3 - EXECUTION	37
3.01 GENERAL.....	37
3.02 CONDUCTORS AND CABLES	39
3.03 CONDUIT MATERIAL SCHEDULE	44
3.04 CONDUIT	44
3.05 CONDUIT FITTINGS, BOXES, AND WIRING DEVICES	51
3.06 MANHOLES AND PULL BOXES	53
3.07 CABLE TRAY INSTALLATION AND TESTING	54
3.08 PANELBOARDS	54
3.09 TRANSFORMERS	55
3.10 DISCONNECT SWITCHES	55
3.11 SUPPORTS	55
3.12 NAMEPLATES	56
3.13 CUTTING AND REPAIRING	57
3.14 DISSIMILAR METALS	57
3.15 WORKMANSHIP	57
3.16 PROTECTION DURING CONSTRUCTION.....	57
3.17 CHECKING, ADJUSTING AND TESTING	58
3.18 CLEANUP	59

SECTION 16050
BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.01 SCOPE

- A. This section specifies the requirements for the fabrication, assembly, delivery, testing, and installation of electrical equipment and material necessary for the electrical work of this Contract.
- B. Contractor shall furnish all labor, supervision, materials, equipment, tests and services to install electrical equipment and material, as specified herein and shown on the Drawings.

1.02 RELATED SECTIONS

- A. The Contract Documents are a single integrated document, and as such all Specification Sections apply. It is the responsibility of the Contractor and its subcontractors to review all sections and ensure a complete and coordinated project.
- B. Related Specification Sections include, but are not limited to, the following:
 - 1. Sections of the Specifications specifying equipment and/or systems requiring electrical work, including basic electrical materials and equipment.
 - 2. Division 16 – Electrical
 - 3. Division 17 – Instrumentation and Controls

1.03 STANDARDS AND CODES

- A. All materials and equipment, including installation of same, shall meet or exceed the applicable requirements of the following standards and codes (latest edition):
 - 1. ANSI American National Standards Institute
 - 2. ASTM American Society for Testing and Materials
 - 3. Fed Spec Federal Specification
 - 4. ICEA Insulated Cable Engineers Association
 - 5. IEEE Institute of Electrical and Electronic Engineers

Basic Electrical Materials and Methods
Section 16050 – 2

6. IESNA Illuminating Engineering Society of North America
 7. NEIS National Electrical Installation Standards
 8. NEMA National Electrical Manufacturers Association
 9. NEC National Electrical Code (NFPA 70)
 10. NETA National Electric Testing Association (NETA)
 11. NFPA 70E Standard for Electrical Safety in the Workplace
 12. NIST National Institute of Standards and Technology
 13. OSHA Occupational Safety and Health Administration (Federal and State)
 14. UL Underwriters Laboratories
- B. Underwriters' Laboratories Approval: All material and equipment furnished by the Contractor shall be listed by and shall bear the label of Underwriters Laboratories (UL) or Edison Testing Labs (ETL).
- C. All electrical materials and equipment, and the design, construction, and installation thereof, shall comply with all applicable provisions of the Federal Occupational Safety and Health Administration (OSHA), and California Occupational Safety and Health Administration (Cal OSHA).
- D. Where the Drawings or these Specifications call for material, equipment and workmanship to be of better quality or higher standard than required by the above standards and codes, and applicable rules and regulations, then said Drawings and Specifications shall prevail. Nothing on the Drawings or in these Specifications shall be construed to permit work in violation of the above standards and codes.
- E. In the event of a conflict or disagreement between the Drawings and Specifications; and standards; codes; federal, state, and local laws and ordinances; utility company regulations; or industry standards; the most stringent requirements shall govern. The Contractor shall promptly notify the District in writing of such differences.

1.04 SUBMITTALS

All submittals shall be in accordance with the General Conditions and requirements specified herein.

Submit for the District's approval material lists, shop drawings, factory test reports and technical data to the extent required in this Section, Section 16010, and the General Conditions.

A. Shop Drawings

Contractor shall submit complete information, drawings, and technical data for all material and equipment, including, but not limited to, the following:

1. Manufacturer's product literature and specifications for all material and equipment required for the project. Product literature and specifications shall be marked to clearly identify all applicable information and crossing out all inapplicable information. Applicable sizes, model numbers, and options shall be clearly marked. Sufficient data and detail shall be provided to demonstrate compliance with these Specifications.
2. Interconnection wiring diagrams (loop diagrams) showing all interconnections between equipment, control panels, RTU, electrical switchgear, MCCs, field instrumentation, etc. Diagrams shall be provided with wire numbers and terminal block numbers.
3. Electrical control drawings, including complete control ladder diagrams and complete interconnect diagrams with appropriate wire and terminal numbering. Control ladder diagrams shall be provided with numbers for each line, including references to the line number where contacts for each relay are shown. Ladder diagrams shall show wire numbers, terminal blocks, and terminal block numbers.
4. Schematic wiring diagrams for all local control stations. Schematic wiring diagrams shall clearly identify internal and external devices, and all remote contacts and signals.
5. Nameplate schedule for all local control stations, including nameplate material, lettering height, and proposed inscriptions.
6. Conduit tag schedule for all conduit tags, listing the proposed engraving for each conduit tag.
7. Conductor identification marker schedule for all field conductors, listing the proposed identification for each conductor at each terminal point.

8. Pull box and manhole schedule, listing all proposed pull boxes and manholes. Schedule shall include structure size and depth, type of cover, cover load rating, and special features (if any).
9. Duct bank drawings and cross sections of all electrical duct banks (two (2) conduits or more). Cross sections shall be provided at each pull box and manhole (entrance and exit). Each conduit in the duct bank cross section shall be labeled. Elevations to the nearest 0.1' shall be provided at the top and bottom of each duct bank cross section.
10. Drawings for all grounding work not specifically shown on the Contract Drawings.

B. Operation and Maintenance Manuals

Contractor shall submit detailed Operation and Maintenance Manuals for each item of equipment in accordance with the General Conditions.

C. Record Drawings

Contractor shall maintain and keep current a complete record set of construction drawings showing every change from the Contract Drawings and Specifications and the exact locations, sizes, and types of equipment and material installed. Record drawings shall show all conduit runs (sizes and number), circuits, and conductors (sizes and numbers). Record drawings shall show depths and routing of all concealed and belowgrade electrical installations. Record drawings shall be available to the District during construction and shall be delivered to the District upon project completion.

1.05 COORDINATION OF WORK AND TRADES

- A. Electrical work shall be performed in cooperation with all other trades so that a neat and orderly arrangement of the work as a whole shall be obtained.
- B. Prior to commencing work, the Contractor shall verify with the equipment manufacturers that equipment dimensions and arrangements will allow for equipment installation in the spaces shown on the Drawings for all motor control centers, variable frequency drives, switchboards, panelboards, control panels, transformers, and other major items of electrical equipment, and that the installation indicated will provide for all required ventilation, clearances, access, and work space.

- C. Before installing any equipment, materials, or raceways, the Contractor shall carefully examine the complete set of Drawings and Specifications, and approved equipment shop drawings and confirm connection methods, and all dimensions and space requirements. Contractor shall confirm size and type of equipment conduit connectors with proposed conduit material and sizes. In addition, Contractor shall confirm stub-up areas beneath equipment panels and areas marked for direct conduit connection, with the proposed number and size of conduit.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Delivery

Deliver electrical materials and equipment in manufacturer's original cartons and containers with seals intact. Deliver conductors on sealed reels. Deliver large multi-component equipment in sections to facilitate field handling and installation.

B. Storage

Unless designed for outdoor exposure, store electrical equipment and material on the ground and under cover. Equipment and material shall be protected from weather, corrosion, contamination, and deterioration. Dents, marred finishes, and other damage shall be repaired to its original condition or replaced as directed by the District.

C. Handling

All equipment and material shall be handled in accordance with the manufacturer's recommendations. Large or heavy items shall be lifted at the points designed by the manufacturer. Equipment and material shall be handled and installed as necessary to prevent damage.

PART 2 - PRODUCTS

2.01 GENERAL

Except as may be specifically indicated otherwise, materials and products furnished under this section shall be new and in accordance with the standards as herein before specified. Products used for the same purpose shall be of the same manufacturer and make. Outdoor equipment, fixtures and wiring devices shall be of approved weatherproof construction or shall be in weatherproof enclosures.

A. Standard Products

Materials and products submitted for approval shall be the cataloged products of companies regularly engaged in the manufacture of such items, shall be the latest standard design that conforms to the specification requirements and shall essentially duplicate materials and products that have been in satisfactory use for at least 2 years.

B. Approved Manufacturers

Wherever on the Drawings or in the Specifications, materials or equipment are identified by the names of one or more manufacturers, it is intended that only these manufacturers will be acceptable. Equal materials or equipment of other manufacturers may be submitted for consideration by the District at least 30 days prior to bid.

2.02 CONDUCTORS AND CABLES

A. General

Conductors and cables shall be new, single conductor, copper, not smaller than #14 AWG (except shielded control wire) unless indicated otherwise on the Drawings. Aluminum conductors and cables are not acceptable.

Conductor insulation shall bear manufacturer's trademark, insulation designation, voltage rating, and conductor size at regular intervals. Each type of conductor or cable shall be the product of a single manufacturer.

B. Conductors Smaller than 250 MCM

1. Above Grade

Conductors smaller than 250 MCM for power service, power feeders, power circuits, lighting feeders, lighting circuits, and control circuits shall be stranded copper, rated 600 volt, with 75°C THWN insulation, UL approved, for installation underground, in concrete, in masonry, or in wet locations.

2. Below Grade

Conductors smaller than 250 MCM for power service, power feeders, power circuits, lighting feeders, lighting circuits, and control circuits shall be stranded copper, rated 600 volt, with 90°C XHHW-2 insulation, UL approved, for installation underground, in concrete, in masonry, or in wet locations.

C. Conductors 250 MCM and Larger

1. Above Grade:

Conductors 250 MCM and larger shall be stranded copper, rated 600 volt, with 75°C THHN or THWN insulation, UL approved, for installation underground, in concrete, in masonry, or in wet locations.

2. Below Grade:

Conductors 250 MCM and larger shall be stranded copper, rated 600 volt, with 90°C XHHW-2 with XLP insulation, UL approved, for installation underground, in concrete, in masonry, or in wet locations.

D. High Temperature Conductors

High temperature conductors shall be provided where indicated on the Drawings. High temperature conductors shall be stranded copper, rated 600 volt, with 90°C THHN insulation, UL approved. High temperature conductors shall only be utilized to compensate for ambient temperature correction factors and adjustment factors per NEC Article 310 with conductors sized based on 75°C ampacity per NEC Tables 310.15(B)(16) and 310.15(B)(17), unless all electrical system connectors, terminals, and lugs for high temperature conductors are rated 90°C.

E. Ground Conductors and Neutral Conductors

Ground conductors shall be provided for required ground wiring.

Equipment ground conductors shall be stranded copper, rated 600 volt, with 75°C THWN insulation, UL approved, for installation underground, in concrete, in masonry, or in wet locations. Equipment ground conductors shall be identified by a continuous green insulation color.

Structure and building ground system conductors shall be stranded bare copper. Minimum conductor size shall be #1/0 AWG.

Neutral conductors shall be stranded copper, rated 600 volt, with 75°C THWN insulation, UL approved, for installation underground, in concrete, in masonry, or in wet locations. Neutral conductors shall be identified by a continuous white insulation color.

F. Instrumentation Signal Cables

Instrumentation signal cables shall be single twisted pair or multi-twisted pairs of stranded, 600 volt, copper cables with 15 mil polyvinyl chloride insulation over each conductor, overall aluminum-mylar tape shield, overall tinned copper drain wire and 45 mil minimum polyvinyl chloride jacket overall. Twisted pair cables that are required to be shielded, shall have aluminum-mylar tape shields and tinned copper drain wires over individual twisted pairs of cable. Single twisted pair cables shall be #16 AWG minimum. Unless indicated otherwise on the Drawings, instrumentation signal cable shall be used for all 4-20 mA signals. Cables shall be manufactured by Belden, Okonite, or equal.

G. Fine Stranded Conductors

Fine stranded conductors, Class C and higher (such as DLO cable), shall only be installed where specifically indicated on the Drawings. All terminations of fine stranded conductors shall be provided with copper flex-cable compression adapters to properly confine the fine strands and prevent overheating of the connection and wire pullout from mechanical lugs. The flex-cable compression adapters shall fit mechanical set-screw mechanical lug type connectors and shall be sized for the full current carrying capacity of the cable. The adapters shall be provided a flared barrel-opening to allow easy cable insertion. The adapter shall be constructed of wrought copper with pin of Class B stranded copper conductor, rated for 600V and 105°C cable, and shall be UL listed. Pin length shall be sufficient to allow full engagement into the mechanical lug. Flex-cable copper compression adapters shall be Shoo-pin PT-FX Series, as manufactured by Greaves Corporation, or equal.

Welding cable shall not be used unless factory installed.

H. Color Coding

System conductors shall be factory color coded by integral insulation pigmentation with a separate color as specified herein. Conductors #6 AWG and larger may be color coded with an approved colored marking tape at all terminations and in all junction boxes, pull boxes, and manholes. Each voltage system shall have a color coded system that shall be maintained throughout the project. Approved conductor colors are as follows:

<u>Power System</u>	<u>Service</u>	<u>Color</u>
480V, 3 Phase, 4 Wire	Phase A	Brown
	Phase B	Orange
	Phase C	Yellow
	Neutral	White
<u>Power System</u>	<u>Service</u>	<u>Color</u>

120/208/240V, 3 Phase, 4 Wire	Phase A	Black
	Phase B	Red
	Phase C	Blue
	Neutral	White
All Equipment All System	Ground	Green
	Ground	Bare Copper

<u>Control System</u>	<u>Service</u>	<u>Color</u>
PLC (Status and Control)	Digital Input	Blue
	Digital Output	Brown
120V	Positive	Red
	Negative	White
24V	Positive	Yellow
	Negative	Blue
12V	Positive	Red
	Negative	Black
120V	Switched Leg	Not Black, Red or Blue
277V	Switched Leg	Not Brown, Orange, or Yellow

2.03 CONDUCTOR AND CABLE CONNECTORS

Connectors shall be provided for splices and terminal connections of all copper conductors and cables. The connector shall be designed to fit the conductor to which it shall be connected.

A. Compression Connectors

1. Connectors for #8 AWG and larger conductors, 600 V rated, shall be non-insulated compression type constructed of copper and tin-plated. Connectors shall be one-hole, flat-tongue style lugs for terminal connections, and two-way sleeves for splice connections.

Non-insulated compression type splice connectors shall be taped with two layers of half lapped liner-less rubber splicing tape and provided with a cold shrink

connector insulator sleeve (pre-slipped over the conductor) over the splice connector. Cold shrink insulators shall be as manufactured by 3M Company, or equal.

2. Connectors for #10 AWG and smaller conductors, 600 V rated, shall be pre-insulated compression type constructed of copper and tin-plated. Connectors shall be split-tongue type for terminal connections, and two-way sleeves for splice connections.
3. Connectors shall be similar to Thomas & Betts "Sta-Kon", or equal. Connectors shall be installed using manufacturer's crimping tools and accessories.
4. Waterproofed splices shall be constructed with cold shrink insulators encapsulated in epoxy resin. Epoxy resin splice kits shall be 3M Scotchkote 82 Series, or equal.

B. Tapered Coil Spring Connectors

Connectors shall have live coil springs, flame retardant thermoplastic shells rated for 105 °C, and shall be UL listed. Connectors shall be provided for #10 AWG and smaller conductors for lighting and receptacles. Connectors shall be as manufactured by Buchanan, Thomas & Betts, Ideal, or equal.

C. Shielded Cable Terminations

Shielded cable shall be terminated with pre-assembled stress cones. Stress cone terminations shall be IEEE Class 1 molded rubber type. Stress cone terminations shall be approved by the cable manufacturer. Contractor shall submit its proposed termination procedures with shop drawings for shielded cable. Stress cone terminations shall be as manufactured by 3M Company, Raychem, or equal.

D. Electrical Tape

Electrical tape shall be premium grade, 7 mil thick, all-weather vinyl-insulating tape. Tape shall be designed to perform continuously in ambient temperatures up to 105 °C, and shall be resistant to abrasion, moisture, alkalis, acids, corrosion, and varying weather conditions (including ultraviolet exposure). The tape shall be compatible with synthetic cable insulations, jackets and splicing compounds, and shall be UL listed. The tape shall be Scotch Super 33 Plus, or equal.

2.04 CONDUCTOR AND CABLE MARKERS

Markers shall be provided to identify all conductors and cables at equipment terminals, and in junction boxes, pull boxes, and manholes. The conductor and cable markers shall be one uniform standardized marking system. Heat shrinking of the markers and clear tubing shall be in

accordance with manufacturer's specifications. The field installed conductor and marker number shall be labeled with the same number as the terminal it is connected to.

A. Markers

The marking system shall consist of heat shrinkable flame retarded identification sleeves that fit tightly over the conductor or cable to be marked. Marker sleeves shall be made of a seamless cross-linked polyolefin with a 3 to 1 shrink ratio.

Conductor and cable marker system shall be UL recognized to Standard 224, MIL-M-81531. Markers shall be smear resistant prior to shrinking and achieve a permanent mark when shrunk, without the need for permatizing equipment. Markers shall be seamless. Markers shall be resistant to common industrial fluids including Freon TF, Isopropyl Alcohol and Ethylene Glycol. Markers shall have a temperature range of -30°C to 105°C and a dielectric strength of 500 V/mil minute. Marks shall be legible after 20 eraser rubs and 30 solvent brush strokes. The markers shall be suitable for indoor or outdoor use. The conductor and cable marker system shall be as manufactured by Raychem/Kroy Cable Marking, or Brady-Permasleeve White Polyolefin (B-342), or equal. Heat shrinkable thermoplastic tags are not acceptable.

B. Clear Tubing

Adhesive type cable markers are not acceptable by themselves. To provide a long-term permanent marker in high ambient temperatures, a translucent (clear) shrink tube shall be placed over each wire marker (extending past both edges of adhesive wire marker) and heat shrunk. The clear tube shall be suitable for high temperature performance, abrasion resistance and cut-through resistance and resistant to chemicals and solvents. The clear tubing shall meet the high temperature performance that meets or exceeds military industrial standards: MIL-1-23053, Test C, with UL VW-1 ratings. Operating temperature range shall be -55°C to 175°C. Product shall be Kynar as manufactured by Raychem, or equal.

2.05 METAL CONDUITS

Each length of conduit shall bear the manufacturer's name and UL label. Minimum conduit size shall be 3/4", unless noted otherwise. Conduit ends shall be threaded. Unless specified otherwise, elbows shall be standard radius sweeps meeting the requirements of the NEC.

A. Rigid Galvanized Steel (RGS) Conduit

1. RGS conduit, couplings, elbows, bends, and nipples shall be in accordance with ANSI C80.1 and UL 6, and shall be hot-dipped galvanized inside and out.

2. RGS conduit ends shall be threaded. Threads shall be hot galvanized after cutting. Color-coded end caps shall be provided to protect conduit threads. Thread-less fittings are not acceptable. A hot-dipped galvanized threaded coupling shall be furnished with each length of conduit.
3. All conduit cut ends shall be reamed or otherwise finished to remove rough edges. Where conduit is threaded in the field, a standard cutting die with NPT tapered threads (3/4-in. taper per foot) shall be used. Running threads are not acceptable.
4. Conduit, couplings, elbows, bends, and nipples shall be as manufactured by Allied Tube & Conduit, Wheatland Tube, Conduit Pipe Products Company, or equal.

B. PVC Coated Rigid Galvanized Steel (PVC-RGS) Conduit

1. PVC-RGS conduit, couplings, elbows, bends, nipples, and connectors shall be in accordance with ANSI C80.1, UL 6 and NEMA RN-1, and shall be hot-dipped galvanized inside and out. A PVC coating of 40 mils (minimum) thickness shall be bonded to the outer galvanized surface of the conduit and a urethane coating of 2 mils (minimum) thickness shall be applied to the interior surface of the conduit. The bond between the PVC coating and the conduit surface shall be greater than the tensile strength of the plastic.
2. PVC-RGS conduit ends shall be threaded. A PVC-coated threaded coupling shall be furnished with each length of conduit. A PVC sleeve equal to the OD of the conduit shall extend 2 inches from each end of the coupling.
3. Factory threaded ends shall be provided a urethane coating. Field cut threads shall be coated as specified in Part 3 herein.
4. Conduit, couplings, elbows, bends, nipples, and connectors shall be as manufactured by Ocal, Perma-Cote, Rob-Roy, or equal.

C. Rigid Aluminum (RA) Conduit

1. RA conduit, couplings, elbows, bends, and nipples shall be in accordance with ANSI C80.5 and UL 6A. RA conduit, couplings, elbows, bends, and nipples shall be constructed of aluminum 6063 alloy in temper designation T-1.
2. RA conduit ends shall be threaded. A threaded coupling shall be furnished with each length of conduit. A graphite based lubricant shall be factory applied to the threads at each end of the conduit. Color-coded end caps shall be provided to protect threads.

3. All conduit cut ends shall be reamed or otherwise finished to remove rough edges. Where conduit is threaded in the field, a standard cutting die with tapered threads (3/4-in. taper per foot) shall be used. Running threads are not acceptable.
4. All RA conduit in direct contact with the ground, concrete, or grout shall be PVC coated as specified herein. Alternatively, RA conduit may be protected by double wrapping with 20 mil PVC tape.
5. RA conduit, couplings, elbows, bends, and nipples shall be as manufactured by Allied Tube & Conduit, Wheatland Tube, Conduit Pipe Products Company, or equal.

D. PVC Coated Rigid Aluminum (PVC-RA) Conduit

1. PVC-RA conduit, couplings, elbows, bends, nipples, and connectors shall be in accordance with ANSI C80.5, UL 6A and NEMA RN-1. A PVC coating of 40 mils (minimum) thickness shall be bonded to the outer surface of the conduit and a urethane coating of 2 mils (minimum) thickness shall be applied to the interior surface of the conduit. The bond between the PVC coating and the conduit surface shall be greater than the tensile strength of the plastic.
2. PVC-RA conduit ends shall be threaded. A PVC-coated threaded coupling shall be furnished with each length of conduit. A PVC sleeve equal to the OD of the conduit shall extend 2 inches from each end of the coupling.
3. Factory threaded ends shall be provided a urethane coating. Field cut threads shall be coated as specified in Part 3 herein.
4. Conduit, couplings, elbows, bends, nipples, and connectors shall be as manufactured by Ocal, Perma-Cote, or equal.

E. Rigid Stainless Steel (RSS) Conduit

1. RSS conduit, couplings, elbows, bends, and nipples shall be in accordance with ANSI C80.1 and UL 6A, and shall be constructed of Type 304 stainless steel.
2. RSS conduit ends shall be threaded. A threaded coupling shall be furnished with each length of conduit. Color-coded end caps shall be provided to protect conduit threads. Thread-less fittings are not acceptable.
3. All conduit cut ends shall be reamed or otherwise finished to remove rough edges. Where conduit is threaded in the field, a standard cutting die with tapered threads (3/4-in. taper per foot) shall be used. Running threads are not acceptable.

4. Conduit, couplings, elbows, bends, and nipples shall be as manufactured by Allied Tube & Conduit, Conduit Pipe Products Company, or equal.

2.06 NONMETALLIC CONDUITS

- A. Nonmetallic conduit, elbows, and couplings shall be constructed of high impact, extruded, rigid polyvinyl chloride (PVC) resin. Nonmetallic conduit and fittings shall be heavy wall, Rigid Schedule 40 or Schedule 80 PVC, and rated of 90 degree C conductors. Conduit shall conform to UL 651, and NEMA TC-2, and shall be listed for underground applications encased in concrete or direct bury. PVC material shall be sunlight resistant.
- B. PVC conduit shall be manufactured with integral bell ends for solvent cement welding. Each length of conduit shall bear the manufacturer's name and UL label. Minimum conduit size shall be 3/4", unless noted otherwise.
- C. Conduit fittings shall conform to NEMA TC-3, and shall be of the same material and strength characteristics as the conduit. Unless specified otherwise, elbows shall be long radius sweeps meeting the requirements of the NEC. Conduit fittings shall be provided with plain ends or bell ends for solvent cement welding.
- D. Conduit, elbows, and couplings shall be as manufactured by Carlon, JM Eagle, or equal.

2.07 LIQUID-TIGHT FLEXIBLE METAL CONDUITS

- A. Liquid-tight flexible metal conduit shall be in accordance with UL 360 and NEC Article 350. Liquid-tight flexible metal conduit shall be constructed of continuously interlocked hot dipped zinc galvanized steel core covered by a sunlight resistant and flame retardant thermoplastic gray PVC jacket that resists heat, oil, and chemical breakdown. Liquid-tight flexible metal conduit shall be approved for both exposed and concealed locations, and shall be rated for temperature ranges of -4 to 140 °F.
- B. Conduits, 1-1/4 inch and smaller, shall have an internal copper bonding conductor wound spirally in the space between each convolution.
- C. Unjacketed or non-metallic flexible conduit is not acceptable.
- D. Liquid-tight flexible metal conduit shall be as manufactured by Anaconda, Electri-Flex, or equal.

2.08 CONDUIT FITTINGS

Conduit fittings shall include hub, liquid-tight connectors, unions, reducers, and plugs as specified herein.

A. Materials

1. Conduit fittings shall be constructed of malleable iron, aluminum, or stainless steel. Materials provided shall be consistent with the conduit material being used (i.e. malleable iron with RSG conduit, aluminum with RA conduit, and stainless steel with RSS conduit).
2. Where PVC coated conduit systems are specified, all conduit fittings shall be PVC coated.

B. Hubs for Rigid Metal Conduits

1. Threaded conduit hubs shall be provided for all conduit connections to enclosures without integral hubs. Each hub shall be furnished with a captive o-ring gasket, insulated throat, and vibration-proof nut equipped with a grounding screw. Machined serrations on hub and nut shall bite into the enclosure assuring a tight, vibration-proof connection.
2. Hubs shall be rated NEMA Type 2, 3, 3R, 4, 4X and 12. Hubs shall be certified for NEC, Class I, Division 2, and Class II, Divisions 1 and 2 hazardous locations.
3. Hubs shall be Crouse-Hinds Types STG, STAG, SSTG, or equal.

C. Connectors for Liquid-Tight Flexible Metal Conduits

1. Connector bodies shall be straight, 45° angle, and 90° angle, as required for the installation conditions. Each connector shall be furnished with an insulated throat, gland nut, ferrule, gland nut sealing ring, sealing gasket and locknut. Connectors shall seal out water, oil, dust, and dirt.
2. Connectors shall be certified for NEC, Class I, Division 2, and Class II, Divisions 1 and 2 hazardous locations.
3. Connectors shall be Crouse-Hinds Types LTB, LT-SA, or equal.

D. Unions

1. Union shall be provided, as required, for conduit connections to threaded outlet bodies, boxes, and equipment, and for connecting two rigid conduits together. Unions shall be male, female, or male and female depending upon application.
2. Unions shall be constructed of cast gray iron, or copper-free aluminum, consistent with conduit material being used.

3. Unions constructed of gray iron shall have finish of zinc plating and aluminum acrylic paint. Unions constructed of copper-free aluminum shall be protected with an epoxy powder coat finish.
4. Unions shall be Crouse Hinds UNY, UNF, UNL, UNA, or equal.

E. Reducers and Plugs

1. Reducers shall be used to reduce conduit hubs to the next smaller size and to connect to different sizes of threaded conduit. Plugs shall be used to close threaded conduit hubs.
2. Reducers shall be constructed of machined steel, cast gray iron, or cast malleable iron. Plugs shall be constructed of machined steel, cast gray iron, or copper-free aluminum, consistent with conduit material being used.
3. Reducers and plugs shall have external NPT tapered threads with a minimum of five threads.
4. Reducers and plugs constructed of ferrous metal shall have a finish of zinc plating with aluminum acrylic paint. Plugs constructed of copper-free aluminum shall be protected with an epoxy powder coat finish.
5. Reducers and plugs shall be Crouse Hinds RE, REC, PLG, or equal.

2.09 CONDUIT OUTLET BODIES AND OUTLET BOXES

- A. Conduit outlet bodies and outlet boxes shall be in accordance with UL 514A, UL 514B, and Fed Spec W-C-586. Conduit outlet bodies and outlet boxes shall be constructed for applications in accordance with the National Electrical Code Article 314.

- B. Conduit outlet bodies shall be furnished in conduit systems to: connect conduit sections, make 90° bends in conduit runs, provide pull outlets when conductors are being installed, and provide openings for making splices in conductors. Conduit outlet boxes shall be furnished in conduit systems to: act as junction boxes, act as pull outlets, accept round base wiring devices and covers, and mount lighting fixtures.
- C. Conduit bodies and boxes shall be provided with threaded hubs and tapered NPT threads. Conduit bodies and boxes shall have an integral bushing to protect wire insulation. Conduit bodies shall be provided with an internal PTFE coating for easier wire pulling. Conduit bodies and boxes shall be provided with covers and neoprene gaskets and shall be weather-proof.
- D. Conduit bodies and boxes shall be constructed of gray iron, copper-free aluminum, or stainless steel, consistent with the conduit material being used, unless indicated otherwise on the Drawings. Covers for conduit bodies and boxes shall be constructed of the same material as the main body.
- E. Conduit bodies and boxes constructed of gray iron shall be protected with a finish of zinc plating and epoxy powder coating. Conduit bodies constructed of copper-free aluminum shall be protected with an epoxy powder coat finish.
- F. Where conduit bodies and boxes are connected to PVC-coated conduit, bodies shall receive the same preparation and PVC-coating as the conduit.
- G. Conduit bodies and boxes constructed of stainless steel shall be made from Type 316 stainless steel investment casting. Covers shall be stamped from Type 316 stainless steel. Screws and sealing washers shall be constructed of Type 18-8 stainless steel. Gaskets and retainers shall be constructed of neoprene rubber. Stainless steel conduit bodies shall be approved for use in wet locations.
- H. Conduit outlet bodies shall be Form 7 or Form 8, as manufactured by Crouse-Hinds, or equal. Conduit outlet boxes shall be Crouse-Hinds GRFX or VXF, or equal.

2.10 EXPLOSION-PROOF CONDUIT COMPONENTS

- A. General
 - 1. All conduit outlet bodies, boxes, sealing fittings, flexible couplings, elbows, reducers, plugs, and unions provided for use in hazardous locations as defined in the NEC, shall be explosion-proof and dust ignition-proof.
 - 2. All products shall be approved for use in Class I, Divisions 1 and 2, Groups A, B, C, and D, and Class II, Divisions 1 and 2, Groups E, F, and G locations.

3. Explosion-proof products shall be UL Listed to UL 886.
4. Explosion-proof products used in outdoor or wet locations, shall be rain-tight and water-tight.
5. Where explosion-proof products are connected to PVC-coated conduit or used in a PVC-coated conduit system, products shall receive the same preparation and PVC-coating as the conduit.

B. Conduit Outlet Bodies and Outlet Boxes

1. Conduit outlet bodies and outlet boxes shall be used for pulling wire, changing direction of conduit, providing access for splicing wires and maintenance, and interconnecting lengths of threaded conduit.
2. Conduit outlet bodies and outlet boxes shall be constructed of gray iron or copper-free aluminum, consistent with the conduit material being used, unless indicated otherwise on the Drawings.
3. Conduit bodies and boxes shall be provided with threaded hubs and tapered NPT threads. Conduit bodies and boxes shall have an integral stop bushing to protect wire insulation and shall be provided with an internal PTFE coating for easier wire pulling. Conduit bodies and boxes shall be provided with covers and neoprene gaskets. Conduit boxes shall be provided with screw on covers for easy access.
4. Gray iron conduit bodies and boxes shall be provided with covers constructed of gray iron. Conduit bodies, boxes, and covers constructed of gray iron shall be protected with a finish of zinc plating and epoxy powder coating.
5. Conduit bodies and boxes constructed of copper-free aluminum shall be protected with an epoxy powder coat finish.
6. Conduit outlet bodies and outlet boxes shall be Crouse Hinds LBH, LBY, EKC, GUA, EAB, EAJ, GUJU, and OE, or equal.

C. Sealing Fittings

1. Sealing fittings shall be provided to restrict the passage of gases, vapors, or flames from one electrical installation to another through the conduit system.

2. Sealing fittings and plugs shall be constructed of gray iron or copper-free aluminum, consistent with the conduit material being used, unless indicated otherwise on the Drawings. Sealing fittings shall be weatherproof and suitable for outdoor exposure.
3. Sealing fittings and plugs constructed of gray iron shall be protected with a finish of zinc plating and epoxy powder coating or aluminum acrylic coating. Sealing fittings and plugs constructed of copper-free aluminum shall be protected with an epoxy powder coat finish.
4. Sealing compound shall be installed in all seal fittings and shall be UL listed, non-shrinking, and resistant to water, oil, and acids. Packing fiber shall be installed to form a positive dam to hold the sealing compound. Packing fiber shall be made from non-asbestos material. Sealing compound and packing fiber shall be provided by the same manufacturer as the sealing fittings.
5. Conduit sealing fittings shall be suitable for installation in the vertical and horizontal position. Conduit sealing fittings shall be Crouse-Hinds EYS, EZS, or equal.

D. Flexible Couplings

1. Flexible couplings shall be used to connect conduit to stationary equipment that vibrates or moves due to changes in temperature or pressure, and to achieve tight bends.
2. Flexible couplings shall have a flexible inner core and outer braided covering attached to NPT tapered threaded fittings. Flexible inner core, outer braided covering and end fittings shall be constructed of stainless steel. The metallic braid and fittings shall be provided completely factory assembled.
3. For severely corrosive locations, couplings shall be furnished with a flexible PVC protective coating.
4. Flexible couplings shall be Crouse-Hinds ECGJH, ECLK, or equal.

E. Elbows, Reducers, Plugs, and Unions

1. Elbows, reducers, plugs, and unions shall be constructed of machined steel, cast gray iron or copper-free aluminum, consistent with the conduit material being used, unless indicated otherwise on the Drawings.

2. Elbows shall be threaded and shall be used to change direction of conduit by 45° or 90°, or when terminating at a box or fitting. Elbows shall be male, female, or male and female depending upon application.
3. Reducers shall be used to reduce conduit hubs to the next smaller size and to connect to different sizes of threaded conduit. Plugs shall be used to close threaded conduit hubs. Reducers and plugs shall have external NPT tapered threads with a minimum of five threads.
4. Unions (three-piece couplings) shall be provided, as required, for conduit connections to threaded outlet bodies, boxes, and equipment, and for connecting two steel conduits together. Unions shall be male, female, or male and female depending upon application.
5. Elbows, plugs, and unions shall be constructed of machined steel, cast gray iron, or copper-free aluminum, consistent with conduit material being used, unless indicated otherwise on the Drawings. Reducers shall be constructed of machined steel, cast gray iron, or cast malleable iron.
6. Elbows, reducers, plugs, and unions constructed ferrous metal shall have finish of zinc plating and epoxy powder coating or aluminum acrylic coating. Elbows, reducers, plugs, and unions constructed of copper-free aluminum shall be protected with an epoxy powder coat finish.
7. Elbows, reducers, plugs, and unions shall be Crouse Hinds EL, RE, REC, REA, PLG, UNY, UNF, UNL, or equal.

2.11 DEVICE BOXES AND COVER PLATES

A. General Purpose Device Boxes - Indoors or Outdoors

1. Device boxes shall be in accordance with UL 514 and ANSI C33.84, and shall be constructed of cast gray iron or copper-free aluminum, consistent with the conduit material being used, unless indicated otherwise on the Drawings. Device boxes shall be weatherproof and suitable for outdoor exposure.
2. Device boxes shall be deep-type, minimum single gang size with threaded hubs, internal ground screw, and neoprene gasket for device cover plate. Device boxes shall be properly sized for the required devices or splicing. Surface mounted boxes shall be provided with integral mounting lugs.

3. Gray iron device boxes shall be provided with a hot dipped galvanized finish. Aluminum device boxes shall be provided with an epoxy powder coat finish (internal and external). Where device boxes are connected to PVC-coated conduit, boxes shall receive the same preparation and PVC-coating as the conduit.
4. Device boxes shall be Crouse-Hinds FD, Appleton FD, or equal.

B. Type 316 Stainless Steel Device Boxes

Where indicated on the Drawings, device boxes shall be constructed of Type 316 stainless steel, minimum single gang size, deep-type, with gasket and Type 316 stainless steel solid cover. Device boxes shall be properly sized for required circuitry or splicing. Surface mounted boxes shall be furnished with mounting lugs or feet. Device boxes shall be NEMA Type 4X, UL listed, and as manufactured by Wiegmann, or equal.

C. Pressed Steel Device Boxes

Device boxes may be constructed of pressed steel in lieu of cast gray iron or aluminum boxes where device boxes are required to be concealed, as indicated on the Drawings. Concealed device boxes shall be recessed in masonry or concrete walls, steel or wood stud walls, and concrete ceilings. Pressed steel device boxes shall be constructed of pre-galvanized steel, 0.062" minimum thickness. Metallic brackets shall be pre-galvanized steel or zinc plated cold roll spring steel. Pressed steel device boxes shall be provided with standard trade size knockouts to support attachment of conduit. Boxes shall be provided with a tapped hole at the bottom for attaching a ground screw. Boxes shall be deep-type and furnished with extensions as necessary for flush mounting of cover plates with the finished wall or ceiling surface. Pressed steel device boxes shall be UL listed, and as manufactured by Thomas & Betts, or equal.

D. Cover Plates

Unless indicated otherwise on the Drawings, cover plates for device boxes shall be as specified herein. Cover plates for device boxes containing toggle switches or receptacles shall be configured to match the mounted device. Cover plates for device boxes containing wiring splices shall be solid.

1. General Purpose - Indoors

Cover plates shall be stainless steel Type 302/304, standard size, smooth finish without grain, and be attached with slotted stainless steel screws. Stainless steel cover plates shall be manufactured by Hubbell, Cooper, or equal.

2. Damp Locations

Cover plates installed in damp locations shall be gasketed cast metal (matching the device box), self-closing, weatherproof cover plates. Weatherproof cover plates shall be manufactured by Hubbell, Cooper, or equal.

3. Outdoor and Wet Locations

Cover plates installed in outdoor and wet locations shall be gasketed cast aluminum, weatherproof, extra duty rated, in use type cover plates. Weatherproof extra duty in use cover plates shall be manufactured by Legrand, Thomas & Betts, or equal.

4. PVC Coating Conduit Systems

Unless indicated otherwise on the Drawings, cover plates installed in PVC coated conduit systems shall be gasketed, cast metal, PVC coated and be manufactured by the same manufacturer as the PVC coated conduit. PVC coated cover plates shall be manufactured by Ocal, Perma-Cote, or equal.

2.12 JUNCTION BOXES

A. General Purpose - Indoors or Outdoors

1. Unless indicated otherwise on the Drawings, junction boxes shall be rated NEMA 4 where located indoors or outdoors. NEMA 3R junction boxes are not acceptable.
2. Junction boxes shall be properly sized for the number and sizes of conductors and conduit entering the box and required splicing or termination. Junction boxes shall be a minimum size of 4" x 4" x 3".
3. NEMA 4 junction boxes shall be constructed of gray iron or sheet metal. PVC junction boxes are not acceptable.
4. Gray iron junction boxes shall be provided with gasketed screw-on covers and shall be hot dipped galvanized. Junction boxes shall be provided with feet where necessary for surface mounting. Gray iron junction boxes shall be Crouse-Hinds WAB, Appleton RS, or equal.

5. Sheet metal junction boxes shall be constructed of 14 gauge minimum sheet steel and shall be galvanized after fabrication and provided with a wash and phosphate undercoat, and ANSI 61 gray acrylic electrocoat finish. Sheet metal junction boxes shall be provided with tabs where necessary for surface mounting. Sheet metal junction boxes shall be provided with gasketed, continuous hinged solid doors and padlockable door hasps. Sheet metal junction boxes shall be as manufactured by Hoffman, Wiegmann, Cooper B-Line, or equal.

B. Wet or Corrosive Locations

1. Unless indicated otherwise on the Drawings, junction boxes shall be rated NEMA 4X where located in wet or corrosive locations. Junction boxes shall be properly sized for the number and sizes of conductors and conduit entering the box and required splicing or termination. Junction boxes shall be a minimum size of 4" x 4" x 3".
2. NEMA 4X junction boxes shall be constructed of Type 316 stainless steel, and provided with gasketed, continuous hinged solid doors and padlockable door hasps. PVC junction boxes are not acceptable.
3. NEMA 4X junction boxes shall be manufactured by Hoffman, Wiegmann, or equal.

2.13 METAL WIREWAYS

A. General

1. Metal wireways shall be UL listed, with NEMA ratings and sizes as indicated on the Drawings, and shall conform to the requirements specified herein.
2. Metal wireways straight sections shall be 4" wide x 4" high (minimum).
3. Wireway fittings and accessories shall conform to straight section width and height.
4. Direction and size changes shall be completed through the use of pre-fabricated fittings provided by the wireway manufacturer.
5. Metal wireways shall be manufactured by Hoffman, Cooper B-Line, or equal.

B. Indoor Locations

1. Unless indicated otherwise on the Drawings, wireways shall be rated NEMA 12 where located indoors.

2. NEMA 12 wireways shall be "lay-in" type and shall be provided with bodies and covers fabricated from 14 gauge galvanized steel. Flanges shall be constructed of 10 gauge galvanized steel. Covers shall be secured to the wireway and fitting body with heavy duty butt hinges and quick release latches. Covers and flanges shall be provided with oil-resistant gaskets. All covers and sealing plates shall be hinged completely open or removed to allow for continuous "lay-in" cable feed.
3. NEMA 12 wireway systems shall be provided with a wash and phosphate undercoat, and an ANSI 61 gray polyester powder finish.

C. Outdoor or Corrosive Locations

1. Unless indicated otherwise on the Drawings, wireways shall be rated NEMA 4X where located outdoors or in corrosive areas.
2. NEMA 4X wireways shall be "feed-through" type and shall be provided with bodies and covers fabricated from 14 gauge Type 304 stainless steel. Flanges shall be constructed of 10 gauge stainless steel. Covers shall be secured to the wireway body with heavy duty hinges on one side and screw clamps mounted on the opposite side. Covers and flanges shall be provided with oil-resistant gaskets. Outer surface of wireway body, cover, and fittings shall be provided with a smooth brushed finish.

2.14 NON-METALLIC WIREWAY

A. General

1. Non-metallic wireway shall be solid bottom type construction with minimum wall thickness of 0.1875". Covers and cover splice plates shall be snap-on type construction requiring no installation fasteners.
2. The wireway system shall conform to the applicable sections of NEC Article 362.
3. The non-metallic wireway system shall be as manufactured by Enduro Composite Systems, Inc., or equal.

B. Construction

1. Wireways, covers, and connector plates shall be pultruded utilizing polyester resin with UV light inhibiting additives and exterior nexus veil coverage.
2. All composite material shall meet ASTM E84, maximum 25 flame spread rating.
3. All cut ends and drilled holes (factory and field) shall be sealed with resin coating.

C. Connections, Accessories, and Supports

1. Connector plates shall be fiberglass and designed to transfer wireway loads to the support system. Fasteners for connector plates shall be Type 316 stainless steel or FRP studs and hex nuts as required.
2. Wireways shall be provided with fiberglass flat snap-on/snap-off covers.
3. Wireway support systems shall be constructed of polyester or vinyl ester resin strut channels (single or double channel as necessary) and appurtenances. Support spacing shall be in accordance with the wireway manufacturer's printed recommendations for the specified loads.

2.15 METAL CABLE TRAY

- A. Metal cable tray shall be constructed of aluminum, and shall be ladder type or ventilated trough type, as specified herein. Cable tray shall be provided with all splice plates, bolts nuts and washers for connecting tray units. Units shall be constructed with rounded edges and smooth surfaces; in compliance with NEMA VE-1.

Cable tray shall be sized by the Contractor to support all the conductors and cables shown on the Drawings plus an additional 20% spare capacity for future use, when supported as a simple span of a maximum of 10 feet. In addition to the conductor and cable load, the cable tray shall support a 200 lb. concentrated load at mid-point of span and centerline of tray.

- B. Metal cable tray straight section and fitting side rails and rungs shall be extruded from aluminum alloy 6063. All fabricated parts shall be constructed from aluminum alloy 5052.
- C. Ladder type trays shall consist of two longitudinal members (side rails) with transverse members (rungs) welded to the side rails. Rungs shall be spaced 6 inches on center. Spacing in radiused fittings shall be 9 inches and measured at the center of the tray's width. Rungs shall have a minimum cable-bearing surface of 7/8 inch with radiused edges. No portion of the rungs shall protrude below the bottom plane of the side rails.
- D. Ventilating trough type trays shall consist of two longitudinal members (side rails) with a corrugated bottom welded to the side rails. The peaks of the corrugated bottom shall have a minimum flat cable-bearing surface of 2-3/4 inches and shall be spaced 6 inches on center. To provide ventilation in the tray, the valleys of the corrugated bottom shall have 2-1/4 inch by 4 inch rectangular holes punched along the width of the bottom.

Basic Electrical Materials and Methods

Section 16050 – 26

- E. Trays shall have 4 inch minimum usable load depth, unless indicated otherwise on the Drawings.
- F. Straight tray sections shall have side rails fabricated as I-Beams. All straight sections shall be supplied in standard 12 or 24 foot lengths, except where shorter lengths are required to facilitate tray assembly as shown on the Drawings.
- G. Tray widths shall be 18 inches, unless indicated otherwise on the Drawings.
- H. All fittings shall have a minimum radius of 12 inches.
- I. Splice plates shall be the bolted type made of 6063-T6 aluminum, using four square neck carriage bolts and serrated flange locknuts. Hardware shall be zinc plated in accordance with ASTM B633, SC1. Hardware shall be Type 316 stainless for aluminum cable tray installed outdoors. Splice plate construction shall be such that a splice may be located anywhere within the support span without diminishing rated loading capacity of the cable tray.
- J. Separate cable tray systems shall be provided for power cables, and for instrumentation cables. Power cable trays shall include conductors for 480 V, 240 V, and 120 V power circuits, and shall be located above instrumentation cable trays, unless indicated otherwise on the Drawings. Instrumentation cable trays shall include cables for instrumentation, signal, communication, and control circuits. Metal barriers shall be installed in instrumentation cable trays to provide separation of analog signals and communication circuits from digital circuits. In addition, metal barriers shall be installed in power cable trays to provide separation of variable frequency drive (VFD) motor circuits from all other power circuits.
- K. Cable tray supports shall be located so that the support spans do not exceed maximum span specified herein, or shown on the Drawings. Supports shall be constructed from 12 gauge steel strut channel (1-5/8 inch by 1-5/8 inch, minimum) with all necessary hardware such as Trapeze Support Kits (9G-55XX-22SH) as manufactured by Cooper B-Line, or equal. Cable trays installed adjacent to walls shall be supported on wall mounted brackets such as B409 as manufactured by Cooper B-Line, or equal.
- L. Trapeze hangers and center-hung supports shall be supported by 1/2 inch (minimum) diameter rods.
- M. Barrier strips shall be placed as specified herein, and shall be fastened into the tray with self-drilling screws.
- N. Special accessories shall be furnished as required to protect, support, and install a cable tray system. Accessories shall consist of but are not limited to; section splice plates, expansion plates, blind-end plates, specially designed ladder dropouts, barriers, etc.

- O. Where cable tray penetrates wall, the penetrations shall be fire-stopped using plates on both sides of the penetration and filling the void in between with UL approved silicone foam as required to provide a 2-hour (minimum) fire rating.
- P. All conductors and cables installed in cable trays shall be tray-rated cable types. Conduits used between equipment and cable tray shall be sized to meet NEC requirements based on the diameters of the tray-rated cables.
- Q. Cable tray systems shall be as manufactured by Cooper B-Line, or equal.

2.16 NON-METALLIC CABLE TRAY

- A. Non-metallic cable tray shall be constructed of glass fiber reinforced polyester or vinyl ester resin, and shall be solid bottom type or ventilated trough type, as specified herein. Cable tray shall be provided with all splice plates, bolts nuts and washers for connecting tray units. Units shall be constructed with rounded edges and smooth surfaces; in compliance with NEMA FG-1.

Cable tray shall be sized by the Contractor to support all the conductors and cables shown on the Drawings plus an additional 20% spare capacity for future use, when supported as a simple span of a maximum of 10 feet, while maintaining a minimum safety factor of 1.5.

- B. Straight section structural elements; side rails, rungs and splice plates shall be pultruded from glass fiber reinforced polyester or vinyl ester resin. Pultruded shapes shall be constructed with a surface veil to insure a resin-rich surface and ultraviolet resistance. Pultruded shapes shall meet ASTM E-84, Class 1 flame rating and self-extinguishing requirements of ASTM D-635.
- C. Ventilating bottom cable trays shall consist of two longitudinal members (side rails) with rungs spaced 4" on center.
- D. Solid bottom cable trays shall consist of two longitudinal members (side rails) with a solid sheet over rungs spaced on 12" centers.
- E. Cable tray loading depth shall be 3 inches per NEMA FG-1, unless indicated otherwise on the Drawings.
- F. Straight sections shall be supplied in standard 10 foot or 20 foot lengths.
- G. Cable tray inside widths shall be 18 inches, unless indicated otherwise on the Drawings. Outside width shall not exceed inside by more than a total of 2".
- H. Straight and expansion splice plates will be of "L" shaped lay-in design. Splice plates shall be furnished with straight sections and fittings.

- I. All fittings must have a minimum radius of 12.
- J. Molded fittings shall be formed with a minimum 3" tangent following the radius.
- K. Systems with 3 inch loading depth shall have 90° and 45° molded fittings in 12 inch or 24 inch radius. Systems with 5 inch loading depth shall have 90° and 45° molded fittings in 24 inch or 36 inch radius. All other fittings shall be of mitered construction.
- L. Unless indicated otherwise on the Drawings, cable trays shall be provided with fiberglass flat covers.
- M. Cable tray support systems shall be constructed of polyester or vinyl ester resin strut channels (single or double channel as necessary) and appurtenances. Support spacing shall be in accordance with the cable tray manufacturer's printed recommendations for the specified loads.

Cable tray manufacturer shall provide all clamps, support assemblies, and appurtenances necessary for the installation of a complete cable tray system.
- N. All conductors and cables installed in cable trays shall be tray-rated cable types. Conduits used between equipment and cable tray shall be sized to meet NEC requirements based on the diameters of the tray-rated cables.
- O. Cable tray systems shall be as manufactured by Cooper B-Line, or equal.

2.17 RECEPTACLES AND SWITCHES

Receptacles and switches shall be specification grade, heavy duty and provided in cast metal boxes with gasketed covers as identified and located on the Drawings. Unless otherwise indicated, the device phenolic color shall be ivory for all receptacles and toggle switches

A. General Purpose Convenience Receptacles

General purpose convenience receptacles shall be duplex, 3-wire grounding type, weather resistant, rated 125 /250 volt, AC, rated 20 amp minimum, NEMA 5-20R, and equipped with double sided screw terminals for copper wire. Convenience receptacles shall be as manufactured by Hubbell, Pass & Seymour, or equal.

B. Ground Fault Interrupter (GFI) Receptacles

GFI receptacles shall be duplex, weather resistant, NEMA 5-20R configured, ivory in color, and shall mount in a standard device box. Units shall trip at 5 mA of ground current and shall comply with NEMA WD-1-1.10 and UL 943. GFI receptacles shall be capable of

individual protection as well as downstream protection, as manufactured by Hubbell, Pass & Seymour, or equal.

C. Toggle Switches

Local single pole switches shall be flush tumbler type AC rated, quiet type, heavy duty, rated 20 amp minimum, rated 120/277 volt, equipped with side screw terminals for copper wire. Switches shall conform to NEMA WD-1 Specifications. Two pole, three-way and other switches shall be similar. Switches shall be as manufactured by Hubbell, Pass & Seymour, or equal.

2.18 PILOT DEVICES AND LOCAL CONTROL STATIONS

A. Pilot Devices

1. Pilot devices consisting of oiltight/watertight push buttons, selector switches, pilot lights, and incidental items shall be as manufactured by Allen-Bradley, Eaton/Cutler Hammer, or Schneider/Square D (no substitutes).
2. Pilot devices shall be heavy duty, suitable for mounting in control stations or on control panels, and other electrical equipment.
 - a. Pilot devices shall be 30.5 mm, NEMA Type 4/13 with cast metal bases, chrome-plated octagonal mounting nuts, and legend plates.
 - b. Push buttons and switch knobs shall be heavy duty plastic. Pilot light lenses shall be shatter resistant plastic. Lens color shall be as indicated on the Drawings.
 - c. Contact blocks shall have AC contact ratings of NEMA A600, 10 A with silver contacts for corrosion resistance and clear side plates for contact inspection.
 - d. Pilot light devices shall be push-to-test type and shall be provided with LEDs and transformers suitable for operation on 120 VAC power.

B. Local Control Stations

1. Local control stations shall consist of various pilot devices mounted in a device box and located as shown on the Drawings. Pilot devices and control wiring shall be as indicated on the Drawings. Pilot devices (e.g. selector switches, pilot lights, and push buttons) shall be in accordance with the requirements specified herein.

2. Local control station device boxes shall be as specified herein and shall have the following NEMA ratings, unless indicated otherwise on the Drawings:
 - a. Non-Hazardous Indoor Locations NEMA 12
 - b. Hazardous Indoor Locations NEMA 7
 - c. Outdoor Locations NEMA 4X
 - d. Hazardous Outdoor Locations NEMA 4 and NEMA 7

Local control station enclosures shall be of adequate size to contain the specified pilot devices, wiring, and components.

3. Local control stations shall be provided with nameplates inscribed with the name of the equipment being controlled and the control station name (e.g. Pump No. 1, Lock-Out-Stop). In addition, each pilot device shall be provided with an integral legend plate, inscribed with the function of the respective pilot device.
4. Mechanical "Lock-Out-Stop" devices where installed on pilot device "Stop" push buttons shall be constructed of stainless steel, and shall be suitable for padlocking in the "Stop" position. Mechanical "Lock-Out-Stop" devices shall be manufactured by the same manufacturer as the push button.

2.19 PANELBOARDS

Panelboards shall be factory assembled, metal enclosed, gasketed, bolted dead front and equipped with thermal-magnetic molded case circuit breakers as shown on the Drawings and as specified in Specification Section 16480, Motor Control Centers, Switchboards, and Panelboards.

2.20 OVERCURRENT PROTECTION

Circuit breakers, fuses, relays and other protective devices that protect conductors and equipment against overload currents and short circuit currents shall be provided as indicated, specified and required. Overcurrent protection devices are specified in Specification Section 16480, Motor Control Centers, Switchboards, and Panelboards.

2.21 DISCONNECT SWITCHES

Provide fusible disconnect switches, or non-fusible disconnect switches, as indicated on the Drawings and as specified herein.

- A. Switches shall be steel enclosed, heavy duty, 2-pole 250 VAC or 3-pole 600 VAC, fusible or non-fusible, as indicated on the Drawings and specified herein. Disconnect switches shall be UL listed and conform to NEMA KS1. Disconnect switches shall be as manufactured by Eaton/Cutler-Hammer, Schneider/Square D, or equal.
- B. The operating mechanism shall be spring driven, with quick-make, quick-break action. Switch contact shall be knife-blade and jaw construction, with visible blades.
- C. Operating handles shall be flange mounted as an integral part of the operating mechanism. The operating handle shall clearly indicate the "On" and "Off" position, and shall have provisions for padlocking with up to three (3) 3/8 inch padlocks.
- D. Switches shall incorporate safety cover interlocks to prevent opening the hinged cover with the switch in the "On" position or prevent closing the switch mechanism and placing the switch in the "On" position with the hinged cover open. Provide a defeater for authorized personnel.
- E. Each switch shall be provided with a factory installed equipment grounding kit and fuse puller kit.
- F. Switches shall be provided with metal enclosures having the following NEMA ratings, unless indicated otherwise on the Drawings
 - 1. Non-hazardous Indoor Locations NEMA 12
 - 2. Hazardous Indoor Locations NEMA 7
 - 3. Outdoor Locations NEMA 4X (Type 316 stainless steel)
 - 4. Hazardous Outdoor Locations NEMA 4 and NEMA 7
- G. Non-fusible switches shall have a minimum short circuit current rating of 10,000 A, when used in conjunction with a circuit breaker of any brand.

- H. Fusible switch units shall be equipped with all required mounting brackets and guides. Unless specified otherwise, fusible switches with 30 A through 600 A frames shall be provided with rejection Class "R" type fuse clips. Unless specified otherwise, fusible switches with 800 A through 1200 A frames shall be provided with Class L type fuse clips. Fusible switches and fuses shall have a minimum short circuit current rating of 200,000 A.

All fuses shall be provided by the manufacturer. Contractor shall confirm fuse type. Contractor shall coordinate with manufacturer, including supplying manufacturer with data on actual equipment to be furnished and results of short circuit coordination study.

- I. Switches shall be provided with a phenolic nameplate on the hinged cover that identifies the load.

2.22 SUPPORTS

Contractor shall provide strut channels, fittings, stanchions, clamps, hangers, and required hardware to support all conduit and equipment, as shown on the Drawings and specified herein, and as required. Refer also to earthquake restraint provisions of Section 11005.

A. Strut Channel Supports

1. Unless indicated otherwise on the Drawings, strut channel shall be single strut type, 1-5/8" x 1-5/8", 12 gauge hot dipped galvanized steel with 9/16" diameter bolt holes on 1-7/8" centers.
2. Where indicated on the Drawings, strut channel shall be single strut type, 1-5/8" x 1-5/8", heavy duty, fiberglass (vinylester) with 1" x 7/16" bolt holes on 2" centers.
3. Where indicated on the Drawings, strut channel shall be single strut type, 1-5/8" x 1-5/8", Type 304 stainless steel with 9/16" bolt holes on 1-7/8" centers.
4. Where indicated on the Drawings, strut channel shall be single strut type, 1-5/8" x 1-5/8", 12 gauge, PVC coated pre-galvanized steel, with 9/16" bolt holes on 1-7/8" centers. PVC coating shall be as specified herein for PVC coat rigid metal conduit.
5. Deep strut or double strut channel shall be provided where required for the support load or configuration.
6. Strut channel supports shall be furnished with all fittings required for a particular support configuration, including: conduit clamps, flat plate fittings, angle fittings, 90° fittings, brace fittings, zee fittings, "U" fittings, wing fittings, and post bases.

7. Strut channel fittings and fasteners shall be fabricated from the same material and receive the same coating, as specified for the strut channel.
8. Strut channels, fittings, and fasteners shall be as manufactured by Power-Strut, Unistrut, or equal.

B. One-Hole Clamps

Clamps shall be malleable iron, hot dipped galvanized, and equipped with clamp-backs. Clamps shall be as manufactured by Crouse-Hinds, Thomas & Betts, Appleton, or equal.

C. Beam Clamps

Clamps shall be malleable iron, hot dipped galvanized, right angle and parallel types. Clamps shall be as manufactured by Crouse-Hinds, Thomas & Betts, Appleton, or equal.

D. U-Bolts

U-bolts shall be heavy-duty steel, electro-galvanized and equipped with two hex steel nuts. U-bolts shall be as manufactured Crouse-Hinds, Efcor, Kindorf, or equal.

E. Conduit Hangers

Conduit hangers shall be heavy gauge formed steel, galvanized and equipped with carriage bolts, 1/4-inch (minimum) rods and nuts. Conduit hangers shall be as manufactured by Kindorf, Appleton, or equal.

F. Lighting Fixture Hangers

Fixture hangers shall be cast iron alloy, cushion type, and equipped with outlet body and cover for fixture wiring. Fixture hanger shall permit the fixture to swing 20° from perpendicular in any direction. Fixture hangers shall be Crouse-Hinds Type ALT, Appleton Type ALT, or equal.

G. Fasteners and Anchors

1. Fasteners and anchors shall be provided to securely mount all equipment and materials.
2. Unless specified otherwise, all fasteners and anchors shall be constructed of Type 304 stainless steel.

3. Stainless steel anchors shall be provided for securing equipment and supports to masonry and concrete walls, concrete foundations, and concrete floors. Stainless steel anchors shall be wedge anchors, sleeve anchors, or epoxy anchors, as manufactured by Red Head, Hilti, or equal.

H. Spacers

Spacers shall be provided to support underground conduits for concrete encasements. Spacers shall be modular, interlocking, and constructed of high impact plastic with sufficient strength to support multiple layers of conduit. Spacers shall be as manufactured by Carlon, JM Eagle, or equal.

2.23 GROUNDING

- A. Grounding and grounding components shall comply with the applicable requirements of the NEC, Article 250.
- B. Grounding conductors shall be stranded copper and shall be sized in accordance with NEC requirements when sizes are not indicated on the Drawings.
- C. Grounding rods shall conform to ANSI/UL 467 and shall be copper-clad steel, 3/4" (minimum) in diameter and 10' (minimum) in length. Rods shall be driven in the ground at least 9'-6" deep.

Provide the number of rods required to obtain proper ground resistance, as applicable to all service entrances, transformers, building/structure ground rings, manholes, pull boxes, etc.

- D. All grounding connections of copper to copper and copper to steel of #8 AWG and larger sized conductors shall be exothermic welded connections (Cadweld). Exothermic welded connections shall create a non-removable fusion of copper grounding conductors and high conductivity copper content alloy connecting sleeves. Exothermic welding systems shall be manufactured by Erico, Furseweld, or equal.
- E. All grounding connections to equipment shall use bolted lugs. When the conductor is #8 AWG and larger, the lug shall be joined to the conductor by the Cadweld exothermic weld process.

When the conductor is smaller than #8 AWG, the lug shall be joined by compression connectors manufactured from pure wrought copper. The connectors shall meet or exceed the performance requirements of IEEE 837, latest revision. The connectors shall be clearly marked with the manufacturer and conductor size. The installation of the connectors shall be made with a compression, tool and die system, as recommended by the manufacturer of the connectors. Each connector shall be factory filled with an oxide-inhibiting compound.

Screwed or bolted clamp style grounding connectors are not acceptable.

- F. Solid State Decouplers shall be UL listed for grounding electrical equipment. Units shall be enclosed in fiberglass housing and be rated for an AC fault current of 1.2 kA. Solid State Decouplers shall be manufactured by Dairyland Industries.

2.24 MANHOLES AND PULL BOXES

- A. Manholes and pull boxes shall be of precast concrete, designed for H-20 traffic loading. Concrete sections shall be modular with tongue and groove joints. A continuous waterproof gasket shall be provided at all section and slab joints. Manholes and pull boxes shall be equipped with galvanized steel pulling irons opposite each duct bank entrance. Manholes and pull boxes shall be provided with a sump opening and 1" ground rod opening in the base section. Sump openings shall be provided with cast iron perforated covers.
- B. Unless indicated otherwise on the Drawings, manhole covers shall be cast iron, 30" round (minimum), and supported on the necking section. Pull box covers shall be hot dipped galvanized checkered plate steel, and shall be bolted down to cast-in hot dipped galvanized steel frames with stainless steel hardware. Unless noted otherwise, manhole and pull box covers shall be designed for H-20 traffic loading and shall be marked with raised lettering according to their contents (e.g. "480V Power", "Control & Instrumentation"). Cover markings shall be confirmed with the District prior to fabrication.
- C. Manholes and pull boxes shall be provided with slotted galvanized steel channel inserts cast-in interior walls for conductor/cable supports. Sufficient inserts shall be provided to allow support of conductors/cables at 3-foot (maximum) intervals.
- D. Manholes and pull boxes shall be provided with knockouts for connections to all underground conduit and duct banks.
- E. Manholes and pull boxes shall be manufactured by Jensen Precast, Oldcastle Precast, or equal.

2.25 NAMEPLATES

Plastic nameplates shall be provided for all electrical panels, MCCs, switchboards, panelboards, individually enclosed disconnect switches, individually enclosed circuit breakers, manual starters, control panels, control stations, junction boxes, termination enclosures, receptacles, local switches, and field instruments, unless otherwise indicated on the Drawings or specified in individual specifications for respective equipment.

All nameplates shall be NEMA ES-1, 3-ply, 1/16-inch thick, beveled and satin finished and shall be securely fastened with stainless steel drive screws or escutcheon pins. Nameplates shall be as manufactured by Brady, or equal.

A. Nameplates

The nameplates shall be laminated black plastic with 1/4-inch high (unless otherwise specified) white letters. Nameplate inscriptions shall include the identifications for the equipment and loads, and shall identify the controls on control equipment as shown on the Drawings. Nameplate inscriptions on receptacles and local switchplates shall include the panelboard number and circuit that the device is connected to, e.g., "LP A-1". Nameplates on receptacles and local switchplates shall have 3/16-inch high letters.

B. Lockout/Tagout Nameplates

Lockout/tagout nameplates shall be provided for all pumps and other mechanical equipment where multiple devices including, but not limited to: switches, circuit breakers, by-pass contactors, VFDs, solid state starters, etc., may cause the equipment to be energized. Said nameplates shall be installed over the main circuit breaker or disconnect switch which will solely remove power from the equipment and all appurtenant controls and circuitry contained in the panel negating the possibility of power being applied by another source.

The nameplate shall be laminated red plastic with 3/8-inch high (unless otherwise specified) white letters. The inscription shall read "LOCKOUT/TAGOUT LOCATION FOR _____" with a description identifying the equipment (e.g. "PUMP P-1").

2.26 MISCELLANEOUS MATERIALS AND COMPONENTS

A. Conduit Tags

All conduits shall be identified with tag number. The conduit tag shall be a one-inch (1") minimum diameter Type 316 stainless steel or brass disc. The tag shall be stamped with the conduit's number for that respective conduit as indicated on the Drawings. The tag shall be attached to the conduit with a stainless steel chain or stranded mechanic wire.

B. Thread Lubricant

1. Thread lubricant shall be provided for all threads in metal conduit, fittings, bodies, boxes, etc. The lubricant shall prevent thread galling, inhibit corrosion and maintain grounding continuity.
2. General purpose lubricant shall be provided on any metal-to-metal threaded joint. General purpose lubricant shall be Crouse-Hinds STL, Thomas and Betts Kopr-Shield, or equal
3. High temperature lubricant shall be provided on lighting fixture threaded joints and on threaded joints of enclosures of any heat-producing apparatus or control. The lubricant shall be effective and stable from -70 to +1800 °F. The lubricant shall be Crouse-Hinds HTL, or equal.

C. Conductor and Cable Pulling Lubricant

Conductor and cable lubricant shall be provided to ease the pulling of conductors and cables in conduits. The pulling lubricant shall be a high performance, temperature stable, non-staining lubricant. The pulling lubricant shall be compatible with all proposed conductor and cable jackets. Conductor and cable manufacturer approvals shall be provided upon District's request. The pulling lubricant shall not contain wax, grease, silicone, or glycol oils. Conductor and cable pulling lubricant shall be American Polywater Corporation, "Polywater J", or equal.

PART 3 - EXECUTION

3.01 GENERAL

Contractor shall provide all conduit/conductor installations and equipment installations, including connections and interconnections, as indicated on the Drawings and specified herein, and required for complete and fully operational equipment systems.

A. Electrical Materials and Products

Installation of all electrical materials and products shall conform to the requirements of the manufacturer's specifications and installation instructions. When code requirements apply to installation of materials and equipment, the more stringent requirements, code, or manufacturer's specifications and installation instructions shall govern the work.

B. Power Supplies to Mechanical Equipment

1. An electric power supply, including conduit, any necessary junction or outlet boxes, and conductors and connections shall be furnished and installed by Contractor for each item of electric motor driven mechanical equipment.
2. Circuit breakers or fused disconnect protection shall be provided for each separate item of electric motor driven mechanical equipment shown on the Drawings, or specified in other sections of the specifications for furnished equipment.
3. Power supplies to individual items of equipment shall be terminated in a suitable outlet or junction box adjacent to the respective item of equipment, or a termination box provided by the manufacturer of the equipment. Sufficient lengths of conductor at each location shall be provided to permit connection to equipment without damaging the conductors.

C. Excavations and Backfills

Earthwork shall be performed for underground conduits, manholes, pull boxes, equipment foundations, and supports, as indicated on the Drawings and specified herein, and as specified in Division 2 of the Specifications.

D. Concrete

Concrete shall be provided for electrical equipment foundations, support foundations and conduit encasements, as indicated on the Drawings and specified herein, and as specified in Division 3 of the Specifications. Concrete shall be Class C, 2,000 psi red colored concrete per District Detailed Provision, Section 03300, Cast-in-Place Concrete.

E. Painting

Painting shall be provided for installations having unfinished surfaces as specified in Division 9 of the Specifications. Field damaged factory finishes on equipment shall be touched-up with paint that is equal in quality and color to the original factory finish.

3.02 CONDUCTORS AND CABLES

Unless indicated otherwise on the Drawings, conductors and cables shall be furnished and installed as specified herein.

A. General

1. Conductors for power feeders, lighting feeders, lighting circuits, and receptacles shall be #12 AWG minimum. Conductors for control circuits shall be #14 AWG minimum.
2. Contractor shall install conductors and cables in accordance with the manufacturer's written instructions. Contractor shall exercise care to protect conductors and cables. Contractor shall avoid: kinking the conductors; cutting, puncturing, or scraping the insulation or jacket; contamination with oil or grease; or any other damage.
3. All conductors and cables shall be installed in conduit, cable trays, wireways, or electrical enclosures. Conductors and cables shall not be installed in conduit runs until all work is completed for each individual conduit run.
4. Apply cable pulling lubricant to ease and reduce the tension stresses when pulling conductors and cables in conduits, except when installing no-lube wire. The conductors and cables shall be free of debris (dirt, mud, etc.) before being pulled into the conduits. Manufacturers recommended pulling tensions shall not be exceeded. Proper and standard pulling techniques shall be used in pulling in the conductors and cables. Conductors and cables shall not be pulled into the conduit using a vehicle draw or tow bar, tow ball, or non-tension devices. Tensioning devices shall have pressure gauges to indicate pulling tensions being exerted on the conductors and cables during the pulling process. Pulling tension shall be continuously monitored during the duration of pulling. Conductor insulation damage will result in the conductors not being approved for energizing. Conductors and cables not passing megger or hi-pot testing or that have insulation damage shall be replaced with new conductors and cables at no additional cost to the District. Repairing of damaged conductor or cable insulation will not be approved.
5. Conductors and cables shall not be pulled tight against bushing nor pressed heavily against enclosures.
6. To prevent loading on cable connections, where cables are installed vertically, cables shall be supported by stainless steel woven grips, Kellems, or equal. In addition, stainless steel woven grips shall be provided on all submersible cables in wet wells to support cable weight and avoid stress on cable insulation.

Basic Electrical Materials and Methods

Section 16050 – 40

7. All conductors or cables in conduit, over 1 foot long, or with any bends, shall be pulled in or out simultaneously.
8. Circuit to supply electric power and control to equipment and devices are indicated on the Drawings. Conductors in designated numbers and sizes shall be installed in conduit of designated size. Circuits shall not be combined to reduce conduit requirements unless approved by the District.
9. All field wiring to/from MCCs, VFDs, and control panels shall terminate at terminal strips in the respective panels and buckets.
10. Furnish and install conduit and conductors as shown on the Drawings, as shown on the control diagrams, and as listed on the "Schedule of Conduit and Conductors" Drawing. Contractor is advised that not all conduit and conductors are listed in the Schedule (particularly 120V lighting and receptacles) and that not all conduits and conductors listed in the Schedule are specifically labeled or called out on other Drawings.
11. Contractor is advised that interconnecting wiring within and between the lineup of MCCs, VFDs, and control panels is not specifically listed or shown on the Drawings. Contractor is directed to the control diagrams and interconnection diagrams on the approved shop drawings. Wiring for said connections shall run within the MCC, VFD, and control panel wireways, or in conduit between MCCs, VFDs, and control panels.
12. Install continuous circuit conductors from source to load without splices or terminations in intermediate junction boxes, manholes, or pull boxes.

B. Splicing and Terminating

1. Where authorized by the District, splices may be made only at accessible locations.
2. Conductors #10 AWG and smaller for lighting and receptacles may be spliced in junction boxes, outlet boxes, and conduit bodies. Lighting and receptacle conductors shall be spliced with tapered coil spring type connectors.

3. Conductors or cable lengths that exceed standard manufactured lengths may be spliced in junction boxes for power conductors or termination cabinets for control and instrumentation conductors. Junction boxes and termination cabinets shall be NEMA 4 in indoor, dry and non-corrosive locations, and shall be NEMA 4X in outdoor, wet, or corrosive locations. Junction boxes and termination cabinets containing splices shall be labeled "Splice". Provide sufficient conductor and cable slack at junction boxes and termination cabinets to make proper splices, and do not pull splices into conduits.
4. Stranded conductors shall be terminated by lugs or compression type connectors. The connectors shall be crimped with a tool that provides uniform and tight connections. Wrapping stranded conductors around screw type terminals is not acceptable.
5. Splices and terminations of #8 AWG and larger conductors, 600 V rated, shall be with non-insulated compression type connectors. Splices and terminations of #10 and smaller conductors, 600 V rated, shall be with pre-insulated compression type connectors.
6. Non-insulated compression type splice connectors shall be taped with two layers of half lapped liner-less rubber splicing tape and provided with a cold shrink connector insulator sleeve (pre-slipped over the conductor) over the splice connector. Cold shrink insulators shall be as manufactured by 3M Company, or equal.
7. Control conductors shall be spliced with pre-insulated crimp type connectors and terminated with split tongue pre-insulated, crimp type connectors.
8. Terminations and splices in all motor terminal boxes shall be made with compression type connectors. Splices to motor leads in the motor terminal boxes shall be compression lug type with motor splice boots to serve as insulators.
9. Splices in underground manholes and pull boxes will not be allowed.
10. All conductors and cables in electrical panels, MCCs and equipment enclosures shall be neatly bundled and fastened.

C. Grounding

1. Grounding shall be provided as shown on the Drawings and in accordance with the NEC.
2. Where indicated on the Drawings, bare copper conductors shall be installed in a ground ring encircling buildings or structures in direct contact with the earth. The

ground ring shall be placed under building or structure footing and be buried at a depth below the earth's surface of not less than 30". When installed beneath building foundation, provide a minimum 3" earth cover from bottom of footing.

3. Ground rods shall be installed as shown on the Drawings and specified herein. Provide additional rods as applicable to all service entrances, transformers, building/structure ground rings, manholes, pull boxes, etc. as required to obtain a maximum ground resistance of 15 ohms at each location. Ground continuity shall be maintained through all manholes and pull boxes. All metal parts in manholes and pull boxes shall be connected to the grounding system.
4. Copper to copper exothermic welded connections (Cadweld) shall be provided for connections between multiple copper grounding conductors, such as equipment ground conductors, buried ground conductors, and building/structure ground rings. Copper to steel Cadweld connections shall be provided for connections between copper grounding conductors and copper-clad steel ground rods, steel rebar mats, steel pipes, and other steel surfaces as indicated on the Drawings.
5. Where indicated on the Drawings, copper conductors not smaller than #4 AWG shall be connected to steel rebar mats of concrete slabs and building floors to supplement the grounding electrode system. Solid State Decouplers shall be installed to provide cathodic protection between the rebar mats and copper conductors.
6. Enclosures of equipment, raceways and fixtures shall be permanently and effectively grounded. A code-sized, copper, insulated green equipment ground shall be provided for all branch circuit and feeder runs. Equipment grounds shall originate at MCC ground bus and shall be bonded to all junction boxes and electrical equipment enclosures. Similarly, equipment grounds shall originate at panelboard ground bus and shall be bonded to all switch and receptacle boxes, and electrical equipment enclosures. Ground terminals on receptacles shall be connected to the equipment grounding conductor by an insulated copper conductor.
7. All flexible conduits shall be provided with an insulated green copper ground conductor, #12 AWG, unless indicated otherwise on the Drawings.
8. Bonding conductors shall be installed between all raceways, enclosures, wireways, and cable trays.
9. Grounding bushings shall be installed on all conduit terminations, including conduit directly connected to enclosures and conduit stubbed up into block-out areas for free standing enclosures. A bonding conductor, #8 AWG minimum, shall be provided between all conduit ground bushings and enclosure ground.

10. SCE equipment grounding shall be provided and installed as required by SCE.

D. Identification

1. All conductors and cables shall be marked with wire markers at each end and at each intermediate junction box, pull box, manhole or enclosure, except for short "jumper" wires. Wire markers shall indicate the designation/destination of the conductors/cables. Example being-LPA CB1 - REC1 to indicate lighting panel A, circuit breaker #1 to receptacle #1; MCCCCB4 - MTR4 indicating Motor Control Center Breaker #4 to Motor #4; etc.
2. Wire markers for conductors and cables shall be heat shrinkable identification sleeves and translucent shrink tubes, as specified herein.
3. Where more than two conductors run through a single outlet, each circuit shall be marked with the corresponding circuit number at the panelboard.
4. Conductors size #6 AWG and larger shall be color coded using specified phase color markers and shall be provided with identification markers.
5. All terminal strips shall have each individual terminal identified with printed markers.
6. All receptacles and switches shall be provided with plastic decal labels on the cover plate, denoting the lighting panel and circuit number.

3.03 CONDUIT MATERIAL SCHEDULE

The required conduit material(s) for the project shall be as indicated on the Drawings. In addition, Contractor shall comply with the following Conduit Material Schedule for permitted materials for various locations and uses.

Location or Use	Conduits Permitted
Underground (not under building slabs, foundations, or concrete slabs on grade)	Concrete encased PVC conduit with PVC-RGS or PVC-RA conduit for horizontal bends, 90 degree stub ups and risers.
Under building slabs, foundations, or concrete slabs on grade	PVC (see below for concrete footing requirements)
¹ .In building concrete slab (if min. 12" thick) or concrete footings	PVC-RGS, PVC-RA conduit (min. 1" clearance to all rebar)
¹ . In concrete walls or masonry walls	PVC, PVC-RGS, PVC-RA
In steel stud or wood stud walls	RGS, RA
In ceiling or attic space	RGS, RA
Exposed outdoors	RGS, RA
Exposed outdoors, corrosive locations	PVC-RGS, PVC-RA
Exposed outdoors, hazardous locations	PVC-RGS, PVC-RA
Exposed indoors, dry locations	RGS, RA, RSS
Exposed indoors, damp or wet locations	PVC-RGS, PVC-RA, RSS
Exposed indoors, corrosive locations	PVC-RGS, PVC-RA
Exposed indoors, hazardous locations	PVC-RGS, PVC-RA
Exposed belowgrade, dry locations	RGS, RA, RSS
Exposed belowgrade, damp or wet locations	PVC-RGS, PVC-RA
Exposed belowgrade, sewage wet wells	RSS

1. Conduit shall be cast in concrete or in masonry walls only where specified on the Drawings.

3.04 CONDUIT

Unless indicated otherwise on the Drawings, conduit shall be installed as specified herein.

A. General

1. Contractor shall install conduit and electrical equipment in locations that will cause minimal interference with the maintenance and removal of mechanical equipment. Conduits and connections are shown schematically on the Drawings. Contractor shall run conduit in a neat manner parallel or perpendicular to walls and slabs, and wherever possible, installed together in parallel runs supported with strut channel support system. All conduits shall be installed plumb, straight, and true with reference to the adjacent work.

2. Unless indicated otherwise on the Drawings, conduits shall be concealed underground, under concrete slabs and footings, or exposed mounted on walls and ceilings. Concealed conduits shall be run in as direct a route as possible and with bends of large radii. Floor penetrations shall be made only at specific approved locations; other penetrations are prohibited.
3. Locations of conduit runs shall be planned in advance of the installation and coordinated with the electrical panel lineup furnished, ductwork, plumbing, ceiling, wall, and footing construction in the same areas. Conduits shall not unnecessarily cross other conduits or pipe, nor prevent removal of nor block access to mechanical or electrical equipment.
4. Minimum conduit size shall be 3/4". Where device or instrument connection size is 1/2", Contractor shall provide the necessary fittings for connection. Alternatively, Contractor may provide 1/2" liquid-tight flexible conduit.
5. Belowgrade (buried) conduit shall be installed with a minimum of 27" cover, including conduit under structures and concrete slabs on grade. Where change in direction is required, long radius elbows shall be installed. Buried conduit shall be installed using approved spacers and cradles. Conduit shall be properly supported/anchored and at sufficient intervals to prevent movement during encasement operations (maximum spacing of 5').
6. Buried conduit shall be completely encased in concrete, including conduit under structures and concrete slabs on grade, and SCE conduit located on District property. Concrete shall be provided with an integral red dye coloring. Provide at least 3 inches of concrete cover from the outside of the conduits to the outside of the encasement. Top of concrete encasement shall be a minimum of 24" below grade. Backfill above concrete encasement shall be compacted to a minimum of 90% relative compaction.

Conduits shall be installed beneath concrete slabs on grade, footings, or trenches with a minimum of 6" clearance between conduit and bottom of concrete. Conduit backfill where installed beneath concrete shall be two sack sand-cement slurry from the top of concrete encasement to subgrade

Conduit shall be cast in concrete or in masonry walls only where specified on the Drawings.

7. Buried conduit shall be supported by modular, interlocking, plastic spacers prior to placing concrete for duct bank encasement. Spacers shall be installed in accordance with the manufacturer's printed instructions and shall be located to maintain a uniform separation between conduits throughout the duct bank alignment.
8. Where power and control/instrumentation conduits are routed in the same duct bank, configure the conduits within the duct bank to provide a minimum separation of 6" between power and control/instrumentation conduits.
9. Prior to installation of conductors in underground conduits, a testing mandrel not less than 6" long and with a diameter 1/4" less than the conduit diameter shall be drawn through after which a stiff bristle brush of the proper size for the conduits shall be drawn through until the conduits are free of all sand and gravel.
11. Where Schedule 40 or Schedule 80 PVC conduit is permitted, horizontal bends and vertical risers and bends shall be PVC-RGS or PVC-RA. Vertical risers and bends shall be completely encased in concrete to finished grade.
12. Where conduit is stubbed through concrete slabs or footings into electrical panels (MCCs, VFDs, switchboards, etc.), a minimum of 1-1/2" clearance shall be provided between rebar and conduit and a minimum of 1" clearance shall be provided between conduits. Adjust rebar spacing as necessary to a maximum of one-half the nominal spacing such that maximum rebar spacing does not exceed 1-1/2 times that specified. The total amount of reinforcing steel shall not be reduced.
13. Prior to installation of conduit, Contractor's submittals for: basic electrical materials, MCCs, VFDs switchboards, panelboards, and control panels shall be accepted by the District.
14. Conduits shall terminate within the respective MCC/electrical panel section, or in adjacent section if additional space is required. Contractor shall adjust location of conduit terminations based on accepted MCC/electrical panel layout.
15. Spare conduits shall be provided with threaded plugs or caps and polyester pull line attached to the threaded plug/cap or enclosure (as applicable).
16. All conduits shall be tightly sealed during construction by use of conduit plugs or "pennies" set under bushings. All conduit in which moisture or any foreign matter has collected before pulling conductors shall be cleaned and dried to the satisfaction of the District.

17. Conduits shall be securely fastened to enclosures, cabinets, boxes, and wireways using hubs and locknuts, and an insulating bushing or specified insulated connectors.
18. All conduits shall be labeled with stainless steel or brass tags as specified herein. Tags shall be stamped with the conduit's number for that respective conduit as indicated on the Drawings. Conduit shall be labeled at both ends and at all intermediate connection points to junction boxes, wireways, pull boxes, and manholes.

Buried conduit shall be labeled within free standing panels, pull boxes, and manholes. Exposed conduit shall be labeled before they enter junction boxes, wireways, wall mounted panels, etc.
19. Aboveground and underground power feed conduits from VFDs to electric motors or from rectifiers to electrical equipment shall be PVC-RGS or PVC-RA.
20. Conduit and device boxes installed abovegrade in buildings shall be surface mounted.
21. Conduit and enclosures shall be installed with a minimum clearance of 12" to hot pipes or surfaces (150°F or higher).
22. Ground conductors shall be installed in all metallic and non-metallic conduits.
23. In addition to grounding conductors, bonding conductors shall be provided on all metallic conduits, device boxes, and enclosures.

B. Liquid-Tight Flexible Metallic Conduit

1. Liquid-tight flexible conduit shall be installed in all locations for connections to equipment, including, but not limited to: motors, HVAC equipment, automatic valves, and similar devices. Liquid-tight flexible conduit length shall not exceed 36" at connections to equipment.
2. Liquid-tight flexible conduit connectors and fittings installed in PVC-RGS or PVC-RA systems shall be PVC coated.
3. A separate ground conductor shall be installed in flexible conduit that does not have an internal copper bonding conductor included by the manufacturer, or where indicated on the Drawings.
4. Stainless steel braided flexible conduit rated for Class 1, Division 1 locations shall be installed in hazardous locations per NEC Article 501 requirements.

C. Rigid Non-Metallic Conduit

1. Schedule 40 or 80 PVC conduit may be used underground where permitted. PVC conduits shall not be run exposed.
2. Ground conductors shall be installed in all non-metallic conduits.
3. Where Schedule 40 or Schedule 80 PVC conduit is permitted, all horizontal and vertical bends, and vertical risers shall be PVC-RGS or PVC-RA. All belowgrade horizontal bends and vertical bends shall be long radius elbows. Bending of straight PVC conduit to avoid installation of the specified PVC-RGS or PVC-RA long radius elbows will not be allowed.
4. Where conduit transition from nonmetallic to metallic is required, provide nonmetallic threaded adapters.

D. Metallic Conduit (RGS and RA)

1. All RGS and RA conduit and fittings in direct contact with the ground, concrete, or grout shall be PVC coated as specified herein. Alternatively, RGS and RA conduit may be protected by double wrapping with 20 mil polyvinyl-chloride (PVC) tape.
2. Defects and scratches on exposed RGS conduit shall be repaired with hot stick galvanizing solder, Galva-Guard, or equal.

E. PVC Coated Metallic Conduit (PVC-RGS and PVC-RA)

1. All device boxes, conduit bodies, cover plates, conduit straps, conduit fittings, and liquid-tight connectors installed in PVC coated metallic conduit systems shall be PVC coated.
2. Cut or damaged PVC coating shall be repaired in strict accordance with the manufacturer's written repair procedures to maintain the integrity of the 40 mil PVC coating system. Repair sprays or paint will not be acceptable.

F. Termination and Joints

1. Conduit shall be joined using specified couplings or transition couplings where dissimilar conduit systems are joined.
2. Conduit terminations at boxes enclosures and boxes shall be water-tight and dust-tight. Conduit terminations shall be made using approved gasketed connectors and hubs.

3. Expansion couplings shall be installed where any conduit crosses a building separation joint.
4. At all conduit terminations and connections to cabinets, boxes and enclosures, etc., conductors shall be protected by a fitting equipped with a plastic bushing having a smoothly rounded insulating surface.

G. Threads

1. All metal conduit cut ends shall be reamed or otherwise finished to remove rough edges.
2. Where conduit is threaded in the field, a standard cutting die with NPT tapered threads (3/4-in. taper per foot) shall be utilized to provide full cut threads. Running threads are not acceptable.
3. All male threads on metallic conduit and fittings shall be coated with a thread lubricant before installing connections. The thread lubricant shall be as specified herein. All connections shall be made watertight.
4. Any exposed threaded surface on RGS conduit shall be thoroughly cleaned with solvent to remove any residual lubricant or other contaminants, and shall then be completely coated with a zinc rich cold galvanizing coating, CRC Zinc-It Cold Galvanize, or equal.

H. Locknuts and Bushings

Locknuts and bushings shall be installed on the threads of metal conduits that enter through close-fit openings in enclosures.

I. Seal Fittings

1. Seal fittings shall be connected to rigid metal conduits in hazardous areas to prevent gases and flames from passing from one area to another through the conduit system. Hazardous areas shall be as defined by NEC, Article 500.
2. Seal fitting locations shall be in accordance with NEC, Article 501.
3. Unless specified otherwise, install seal fittings not less than 4 inches from finish floor or wall, but not more than 18 inches.

J. Stub-Ups

1. Unless indicated otherwise herein or on the Drawings, all indoor and outdoor conduit stub-ups shall be provided with a threaded coupling, and shall extend 2" above slab, grade, or structure.
2. Exposed conduit, stubbing up through floor slabs or slabs on grade into the bottom of exposed panels, cabinets, or equipment, shall be properly aligned and spaced for connection to same, and shall be straight and plumb. Offset rigid conduit or flexible conduit installed with an offset will not be allowed. Conduits shall be installed at sufficient depth below slab to eliminate any part of the bend above top of slab.
3. Where spare conduit is stubbed through concrete slabs adjacent to walls or equipment, conduit shall extend approximately 2" above the top of the concrete slab and shall be provided with a threaded coupling and plug.

Where spare conduit is stubbed through concrete slabs in open floor areas, conduit shall be provided with a threaded coupling and plug installed flush with the finished floor.

K. Conduit Through Roof

Provide a watertight seal around conduits that penetrate through the roof. Coordinate the conduit installation work with the roofing installation.

L. Duct Banks

1. Contractor shall be responsible for layout/configuration of duct banks and coordination of pull box sizes. Proposed duct bank layouts and cross sections shall be submitted to District for review prior to commencing installation. Contractor's as-built drawings shall include cross sections (drawn by Contractor) of all electrical duct banks. Said duct bank cross sections and as-built drawings shall be prepared as the project proceeds and shall be reviewed by Contractor with District at least monthly.
2. Complete as-built electrical duct bank drawings shall be submitted to District upon completion of construction.

M. Labeling

Contractor shall field number and label all conduits and provide complete as-built drawings to District. All conduits within manholes and pull boxes shall be permanently labeled therein and labeled where they stub up to an MCC, switchboard, panelboard, VFD, control panel, cabinet, or junction box. Conduits shall be labeled with brass or stainless steel tags attached to conduit with stainless steel stranded wire.

3.05 CONDUIT FITTINGS, BOXES, AND WIRING DEVICES

Conduit fittings, outlet boxes, wiring devices, and appurtenances shall be installed as indicated on the Drawings, specified herein, and required.

A. Materials

1. Conduit fittings, outlet bodies, outlet boxes, and device boxes shall be constructed of ferrous metal, aluminum, or stainless steel. Materials provided shall be consistent with the conduit material being used (i.e. ferrous metal with RSG conduit, aluminum with aluminum conduit, and stainless steel with stainless steel conduit).
2. Where PVC coated conduit systems are specified, all conduit fittings, outlet bodies, outlet boxes, and device boxes shall be PVC coated.

B. Hubs

1. Enclosures without integral hubs shall be provided with close-fit holes for conduit connections. Conduit connections shall be made with water-tight and dust-tight hubs.
2. Hubs shall be furnished with vibration-proof nuts equipped with grounding screws.
3. All hub ground nuts in an enclosure shall be bonded with a ground conductor (green insulated #12 AWG, minimum) to the enclosure ground.

C. Boxes

1. All outlet boxes and device boxes shall be surface mounted on walls, ceilings, and floors, except where indicated on the Drawings to be concealed and finished flush.

2. Outlet boxes and device boxes specified to be finished flush in concrete, masonry, or gypsum board covered walls shall be furnished with box extensions as necessary to provide a flush finished installation for the box cover plates. Pressed steel boxes shall be wrapped with PVC tape to prevent concrete or grout from entering the box through unused holes or knockouts during placement operations.
3. Cast device boxes shall be provided for all toggle switches and receptacles.
4. No unused openings shall be left in any box. Close-up plugs shall be installed as required to seal openings.
5. Boxes in outdoor, damp, and wet locations shall be provided with gasketed, cast metal cover plates.
6. Device boxes for convenience receptacles and switches in damp locations shall be provided with self-closing, gasketed, cast metal cover plates.
7. Device boxes for convenience receptacles in outdoor and wet locations shall be provided with gasketed, cast metal, weatherproof, extra duty rated, in-use type cover plates.

D. Box Layout

1. Outlet and device boxes shall be installed at the locations and elevations shown on the Drawings or specified herein. Adjustments to locations shall be made as required by structural conditions and to suit coordination requirements of other trades. Where specified to be flush mounted on concrete masonry wall, center box in course of concrete block.
2. Unless indicated otherwise on the Drawings, device boxes for convenience receptacles shall be installed 18" above finished floor or finished grade.
3. Unless indicated otherwise on the Drawings, device boxes for toggle switches shall be installed 48" above finished floor or finished grade.

3.06 MANHOLES AND PULL BOXES

- A. As a minimum, underground manholes and pull boxes shall be sized and located as indicated on the Drawings. Depending on the Contractor's duct bank routings and configurations, additional or larger manholes and pull boxes may be necessary. Manhole/pull box knockout areas shall be sized according to Contractor's duct bank configurations and dimensions. Contractor shall be responsible for coordinating manhole and pull box sizes and knockout dimensions/locations with the manufacturer. All costs for additional, larger, or custom manholes and pull boxes shall be borne by the Contractor.
- B. Place bottom of manholes and pull boxes on 12" thick (minimum) graded 3/4" crushed rock compacted to 95% relative compaction. Unless noted otherwise, provide crushed rock (2' deep by 2' square) beneath each drain sump, and knock out concrete sump bottom for drainage.
- C. Install a continuous waterproof gasket at all manhole and pull box section and slab joints.
- D. Manholes and pull boxes shall be provided with conductor/cable supports as required to support conductors/cables at 3-foot (maximum) intervals. Supports shall be fabricated from hot dipped galvanized or fiberglass strut channel and attached to cast-in channel inserts. Provide glazed porcelain insulators with channel clamps for support channels. Strap conductors/cables to insulators with plastic tie wraps. All phase and ground conductors in each circuit shall be kept together and contained on/in the porcelain insulators. No phase conductors shall be run separate from the other two phases and ground.
- E. All duct bank and conduit penetrations shall be grouted all around with non-shrink grout. Non-shrink grout shall be finished flush with the interior wall surface. All conduits shall be terminated with flush-end bells.
- F. One ground rod shall be provided for each manhole and pull box. Provide a #4/0 bare stranded copper ground wire completely around the inside perimeter of each manhole and pull box, and anchor the ground wire to walls. Connect the ground wire to the ground rod. Bond the bare copper ground wire to any splice shield wires, ground wires, metal cable racks, cover frames, sump frames and other metal items in the manholes. All separate ground wires accompanying circuits shall be grounded in each manhole or pull box passed through.

3.07 CABLE TRAY INSTALLATION AND TESTING

- A. Cable trays shall be installed as indicated on the Drawings and as specified herein. Installation shall be in accordance with equipment manufacturer's instructions, and with recognized industry practices, including NEMA VE-2, to ensure that cable tray equipment comply with requirements of NEC and applicable portions of NFPA 70B.
- B. Coordinate cable tray installation with other electrical work as necessary to properly integrate cable tray work with other work.
- C. Provide sufficient space encompassing cable trays to permit access for installing and maintaining cables.
- D. Cable tray fitting supports shall be located such that they meet the strength requirements of straight sections. Install fitting supports per NEMA VE-2 guidelines, and in accordance with manufacturer's instructions.
- E. Test cable trays to ensure electrical continuity of bonding and grounding connections, and to demonstrate compliance with specified maximum grounding resistance. Testing and test methods shall be in accordance with NFPA 70B, Chapter 18.
- F. Manufacturer shall provide test reports witnessed by an independent testing laboratory of the "worst case" loading conditions outlined in this specification and performed in accordance with the latest revision of NEMA VE-1; including test reports verifying rung load capacity in accordance with NEMA VE-1, Section 5.4.

3.08 PANELBOARDS

Panelboards shall be factory assembled, and shall be installed as indicated on the Drawings and specified herein.

- A. Panelboards shall be installed 6 feet from grade or floor to top of the enclosure.
- B. Provide at least 1/2 inch clearance between the back of the panelboard enclosure and masonry or concrete wall.
- C. Securely attach the panelboard to the wall or support structure with anchor bolts or machine bolts.
- D. Attach locking devices on the handles of branch circuit breakers for the "ON" position as indicated on the Drawings.
- E. Completely type the directory card to identify each connected and spare circuit.
- F. Provide tight connections for all feeder and branch circuit conduit and wiring.

3.09 TRANSFORMERS

- A. Transformers shall be installed in accordance with manufacturer's printed instructions, including minimum clearances for ventilation and cooling. Transformers installed against a wall shall have readily accessible primary and secondary terminals.
- B. Transformers shall be installed on vibration pads designed to suppress the transformer vibrations. Pads shall be selected based on the actual transformer weight and a minimum safety factor of 2:1. Vibration pads shall be located in accordance with the manufacturer's recommendations.
- C. Conduit connections to the transformer shall be with liquid-tight flexible conduit.
- D. During startup and testing, Contractor shall obtain primary and secondary voltage readings, and if necessary, tap connections shall be adjusted to provide the specified nominal supply voltage.

3.10 DISCONNECT SWITCHES

Disconnect switches shall be factory assembled, and shall be installed as indicated on the Drawings and specified herein.

- A. Disconnect switches shall be installed 5 feet from grade or floor to the top of the enclosure.
- B. Securely attach disconnect switches to walls or support structures with anchor bolts or machine bolts.

3.11 SUPPORTS

Unless indicated otherwise on the Drawings, electrical conduit, boxes, enclosures, cabinets, panels, and equipment shall be supported as specified herein.

- A. Install the required strut channels, fittings, clamps, U-bolts, hangers, anchors, hangers, fittings, and other hardware to securely attach and support all the equipment and conduits. Unless indicated otherwise on the Drawings, all support materials shall be steel, malleable iron, or other ferrous metals, and shall be hot dipped galvanized after fabrication. Where indicated on the Drawings, support material shall be fiberglass, stainless steel, or PVC coated steel and malleable iron.
- B. Exposed conduit shall be supported with strut channel, clamps, and hanger supports spaced per NEC requirements (8'-0" maximum spacing) and within 18" of couplings, bends, enclosures, boxes, etc.

- C. Multiple conduit runs shall be supported using "trapeze" hangers, consisting of approved strut channels suspended on 3/8" (minimum) steel rods from beam clamps or ceiling inserts located not more than 8' apart. Sizes of channels and rods shall be selected as recommended by the manufacturer for span and loading conditions.
- D. Unless indicated otherwise on the Drawings, Contractor shall use Type 304 stainless steel fasteners and anchors, including wedge anchors, sleeve anchors, epoxy anchors, machine bolts, etc., for mounting electrical equipment and conduit. No type of explosive anchor will be permitted.
- E. Strut channel shall be neatly cut and provided with squared ends. All burrs shall be removed and sharp edges shall be rounded. Channel ends shall then be treated as follows:
 - 1. Hot dipped galvanized strut channel - solvent clean to remove any contaminants and coat with a zinc rich cold galvanizing coating, CRC Zinc-It Cold Galvanize, or equal.
 - 2. Fiberglass strut channel - seal with fiberglass resin in accordance with the manufacturer's recommendations.
 - 3. PVC coated pre-galvanized strut channel - solvent clean to remove any contaminants and coat with PVC repair coating in accordance with the manufacturer's recommendations.
 - 4. Stainless steel strut channel - no additional treatment required.

3.12 NAMEPLATES

- A. Plastic nameplates shall be positioned and lined-up to provide a neat appearance. They shall be attached to the cleaned metal surfaces of enclosures with stainless steel machine screws or escutcheon pins. Nameplates shall be attached to receptacle and local switch cover plates with an adhesive or equal for circuit identification and placed above the device.
- B. Nameplates shall be installed on all motor control centers, switchboards, panelboards, individually enclosed circuit breakers and disconnect switches, control panels, control stations, junction boxes, termination cabinets, toggle switches, and convenience receptacles.

3.13 CUTTING AND REPAIRING

- A. Where conduit installation requires penetrating existing concrete or masonry structures (walls, floors, or ceilings), Contractor shall core drill the existing structure and fill the remaining annular space with non-shrink grout.
- B. Other demolitions methods for other cutting or removing shall be approved by the District prior to commencing the work. Contractor shall repair all damage to remaining facilities caused said demolition to the satisfaction of the District.

3.14 DISSIMILAR METALS

- A. Where practicable, dissimilar metals in contact anywhere in the system shall be avoided to eliminate the possibility of galvanic action.
- B. Wherever dissimilar metals come in contact, Contractor shall isolate these metals as required with neoprene washers or gaskets.
- C. Where fastening aluminum items, stainless steel bolts shall be used.
- D. Wherever steel and aluminum join, isolation bushings shall be used to separate these dissimilar metals and grounding jumpers shall be provided across these joints.

3.15 WORKMANSHIP

- A. Preparation, handling, and installation shall be in accordance with manufacturer's written instructions and technical data particular to the product specified and/or approved, except as otherwise specified.
- B. Work shall be furnished and placed in coordination and cooperation with other trades.
- C. Work shall conform to the National Electrical Contractors Association Standard of Installation for general installation practice.

3.16 PROTECTION DURING CONSTRUCTION

- A. Conduits, junction boxes, outlet boxes, and other openings shall be kept closed to prevent entry of foreign matter.
- B. Fixtures, equipment, and apparatus shall be covered and protected against dirt, paint, water, chemical or mechanical damage, before and during the construction period.

- C. Damaged fixtures, apparatus, or equipment shall be restored to original condition prior to final acceptance, including restoration of damaged shop coats of paint. Brightly finished surfaces and similar items shall be protected until in service. No rust or damage will be permitted.

3.17 CHECKING, ADJUSTING AND TESTING

Provide the required labor and equipment, and all checking, adjusting and testing operations on the electrical installations.

- A. Check

All wire terminals shall be checked to assure tight connections.

- B. Adjust

Adjust repeat cycle timers, interval timers and time delay relays and other devices so the controls shall operate in the indicated sequence.

- C. Wiring Tests

The tests shall be performed to detect wrong connections, short circuits, continuity and grounds. Insulation tests shall be made with a hand crank or battery operated test instrument on all cables, conductors and motors. Power feeders branch conductors and motors shall be tested phase-to-phase, and phase-to-ground. A copy of the test results for feeders and motors shall be submitted to the District when completed (after any deficiencies have been noted and corrected). Correct any installation and electrical defects in the wiring systems.

- D. Equipment Tests

Perform equipment tests as indicated and directed by the manufacturer, and as specified in Section 16010 and Sections of the Specification specifying equipment and/or systems.

- E. Test Data

Test data for equipment, shielded cables and supply voltage shall be submitted to the District.

- F. Supply Voltage

Test the supply voltage while the normal plant loads are operating. If the voltage is not within normal limits (plus or minus one percent), notify the District.

G. Operation Tests

Perform operation tests and observe that all electrical loads operate satisfactorily as specified in Section 16010 and Sections of the Specifications specifying equipment and/or systems.

3.18 CLEANUP

- A. All parts of the electrical materials and equipment shall be left in a clean condition. Exposed parts shall be clean of cement, plaster and other materials, and all oil and grease spots shall be removed with a non-flammable cleaning solvent. Such surfaces shall be carefully wiped and all cracks and corners scraped out. Paint touch-up shall be applied to all scratches on panels and cabinets. Interiors of electrical cabinets or enclosures shall be free of spider webs and shall be vacuumed clean.
- B. During the progress of the work, the Contractor shall clean up after his workers and shall leave the premises and all portions of the site in which he is working free from debris and surplus materials.

END OF SECTION 16050

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