

SECTION 16000

GENERAL PROVISIONS

PART 1 GENERAL

1.1 PERMITS, FEES AND SERVICE CHARGES

- A. The CONTRACTOR shall obtain all electrical permits required to complete the work and pay all associated fees.
- B. The CONTRACTOR shall coordinate and provide for the installation and operation of franchise utility service (including any telephone and/or leased lines specified) as required during construction, startup, testing, and operation of the work until substantial completion.

1.2 INTENT OF DRAWINGS AND SPECIFICATIONS

- A. Riser and other diagrams are schematic and are intended to show the approximate location of equipment, and the general alignment of conduits and piping, and shall not be used for obtaining quantities. Dimensions given on the plans shall take precedence over scaled dimensions and all dimensions whether in figures or scaled, shall be verified in the field.
- B. The electrical drawings do not show complete details of the site conditions. The CONTRACTOR shall check actual conditions.
- C. The exact location of apparatus, fixtures, equipment, conduit and piping shall be ascertained by the CONTRACTOR in the field, and the work shall be laid out accordingly. Should the CONTRACTOR fail to ascertain such locations or coordinate with work performed by other trades, the work shall be changed at no additional cost to the OWNER when so ordered by the ENGINEER. The ENGINEER reserves the right to make minor changes in the location of conduit, piping and equipment up to the time of installation without additional cost to OWNER.
- D. CONTRACTOR shall provide all labor, materials, equipment, machinery, and tools necessary to provide all electrical equipment specified and shown on the Drawings. All items not specified in detail or shown on the Drawings but necessary for complete installation shall be provided by the CONTRACTOR.

1.3 SUBMITTALS

- A. Contractor shall submit all the product data in Division 16 at the same time. Piecemeal submittals will be rejected as incomplete.
 - 1. The product data shall be bound in a three ring binder with tabs for each Section. The tabs shall be numbered to match the specification Section numbers. Submittals not bound and labeled as specified will be rejected as incomplete.

APPENDIX A: ELECTRICAL TECHNICAL SPECIFICATIONS

2. A submittal is required for each product specified. Each individual product submittal shall have the corresponding Reference Keynote Number (example - 16000.A01) typewritten in the upper right hand corner of the submittal. The submittals within each Section tab shall be in the same sequential order as they are listed in the specification Section. Submittals not containing the Reference Keynote Number will be rejected as incomplete.
 3. No typical submittals will be accepted. Each submittal shall be project specific and clearly identify specifically which components or parts are being submitted for approval. Any product submittals, such as a catalog sheet, which do not clearly identify which components or parts are being submitted for approval, will be rejected as incomplete.
- B. Submittals shall be in accordance with the requirements of these Contract Documents and shall include the following:
1. Submittals shall include information and literature as required for all equipment and materials provided under this and related sections.
 2. Shop Drawings: Shop drawings shall include the following along with any special requirements listed in the individual Specification Sections:
 - a. Installation instructions and drawings
 - b. Wiring schematics with termination point identification
 - c. Motor information
 - d. Materials of construction
 - e. Manufacturer's name and model
 - f. Manufacturer's catalog data
 - g. Supplementary structural framing for electrical equipment including design loads, member size and location. When supplementary framing is indicated, verify that dimensions are suitable for the equipment furnished. Provide additional strength when equipment furnished is heavier than that specified.
 3. Manufacturers' Literature: Literature indicating the compliance of the products with the Specifications shall be included with all submittals. This shall include catalogs and other descriptive bulletins. Relevant portions of the literature shall be clearly identified by highlighting or underlining.
 4. Test Logs: The CONTRACTOR shall submit test logs as outlined below and as specified in subsequent electrical sections and drawings.
 - a. A log of the complete results of tests for shorts and grounds for each circuit. All circuits and tests shall be clearly identified.
 - b. A log of complete results of insulation resistance measurements of each circuit. All circuits and tests shall be clearly identified.
 5. Operation and maintenance information for all equipment furnished and/or installed.
 6. Programming instructions for any controllers or other programmable equipment. Copies of the any required software, including registration cards, shall be provided with the O&M manuals.
- C. The CONTRACTOR shall indicate on the submittals all variances from the Specifications.

- D. Record Drawings. After the completion of construction, the CONTRACTOR shall provide one set of “as-built” drawings to the ENGINEER as specified herein showing the location of buried conduits and all changes or deviations from the original drawings.
- E. After the completion of construction, a printout and electronic copy of any programming and/or set-points for controllers, PLCs, meters or other programmable equipment, including VFDs.
- F. Final inspection certificates shall be submitted prior to final payment.

1.4 COORDINATION OF WORK

- A. The CONTRACTOR shall plan his work in coordination with the other trades and with the power and telephone utility authorities.
- B. The CONTRACTOR shall field verify all dimensions of equipment to be installed or provided by others so that correct clearances and connections may be made between the work installed by the CONTRACTOR and equipment installed or provided by others.
- C. The CONTRACTOR shall arrange all conduit runs so that they do not interfere with piping, structural members, etc.
- D. All working measurements shall be taken from the sites, checked with those shown on the drawings, and if they conflict, reported to the ENGINEER at once, and before proceeding with the work. Should the CONTRACTOR fail to comply with this procedure, he shall alter his work at his own expense as directed by the ENGINEER.
- E. No additional payments will be allowed where obstructions in the work of other trades, or work under this contract requires offsets to conduit runs.
- F. The CONTRACTOR is responsible for all alterations in the work to accommodate equipment differing in dimensions or other characteristics from that shown or specified.
- G. The CONTRACTOR shall provide all temporary power necessary for existing site equipment and for all construction needs.

1.5 SUPERVISION

- A. The CONTRACTOR shall maintain adequate supervision of the work and shall have a responsible person in charge at the site during all times that work under this contract is in progress, or when necessary for coordination with other work.

1.6 CODES

- A. Work shall conform to the National Electrical Code (NEC), and State Codes and other applicable codes, even though not specifically mentioned for each item. These shall be regarded as the minimum standard of quality for materials and workmanship.

1.7 CONTRACTOR'S RECORD DRAWINGS & AS-BUILTS

- A. The CONTRACTOR shall maintain a neatly marked set of record drawings showing the locations of all buried conduits and other utilities encountered or installed during construction. The final locations of panels, field mounted instruments and panels, terminal boxes, junction boxes, receptacles, light switches and other materials included in the work shall be shown, as well as conduit routing between them to the extent it differs from the design drawings. Record drawings shall be kept current with the work as it progresses and shall be subject to inspection by the OWNER's Representative at any time. Failure to keep field record drawings current may result in the issuance of a stop work order or delay in the processing of pay requests until the record drawings are made current.
- B. The CONTRACTOR shall provide one complete set of as-built electrical schematics for all panels and equipment provided, including PLC I/O schematics as applicable, panel elementary diagrams, interconnecting wiring diagrams, wire numbers, termination strip locations and numbers. These shall be in the same format and style as those in the Contract Documents and submittal requirements.
- C. All information shown on the CONTRACTOR's field record drawings and as-built schematics shall be subject to verification by the OWNER's Representative. If significant errors or deviations are noted by the OWNER's Representative, new as-builts shall be completed at the CONTRACTOR's expense.

PART 2 PRODUCTS

2.1 PORTABLE OR DETACHABLE PARTS

- A. The CONTRACTOR shall retain in his possession and shall be responsible for all portable and detachable parts or portions of installations such as fuses, key locks, adapters, blocking chips and inserts until completion of his work.
- B. These parts shall be delivered to the ENGINEER and an itemized receipt obtained. This receipt, together with 2 copies of the final inspection certificate, shall be attached to the CONTRACTOR's request for final payment.
- C. All equipment shall be demonstrated to operate in accordance with the requirements of this specification and the manufacturer's recommendations.

2.2 NEW PRODUCTS

- A. All products shall be new without defects and covered by Manufacturer's warranty. Products shall be re-used only where indicated on the Drawings.
- B. All products shall be listed, labeled, and certified by a testing agency approved by the state of Oregon.
- C. All equipment of the same type and capacity shall be by the same manufacturer.

PART 3 EXECUTION

3.1 IDENTIFICATION

- A. All identification labeling shall be in compliance with Section 16075 Electrical and Control Identification.

3.2 WORKMANSHIP & COORDINATION

- A. All work shall be performed by personnel skilled in the particular trade in a workmanlike manner. Workmanship shall conform to the standards of the NEC and the National Electrical Installation Standards (NEIS).
- B. The ENGINEER shall be the sole judge as to whether or not the finished work is satisfactory; and if in his judgment any material or equipment has not been properly installed or finished, the CONTRACTOR shall replace the material or equipment whenever required, and reinstall it in a manner entirely satisfactory to the ENGINEER without any increase in cost to the OWNER.
- C. The CONTRACTOR shall coordinate and verify the installation of all equipment furnished by him to other trades, or equipment provided and installed by other trades that is connected to the electrical or control systems. Work shall include the furnishing of all labor, materials, and equipment required for the installation of a complete and operable system as hereinafter specified and as indicated on the drawings. The Contract Documents are complementary and what is called for by any one shall be as binding as if called for by all. Unless otherwise specifically stipulated, the term "furnished and installed complete" shall be considered a part of this section.
- D. Controls and systems shall be complete with transformers, switches, relays, contactors, control valves, control devices, instrument piping, fittings, valves, control wiring, thermometers, pressure gauges, thermostats, damper operators, miscellaneous control cabinets to fill the intent of the Specifications and shall provide control for the various units and systems. All control valves and motorized dampers shall be provided with position indicators.
- E. Unless otherwise specified or shown on the drawings, switches or relays shall be installed in, or adjacent to the motor starter or other electrical device to which they are to be connected. Control and interlock wiring shall be included as necessary from breakers specified herein or shown on the drawings.
- F. Each control schematic intended to control a series of motor operated louvers, fans, and thermostats shall contain a switch for maintenance to meet the NEC requirements regarding disconnect switches for motors. This switch shall be local if any unit controlled is out of sight of the switch. This switch shall disconnect all power to all motor operated devices within the circuit.

3.3 TEMPORARY HEATING, LIGHTING AND POWER

- A. The CONTRACTOR shall provide all heat, lighting and power required to construct and protect the work until the work is placed in service by the OWNER for beneficial use of the OWNER. Temporary heaters shall be provided as required to keep the work area and all new electrical components dry.
- B. The source for temporary power shall be from the electric utility or OWNER approved CONTRACTOR supplied auxiliary power units. The installation for electric power shall meet the requirements of local authorities and of OSHA.
- C. The CONTRACTOR shall obtain all permits and pay all costs for connecting temporary power service at no expense to the OWNER.

3.4 SUPPORT BACKING

- A. Provide any necessary backing required to properly support all fixtures and equipment installed under this contract.

3.5 CUTTING, PATCHING AND FRAMING

- A. The CONTRACTOR shall determine in advance the locations and sizes of all sleeves, chases, and openings necessary for the proper installation of his work.
- B. Whenever practical, inserts or sleeves shall be installed prior to covering work. Cutting and patching shall be held to a minimum. All required holes in concrete construction shall be made with a core drill and patched with non-metallic non-shrink grout.
- C. Cutting, fitting repairing and finishing of carpentry work, metal work, or concrete work, and the like, which may be required for this work shall be done by craftsmen skilled in their respective trades. When cutting is required, it shall be done in such a manner as not to weaken walls, partitions, or floors; and holes required to be cut in floors must be drilled without breaking out around the holes.

3.6 TESTS

- A. The CONTRACTOR shall furnish all labor, material, instruments and tools to make all connections for testing of the electrical and instrumentation installation. All equipment shall be demonstrated as operating properly prior to the acceptance of the work. All protective devices shall be operative during testing of equipment. The tests shall be made under the supervision of the ENGINEER. All deficiencies or unsatisfactory conditions as determined by the ENGINEER or inspecting authorities shall be corrected by the CONTRACTOR in a satisfactory manner at his own expense.
- B. After visual inspection of joints and connections and the application of tape and other insulating materials, all sections of the entire wiring system shall be thoroughly tested for shorts and grounds. A log of results for each circuit shall be kept by the CONTRACTOR and presented to the ENGINEER.

APPENDIX A: ELECTRICAL TECHNICAL SPECIFICATIONS

- C. A phase rotation check shall be made to demonstrate that all power receptacles, service feeders, main power feeders and auxiliary power generators have the same A - B - C phase rotation and ground relationships.
- D. Equipment shall be tested by operating all electric motors, relays, controls, switches, heaters, etc., sufficiently to demonstrate proper installation and electrical connections. Control and emergency conditions shall be artificially simulated where necessary for complete system or subsystem.

3.7 CLEANING AND TOUCH-UP PAINT

- A. Upon completion of work, all electrical equipment shall be cleaned.
 - 1. Vacuum all dirt, metal shavings, and foreign materials from all enclosures. The use of compressed air shall not be acceptable.
 - 2. All stains, dirt, and fingerprints shall be removed from switchboards, motor control centers, panelboards, light fixtures, enclosures, and all other electrical equipment covers.
- B. Provide touch-up paint on equipment that has been scraped, scratched, or chipped during construction. Paint color shall match color of equipment.

END OF SECTION

SECTION 16057

ELECTRICAL SYSTEMS ANALYSIS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. The section includes the requirements for a Short-Circuit Study, Protective Device Coordination Study, Arc Flash Study, and Arc Flash Warning Labels.

1.2 REFERENCES

A. Referenced Standards:

1. American National Standards Institute (ANSI).
2. Institute of Electrical and Electronics Engineers (IEEE):
 - a. 242, Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.
 - b. 399, Recommended Practice for Industrial and Commercial Power System Analysis.
 - c. 1584, Guide for Performing Arc Flash Hazard Calculations.
3. National Electrical Manufacturers Association (NEMA): Z535.4, Product Safety Signs and Labels.
4. National Fire Protection Association (NFPA):
 - a. 70, National Electrical Code (NEC).
 - b. 70E, Standard for Electrical Safety in the Workplace.
5. Occupational Safety and Health Standards (OSHA): 29 CFR, Part 1910, Subpart S, Electrical.

1.3 SUBMITTALS

- A. Contractor shall submit all the product data in Division 16 at the same time. Piecemeal submittals will be rejected as incomplete.
1. The product data shall be bound in a three ring binder with tabs for each Section. The tabs shall be numbered to match the specification Section numbers. Submittals not bound and labeled as specified will be rejected as incomplete.
 2. A submittal is required for each product specified. Each individual product submittal shall have the corresponding Reference Keynote Number (example - 16057.S21) typewritten in the upper right hand corner of the submittal. The submittals within each Section tab shall be in the same sequential order as they are listed in the specification Section. Submittals not containing the Reference Keynote Number will be rejected as incomplete.
 3. No typical submittals will be accepted. Each submittal shall be project specific and clearly identify specifically which components or parts are being submitted for approval. Any product submittals, such as a catalog sheet, which do not clearly

identify which components or parts are being submitted for approval, will be rejected as incomplete.

- B. Product Data:
 - 1. Pursuant to 01300 Submittal Procedures.
 - 2. Arc Flash Warning Label templates.

1.4 QUALITY ASSURANCE

- A. Short circuit and arc flash studies shall be provided by a corporately and financially independent, unbiased, testing authority. The testing authority shall be independent of manufacturers, suppliers, and installers of equipment being tested. The testing authority shall have a minimum of five (5) years experience testing similar projects.

1.5 SEQUENCING AND SCHEDULING

- A. Initial complete protective device coordination and arc flash studies shall be submitted within 90 days after approval of initial short circuit study.
- B. Revised short circuit, protective device studies, arc flash studies, and arc flash labels shall be submitted 10 days before energizing electrical equipment.
- C. Final short circuit, protective device studies, and arc flash studies shall be completed prior to project completion. Final version of study shall include as-built equipment, materials, and parameter data or settings entered into equipment based on study.
- D. Submit final arc flash labels described herein and in compliance with NEMA Z535.4 prior to project completion.

1.6 GENERAL STUDY REQUIREMENTS

- A. The Study shall pertain only to the electrical equipment related to the project. The equipment required to be modeled in the Study is shown on the Drawings and identified as follows:
 - 1. Electrical Service
 - 2. Control Panel
- B. The CONTRACTOR shall be responsible for providing all information to the Agent responsible for performing the Study. At minimum, the CONTRACTOR shall provide the following:
 - 1. Service transformer nameplate information
 - 2. Service entrance feeder conductor size, type, length and feeder conduit size, type, and length.
 - 3. Service entrance equipment nameplate information.
 - 4. Motor load nameplate information.
 - 5. Distribution feeder size, type, and length.
 - 6. Overcurrent protection device nameplate information and trip settings.
 - 7. Panelboard nameplate information.

8. Any other information requested by the testing Agent.
- C. Equipment and component titles used in the studies shall be identical to equipment and component titles shown on the Drawings.
- D. Perform studies using one of the following electrical engineering software packages:
 1. SKM Power Tools for Windows
 2. ETAP
 3. EDSA
 4. Easy Power
- E. Perform complete fault calculations for all new and future loads indicated on the Drawings.
- F. Provide individual protective device time-current characteristics for the low voltage distribution system.

PART 2 STUDIES AND PRODUCTS

2.1 SHORT CIRCUIT STUDY

- A. General
 1. Prepare a Short Circuit Study in accordance with IEEE 39.
 2. Cable impedances shall be based on copper conductors.
 3. Bus impedances shall be based on copper buses.
 4. Cable and bus resistances shall be calculated at 25 degrees Celsius.
 5. Medium voltage cable reactance shall be based on typical dimensions for standard cables with 133% insulation levels.
 6. 600-volt cable reactance shall be based on the typical dimensions of THWN-2 conductors.
 7. Transformer impedances shall be 92.5% of nominal impedance based on tolerances specified in IEEE C57.12.00.
- B. The Short Circuit Study final report shall include the following:
 1. Basic description, purpose, and scope of the study.
 2. Descriptions of the scenarios evaluated and identification of the scenario used to evaluate short circuit ratings.
 3. Explanation of bus and branch numbering system.
 4. Prevailing conditions.
 5. Selected base per unit quantities.
 6. Source impedance data, including electric utility system, generator, and motor fault contribution characteristics.
 7. Impedance diagrams.
 8. Zero-sequence impedance diagrams.
 9. One line diagrams and associated tabulations of data used to model the system components.
 10. Calculation methods and assumptions.

11. Typical calculations.
 12. Tabulation of calculation quantities.
 13. Results, conclusions, and recommendations.
- C. The short circuit interrupting and momentary (when applicable) duties for an assumed three-phase bolted fault shall be calculated at each:
1. Utility Service point.
 2. Medium Voltage Switchgear.
 3. Low Voltage Switchgear.
 4. Switchboard.
 5. Motor Control Center.
 6. Automatic Transfer Switch.
 7. Distribution Panel.
 8. Branch Circuit Panelboard.
 9. Future load contributions as shown on the One-Line Diagram.
 10. Any additional point within the power distribution system as specified by the Engineer.
- D. The Short Circuit Study shall be used to verify the following:
1. Equipment and protective devices are applied within their ratings.
 2. Adequacy of distribution equipment bus bars to withstand short circuit stresses.
 3. Cable and bus way sizes for ability to withstand short circuit heating, in addition to normal current loads.
- E. Provide a tabulation of equipment short circuit versus available fault duties. The tabulation shall identify percentage of rated short circuit current and clearly identify equipment with insufficient ratings.
1. General Data
 - a. Short circuit reactance of rotating machines.
 - b. Cable and conduit material data.
 - c. Bus data.
 - d. Transformer data.
 - e. Circuit resistance and reactance values.
 2. Short Circuit Data
 - a. Fault impedances.
 - b. X/R ratios.
 - c. Asymmetry factors.
 - d. Motor contributions.
 - e. Short circuit kVA.
 - f. Symmetrical and asymmetrical fault currents.
 3. Equipment Evaluation
 - a. Equipment bus bracing, equipment short circuit rating, transformer, cable, busway.
 - b. Maximum fault current available.
- F. Provide a written summary at the end of the Short Circuit Study, which shall include the following:

1. Selected equipment deficiencies.
 2. Results of short circuit study.
 3. Conclusions and recommendations.
- G. The Contractor shall be notified in writing of existing circuit protective devices improperly rated for new fault conditions.
- H. The Short Circuit Study data shall be revised for as-built conditions.

2.2 ARC FLASH STUDY

- A. Perform an Arc Flash Hazard Study after short circuit and protective device setting recommendations have been completed, reviewed, and accepted by the Engineer. Perform the analysis under worst-case arc flash conditions for all modes of operation. Provide an analysis of all operating scenarios which will be or have been influenced by the proposed or completed additions to the subject system.
- B. The Arc Flash Hazard Study shall be performed in accordance with NFPA 70E, OSHA 29 CFR, Part 1910 Subpart S, and IEEE 1584.
- C. The Arc Flash Hazard Study shall include the following:
1. Basic description, purpose, and scope of the study.
 2. One Line Diagram.
 3. Short Circuit Study.
 4. Protective Device Settings Study.
 5. Calculation methods and assumptions.
 6. Typical calculation.
 7. Evaluation summary spreadsheet.
 8. Conclusions and recommendations.
- D. Base Calculation: For each major part of the power distribution system, the following shall be determined:
1. Flash hazard protection boundary.
 2. Limited approach boundary.
 3. Restricted approach boundary.
 4. Prohibited approach boundary.
 5. Incident energy level.
 6. Personal protection equipment (PPE) hazard/risk category.
 7. Type of PPE required.
- E. Produce arc flash warning labels that list items in Part C above and provide the following additional items:
1. Bus name.
 2. Bus voltage.
- F. Produce detail sheets that list items in Part C above and the following items:
1. Bus name.
 2. Upstream protective device name, type, and settings.

3. Bus-to-line voltage.
- G. Produce arc flash evaluation summary sheet listing the following additional items:
1. Bus name.
 2. Upstream protective device name, type, and settings.
 3. Bus-to-line voltage.
 4. Protective device bolted fault current.
 5. Arcing fault current.
 6. Protective device trip/delay setting.
 7. Breaker opening time.
 8. Solidly grounded column.
 9. Equipment type.
 10. Gap.
 11. Arc flash boundary.
 12. Working distance.
 13. Incident energy.
 14. Required protective fire rated clothing type and class.
- H. Analyze short circuit, protective device coordination, and arc flash calculations and highlight equipment that is determined to be underrated or causes incident energy values greater than 40 cal/cm². Provide proposals to reduce energy levels.
- I. Provide a written summary at the end of the Arc Flash Hazard Study, which shall include the following.
1. Equipment manufacturer's information used to prepare study.
 2. Assumptions made during study.
 3. Copy of one line diagram.
 4. Arc flash evaluations summary spreadsheet.
 5. Bus detail sheets.
 6. Arc flash warning labels printed in color on adhesive backed labels.

2.3 ARC FLASH WARNING LABELS

- A. Provide arc flash warning labels per NEC 110.16
- B. All identification labeling shall be in compliance with Section 16075 Electrical and Control Identification.

PART 3 EXECUTION

3.1 GENERAL

- A. Adjust relay and protective device settings according to reduce arc flash while maintaining coordination between downstream circuit breakers and the upstream main circuit breaker.

APPENDIX A: ELECTRICAL TECHNICAL SPECIFICATIONS

- B. Perform minor modifications to equipment as required to accomplish conformance with short circuit study.
- C. Notify Contractor in writing of required major equipment modifications.
- D. Provide laminated one-line diagrams (minimum size 11" x 17") to post on interior of electrical room doors.
- E. Provide arc flash warning labels on equipment as specified on this Section.

END OF SECTION

SECTION 16060

GROUNDING AND BONDING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes.

1. The section includes requirements for grounding electrodes, equipment grounding and electrical bonding.

1.2 SUBMITTALS

A. Contractor shall submit all the product data in Division 16 at the same time. Piecemeal submittals will be rejected as incomplete.

1. The product data shall be bound in a three ring binder with tabs for each Section. The tabs shall be numbered to match the specification Section numbers. Submittals not bound and labeled as specified will be rejected as incomplete.
2. A submittal is required for each product specified. Each individual product submittal shall have the corresponding Reference Keynote Number (example - 16060.G01) typewritten in the upper right hand corner of the submittal. The submittals within each Section tab shall be in the same sequential order as they are listed in the specification Section. Submittals not containing the Reference Keynote Number will be rejected as incomplete.
3. No typical submittals will be accepted. Each submittal shall be project specific and clearly identify specifically which components or parts are being submitted for approval. Any product submittals, such as a catalog sheet, which do not clearly identify which components or parts are being submitted for approval, will be rejected as incomplete.

B. Product Data

1. Pursuant to Section 01300 Submittal Procedures.
2. Manufacturer's data including materials of construction, methods of installation and related information for each item specified in PART 2 PRODUCTS.

PART 2 PRODUCTS

2.1 MATERIALS

A. **Ground Rods (16060.G01)**

1. Ground rods shall be provided as shown on the drawings.
2. Ground rods shall be copper clad.
3. Ground rods shall be a minimum of 5/8 inch diameter.
4. Ground rods shall be a minimum of 10 feet long.
5. Compression Connectors (16060.C20).

6. Compression connections shall be provided as shown on the drawings and as required for bonding end-use equipment.
7. Compression connections shall be compress-deforming type, extruded copper material.
8. Compression connections shall be tin electroplated for corrosion resistance.
9. Compression connections shall be ring-type connectors. Forked connectors shall not be used on grounding conductors.
10. Provide Burndy products, or approved equal

B. Compression Connectors (16060.C20).

1. Compression connections shall be provided as shown on the drawings and as required for bonding end-use equipment.
2. Compression connections shall be compress-deforming type, extruded copper material.
3. Compression connections shall be tin electroplated for corrosion resistance.
4. Compression connections shall be ring-type connectors. Forked connectors shall not be used on grounding conductors.
5. Provide Burndy products, or approved equal.

PART 3 EXECUTION

3.1 INSTALLATION

A. General.

1. All identification labeling shall be in compliance with Section 16075 Electrical and Control Identification.
2. Maintain equipment ground continuity throughout the facility by means of a grounding conductor routed in all raceways.
3. Provide grounding conductors pursuant to Section 16121. Conductors shall be copper and shall be sized per the Drawings or the NEC, whichever is greater.
4. Provide ground bushings for all conduits that do not terminate in a hub type fitting and install at the source of power with a bonding conductor fastened to the ground bushing.
5. Provide ground bar kits as shown on the Drawings and where two (2) or more grounding conductors are terminated in a box or enclosure.
6. Install ground rods at the locations and in the number shown on the Drawings or per the NEC, whichever is greater.
7. Bond the grounding electrode system to all metallic water and wastewater piping.

B. Grounding Conductors.

1. Brush grounding conductors clean of debris before connections are made.
2. Strip insulated conductor insulation in a neat, workman like manner where insulated conductors are used.
3. Fasten all conductors securely.

C. Connections.

APPENDIX A: ELECTRICAL TECHNICAL SPECIFICATIONS

1. Install connectors according to the manufacturer's directions, using the proper dies, tools, molds, shots, loads, etc. designed specifically for this purpose.
2. Provide compression connector type connections to end use equipment and bolt to the equipment using washers and split lock washers for secure fastening. Bolts shall be grade 5 for grounding connections and shall be tightened to the manufacturer's recommend torque.

END OF SECTION

SECTION 16070

HANGERS AND SUPPORTS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. This section includes requirements pertaining to electrical equipment anchoring and electrical equipment hanging and support.

1.2 SUBMITTALS

A. Contractor shall submit all the product data in Division 16 at the same time. Piecemeal submittals will be rejected as incomplete.

1. The product data shall be bound in a three ring binder with tabs for each Section. The tabs shall be numbered to match the specification Section numbers. Submittals not bound and labeled as specified will be rejected as incomplete.
2. A submittal is required for each product specified. Each individual product submittal shall have the corresponding Reference Keynote Number (example - 16070.H01) typewritten in the upper right hand corner of the submittal. The submittals within each Section tab shall be in the same sequential order as they are listed in the specification Section. Submittals not containing the Reference Keynote Number will be rejected as incomplete.
3. No typical submittals will be accepted. Each submittal shall be project specific and clearly identify specifically which components or parts are being submitted for approval. Any product submittals, such as a catalog sheet, which do not clearly identify which components or parts are being submitted for approval, will be rejected as incomplete.

B. Product Data.

1. Pursuant to Section 01300 Submittal Procedures.
2. Manufacturer's data including materials of construction, equipment weight and related information for each item specified in PART 2 PRODUCTS.

PART 2 PRODUCTS

2.1 MATERIALS

A. **Galvanized Hardware (16070.H11).**

1. Bolts shall be hot dipped galvanized steel and sized for the load served and have a hex head unless specifically specified otherwise elsewhere.
2. Nuts shall be hot dipped galvanized steel hex nut.
3. Washers shall be hot dipped galvanized steel, USS pattern flat washers.
4. Split lock washers shall be hot dipped galvanized steel.

5. Threaded rods and couplings shall be hot dipped galvanized steel.
6. Eye-bolts, u-bolts, bent-bolts and similar connecting hardware shall be hot dipped galvanized steel.

B. Galvanized Anchors (16070.A11).

1. Wedge or stud anchors installed in concrete or masonry shall be hot dipped galvanized steel and sized for the load served.
2. Toggle type fasteners shall only be used in hollow sheetrock wall. The wing part of the fastener may be mild steel, but the bolt shall be hot dipped galvanized steel.

C. Galvanized Strut Channel (16070.S01).

1. Galvanized strut channel shall be hot dipped galvanized after fabrication and shall be a minimum of 12 gauge.
2. Galvanized strut channel shall have factory pre-drilled holes.

PART 3 EXECUTION

3.1 INSTALLATION

A. General.

1. Hardware shall be set to a torque as recommended by the manufacturer.
2. Washers and split lock washers shall be installed on all bolts, threaded rods and anchors.
3. Lead or plastic type anchors are prohibited from use on the project.
4. When threaded rods are installed in drop-in type anchors, a washer, split lock washer and a jamb nut shall be installed at the anchor to ensure stability.
5. When channel (strut) is installed as a hanger or support from threaded rod, washers, split lock washers and jamb nuts shall be installed on both sides of the strut to lock it in place.
6. Cut ends of channel, strut, threaded rods or other cut fittings shall be filed smooth before installation.
7. Cut ends of hot dipped galvanized channel and strut shall be coated with three coats of cold galvanizing compound after the channel has been filed to prohibit rust.
8. Concrete anchors shall be installed as per the manufacturer's directions and set using the manufacturer's supplied tool.
9. Threaded rod shall not extend more than one (1) inch beyond the channel, strut or other material it is supporting.
10. Hangers and supports shall be installed level and plumb.
11. Hangers and supports shall be installed per the National Electrical Code, Building Code and Structural Code and shall be designed to safely support the load. The ENGINEER may request the CONTRACTOR provide a copy of their design calculations for the seismic requirements and the load served.

END OF SECTION

SECTION 16075

ELECTRICAL AND CONTROL IDENTIFICATION

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes

1. Requirements for identification of electrical, safety, measurement, data, fire alarm, security, monitoring, control and related components and equipment.

1.2 SUBMITTALS

A. Contractor shall submit all the product data in Division 16 at the same time. Piecemeal submittals will be rejected as incomplete.

1. The product data shall be bound in a three ring binder with tabs for each Section. The tabs shall be numbered to match the specification Section numbers. Submittals not bound and labeled as specified will be rejected as incomplete.
2. A submittal is required for each product specified. Each individual product submittal shall have the corresponding Reference Keynote Number (example - 16075.S21) typewritten in the upper right hand corner of the submittal. The submittals within each Section tab shall be in the same sequential order as they are listed in the specification Section. Submittals not containing the Reference Keynote Number will be rejected as incomplete.
3. No typical submittals will be accepted. Each submittal shall be project specific and clearly identify specifically which components or parts are being submitted for approval. Any product submittals, such as a catalog sheet, which do not clearly identify which components or parts are being submitted for approval, will be rejected as incomplete.

B. Product Data

1. Pursuant to Section 01330 – Submittal Procedures.
2. The initial submittal shall contain all the products, samples and data base specified. An initial submittal that does not contain all the specified data shall be returned as incomplete.

C. Samples

1. Provide a sample of each type and size of nameplate, label, tag and means of attachment specified for approval by the OWNER.

D. Quality Assurance / Quality Control Submittals

1. The CONTRACTOR shall be responsible for submitting a data base of all identification nameplates, labels, panel schedules and tags required for the Work. The data base shall be developed in the most current edition of Microsoft Excel for the OWNER's future use.

E. Closeout Submittals

1. Pursuant to Section 01780 – Closeout Submittals.
2. As-built electronic copy of the identification Excel data base.

PART 2 PRODUCTS

2.1 MATERIALS

A. **Conduit Trench Marker Tape (16075.T21).**

1. Shall be a minimum of six (6) inches wide, polyethylene tape manufactured for this purpose.
2. Color code for tape shall be as listed below and the verbiage on the tape shall identify the type of system i.e. “Caution Buried Electric Line Below”.
 - a. Electric Power – RED
 - b. Fiber Optic – ORANGE
 - c. Data/Phone – ORANGE
 - d. Control – ORANGE
3. Provide products manufactured by Seaton Identification Products, Harris Industries, or approved equal.

B. **Conductor and Cable Identification Sleeves (16075.T31).**

1. The identification sleeves shall be properly sized for the cable or conductor.
2. Sleeves shall be white with black machine generated characters.
3. Provide Brady wire and cable sleeves, or approved equal.

C. **Arc Flash Labels (16075.A11).**

1. Reference Section 16057 – Electrical Systems Analysis for additional details.
2. Shall be self adhesive and manufactured specifically for this purpose.
3. Shall be four (4) inches high by six (6) inches wide minimum.
4. Shall be based on the latest edition requirements of the National Fire Protection Association (NFPA) 70E – Standard for Electrical Safety.
5. At a minimum the label shall contain the following information.
 - a. Date calculation was performed and who did the calculation.
 - b. Danger or Warning level based on the incident energy. When above 40 cal/cm sq. the label shall read “Danger”.
 - c. Shall identify the hazard as being both arc flash and shock hazard.
 - d. Shall clearly state the incident energy and the level of personal protective equipment (PPE) required.
 - e. Provide labels manufactured by Dura Label, SKM System Analysis, Inc., or approved equal.

D. **Conductor Color Coding (16075.C89).**

1. Conductors shall be colored as specified in the table below. The technical specification requirements for the conductors are specified elsewhere.

Conductor Color Coding

System	Conductor	Color	
All Systems	Equipment Grounding	Green	
IT / Data	Data Cable Sheath (outer cover)	Blue	
24 Volt DC	Positive	Blue	
	Negative	White w/Blue Stripe	
	Discrete Input Line (hot leg) Side	Blue	
	Discrete Input Switch Leg	Blue w/White Stripe	
	Discrete Output Line (hot leg) Side	Blue	
	Discrete Output Switch Leg	Blue w/Orange Stripe	
	24 Volt AC	Hot Leg	Red
		Neutral	White
	Discrete Input Line (hot leg) Side	Red	
	Discrete Input Switch Leg	Red w/Blue Stripe	
	120 Volt AC Control	Hot Leg	Red
		Neutral	White
	Discrete Input Line (hot leg) Side	Red	
	Discrete Input Switch Leg	Red w/White Stripe	
	Discrete Output Line (hot leg) Side	Red	
	Discrete Output Switch Leg	Red w/Orange Stripe	
120/240 Volt Single Phase	Hot Leg # 1	Black	
	Hot Leg # 2	Red	
	Neutral	White	
120/208 Volt Three Phase	Phase A	Black	
	Phase B	Red	
	Phase C	Blue	
	Neutral	White	
120, 208, 277 Volt	Switch Legs	Pink	
480 Volt Three Phase	Phase A	Brown	
Wye or Delta Corner Tap	Phase B	Purple	
	Phase C	Yellow	
	Neutral	Gray	
120/240 Delta Three Phase	Phase A	Brown	
	Phase B	Orange	
	Phase C	Yellow	
	Neutral	Gray	

PART 3 EXECUTION

3.1 INSTALLATION

A. Conduit Trench Marker Tape

1. Provide conduit trench marker tape for single or multiple buried conduits. The color and verbiage shall match the type of system installed. If the trench contains several systems, one of which is electric power, the tape shall be for electric power.
2. The tape shall be installed 12 inches below finished grade and shall be laid flat and parallel to the conduits.
3. Provide # 14 AWG, red, THWN-2 tracer wire fastened to one of the conduits. Tracer wire shall be fastened to the conduit with nylon cable ties at five (5) foot spacing or less. The tracer wire shall be brought up with the conduit to points where it terminates or enters in-ground boxes and vaults. The tracer wire shall be fastened above ground with stainless steel cable ties. Label the wire "tracer wire" and seal the end so water cannot penetrate with a heat shrink tubing type cap.

B. Conductor and Cable Identification Sleeves

1. Provide heat shrink, machine generated, white labels with black characters for all cables and conductors. Explanation is provided below on how various systems shall be identified. In many cases the information necessary to develop the unique identification labels will be provided on the Contract Drawings. The verbiage required for the identification shall be as identified on the Contract Drawings. The CONTRACTOR shall request the required verbiage from the ENGINEER should it not be available or clear based on the information provided on the Contract Drawings.
2. The labels shall be installed between 6 to 8 inches from the end and shrunk. Conductors shall be labeled at all splices and points of termination.
3. Power conductors and cables, including the neutral and the ground conductors shall all be identified individually. The identification label will be developed as follows: The first set of characters will be the equipment code identifying the source of power "PNL208" followed by the circuit number "CKT 12" and a forward slash followed by the room number where the utilization is located and then the utilization equipment. Using the first sequential unit heater in room 2334 as an example, the label would read "PNL208-CKT 12/ 2334-UH-1".
4. Control conductors, including grounds, shields, etc. shall be identified individually. The label shall identify the point of origin and the utilization equipment it serves. The identification label will be developed as follows: An sample label for a conductor fed from terminal strip 2, terminal block 33 in control panel # 1 (CP-1) to an terminal strip 1, terminal block 4 in automatic transfer switch # 1 (ATS-1) would read CP-1 TS2-TB33 / ATS-1 TS1-TB4.

END OF SECTION

SECTION 16095

MINOR ELECTRICAL DEMOLITION

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes.
 - 1. Removal of existing electrical equipment, wiring and conduit in areas to be remodeled. Removal of designated construction, dismantling, cutting and alterations for completion of the Work.
 - 2. Disposal of materials.
 - 3. Storage of removed materials.
 - 4. Identification of utilities.
 - 5. Salvaged items.
 - 6. Protection of items to remain as identified in the schedules at the end of this Section.
 - 7. Relocate existing equipment.
 - 8. Removal of temporary electrical equipment prior to completion of the Work.

1.2 SUBMITTALS

- A. Contractor shall submit all the product data in Division 16 at the same time. Piecemeal submittals will be rejected as incomplete.
 - 1. The product data shall be bound in a three ring binder with tabs for each Section. The tabs shall be numbered to match the specification Section numbers. Submittals not bound and labeled as specified will be rejected as incomplete.
 - 2. A submittal is required for each product specified. Each individual product submittal shall have the corresponding Reference Keynote Number (example - 16955.S21) typewritten in the upper right hand corner of the submittal. The submittals within each Section tab shall be in the same sequential order as they are listed in the specification Section. Submittals not containing the Reference Keynote Number will be rejected as incomplete.
 - 3. No typical submittals will be accepted. Each submittal shall be project specific and clearly identify specifically which components or parts are being submitted for approval. Any product submittals, such as a catalog sheet, which do not clearly identify which components or parts are being submitted for approval, will be rejected as incomplete.
- B. Product Data.
 - 1. Pursuant to Section 01300 Submittal Procedures.
 - 2. Manufacturer's data including materials of construction, methods of installation and related information for each item specified.
- C. Shop Drawings.

1. Provide shop drawings indicating the location and construction of temporary work. Describe demolition procedures related to items listed in the schedules at the end of this Section.

1.3 CLOSEOUT SUBMITTALS

- A. Refer to the Contract Documents for general closeout submittal requirements.
- B. Project Record Drawings shall be provided that record actual locations of capped conduits and equipment abandoned in place.

1.4 SEQUENCING

- A. Sequencing of the Work shall be as noted in the Contract Documents.

1.5 SCHEDULING

- A. Refer to the Contract Documents.
- B. Coordinate the schedule of noisy, malodorous and dusty work with the ENGINEER.

1.6 COORDINATION

- A. Refer to Contract Documents.
- B. Conduct demolition to minimize interference with adjacent or occupied areas.
- C. Coordinate demolition work with other trades.
- D. Coordinate and sequence demolition so as not to cause shutdown or interruption of operation of surrounding areas.
- E. Arrange timing of shutdowns with the OWNER. Do not shutdown any utility service without prior written approval. Keep shutdown periods to a minimum.
- F. Identify salvage items in cooperation with the OWNER.

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify wiring and equipment scheduled for demolition serve only abandoned process and facilities.
- B. Verify termination points for demolished services.

3.2 DEMOLITION

- A. Items scheduled for demolition shall be legally disposed of by the CONTRACTOR.
- B. Remove exposed abandoned conduit.
- C. Disconnect electrical systems in walls, floors and ceilings scheduled for removal.
- D. Reconnect equipment being disturbed by renovation work and required for continued service.
- E. Disconnect or shut off service to areas where electrical work is to be removed. Remove electrical fixtures, equipment, switches, receptacles, conduit, and conductors which are not part of the completed project.
- F. Install temporary wiring and connections necessary to maintain existing systems in service during construction.
- G. Remove, relocate and extend existing installations to accommodate new construction.
- H. Repair adjacent construction and finishes to original condition that are damaged during demolition and extension work.
- I. Remove abandoned grounding and bonding components, fasteners, supports and electrical identification components. Cut embedded support elements flush with wall, floors and ceilings.
- J. Clean and repair existing equipment scheduled to be reinstalled.
- K. Protect and retain power to existing active equipment remaining.
- L. Cap abandoned empty conduit at both ends.

3.3 EXISTING PANELBOARDS

- A. Trace out circuits in existing panelboards and document the as-built conditions, including what each circuit feeds, the size of the conductors for each circuit and the total volt-amp load on each circuit.
- B. Remove all unused conductors due to scheduled demolition.
- C. Provide as-built panel schedules at the completion of the Work.

3.4 SALVAGE ITEMS

- A. Remove and protect items scheduled to be salvaged. Coordinate with OWNER where you are to locate these items

3.5 REUSEABLE ELECTRICAL EQUIPMENT

- A. Unless specifically identified for reuse, no used electrical equipment, conduit, conductors, components of any sort scheduled for demolition, disposal or salvage shall be installed for reuse on the project.
- B. Electrical equipment identified specifically as being reused on the project shall be cleaned and protected until such time as it is reinstalled.

END OF SECTION

SECTION 16121

600 VOLT CONDUCTORS AND CABLES

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes.
 - 1. The section includes the requirements for conductors and cables used to conduct potentials of 600 volts and less.
 - 2. All conductors and cables shall be installed in conduit or approved raceways regardless of which Division the conductors or cables are specified.

1.2 REFERENCES

- A. The following is a list of Standards which may be referenced in the Section.
 - 1. American Society for Testing and Materials (ASTM).
 - a. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard or Soft.
 - 2. National Electrical Contractors Association, Inc. (NECA): National Electrical Installation Standards (NEIS).
 - 3. National Electrical Manufacturers Association (NEMA).
 - a. WC 3, Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
 - b. WC 5, Thermoplastic Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
 - c. WC 7, Cross Linked-Thermosetting Polyethylene Wire and Cable for the Transmission and Distribution of Electrical Energy.
 - d. WC 55, Instrumentation Cables and Thermocouple Wire.
 - 4. National Fire Protection Association (NFPA). 70, National Electrical Code (NEC).
 - 5. Underwriters Laboratories, Inc. (UL).
 - a. 13, Standard for Power-Limited Circuit Cables.
 - b. 44, Standard for Safety Rubber-Insulated Wires and Cables.
 - c. 62, Standard for Safety Flexible Cord and Fixture Wire.
 - d. 510, Standard for Safety Insulating Tape.
 - e. 854, Standard for Safety Service-Entrance Cables.
 - f. 910, Standard for Safety Test Method for Fire and Smoke Characteristics of Electrical and Optical Fiber Cables Used in Air Handling Spaces.
 - g. 1277, Standard for Safety Electrical Power and Control Tray Cables.
 - h. 1581, Standard for Safety References for Electrical Wires, Cables and Flexible Cords.

1.3 SUBMITTALS

- A. Contractor shall submit all the product data in Division 16 at the same time. Piecemeal submittals will be rejected as incomplete.

APPENDIX A: ELECTRICAL TECHNICAL SPECIFICATIONS

1. The product data shall be bound in a three ring binder with tabs for each Section. The tabs shall be numbered to match the specification Section numbers. Submittals not bound and labeled as specified will be rejected as incomplete.
2. A submittal is required for each product specified. Each individual product submittal shall have the corresponding Reference Keynote Number (example - 16121.C01) typewritten in the upper right hand corner of the submittal. The submittals within each Section tab shall be in the same sequential order as they are listed in the specification Section. Submittals not containing the Reference Keynote Number will be rejected as incomplete.
3. No typical submittals will be accepted. Each submittal shall be project specific and clearly identify specifically which components or parts are being submitted for approval. Any product submittals, such as a catalog sheet, which do not clearly identify which components or parts are being submitted for approval, will be rejected as incomplete.

B. Product Data.

1. Pursuant to Section 01300 Submittal Procedures.
2. Manufacturer's data including materials of construction, weight, and related information for each item specified in PART 2 PRODUCTS.

PART 2 PRODUCTS

2.1 MATERIALS

A. **Single Conductors (16121.C01).**

1. Conductors shall be rated for 600 volts and conform to applicable requirements of NEMA.
2. Conductors shall be stranded copper.
3. Insulation type shall be XHHW-2.
4. Conductors shall be sized per the Drawings and the NEC, whichever is greater.
5. Rome Cable Corporation, Southwire Company, Okonite Company, or approved equal.

2.2 ACCESSORIES

A. **Colored Tape (16121.T01).**

1. Colored tape shall be used to identify individual conductors larger than # 6 AWG.
2. 3M colored tape, or approved equal.

B. **Cable Ties (16121.T05).**

1. Cable ties shall be nylon, adjustable, self-locking, and properly sized for the bundle and force implied.
2. Thomas and Betts, Panduit, or approved equal.

C. **Pulling Compound (16121.P01).**

1. Pulling compound shall be non-corrosive, noncombustible, nonflammable waxed based lubricant listed for this use.

2. Ideal Company, Polywater, Inc., or approved equal.

PART 3 EXECUTION

3.1 INSTALLATION

A. General.

1. All identification labeling shall be in compliance with Section 16075 Electrical and Control Identification.
2. Conductor and cable installations shall meet or exceed the NECA National Electrical Installation Standards.
3. Twisted Shielded Pair (TSP) cable installation and termination methods are specified in Section 13410 Basic Measurement and Control Instrumentation Materials and Methods and Section 13430 Boxes, Control Panels and Control Centers.
4. CONTRACTOR shall not exceed the manufacturer's recommendations for maximum pulling tensions or minimum bending radii for respective conductors or cables.
5. Pulling compound is recommended for all conductor or cable installations and shall be used on all installations requiring a mechanical pulling device.
6. CONTRACTOR shall furnish and use a dynamometer on all conductor or cable installations requiring the use of a mechanical pulling device. The dynamometer shall be used to verify the maximum pulling tensions are not exceeded. Should the pulling tensions be exceeded, the conductor or cable shall be removed from the raceway and discarded. It shall not be reused under any circumstance on the project. The CONTRACTOR shall be responsible to make the alterations necessary before attempting to re-pull new conductors or cables.
7. Immediately after pulling in conductors or cables, the pulling compound shall be completely removed from the conductors or cables, from boxes, enclosures, floors, walls, etc.
8. Conductor and cable installations shall be continuous without splices or intermediate terminations unless specifically identified on the Drawings or prior written approval from the ENGINEER.
9. Where conductors or cables are routed in boxes enclosures or cable tray they shall be neatly bundled with cable ties at intervals not to exceed 12 inches on center. The tension for the cable ties shall be set with a tool specifically manufactured for that purpose and of the same manufacturer as the cable tie. Side cutters, linemen pliers and similar tools shall not be used to cut the tail end of the cable tie. The CONTRACTOR shall only use the tool specifically manufactured for this purpose and of the same manufacturer as the cable tie.
10. Conductors and cables shall not be installed until the raceway, boxes, enclosures, conduit bushings, etc. have all been installed. Where conductors or cables have been installed prior to meeting this requirement, the ENGINEER shall at their discretion elect to have the conductors or cables removed, disposed of and replaced with new product.
11. Should the outer jacket of any conductor or cable be damaged in any way, they

APPENDIX A: ELECTRICAL TECHNICAL SPECIFICATIONS

shall be removed, disposed of and replaced with new product.

12. An equipment grounding conductor shall be installed in all raceways. Size shall be as identified on the Drawings or the NEC, whichever is greater, but in no case shall it be less than # 16 AWG for under 50 volts and no less than # 14 for 50 volts or above.

END OF SECTION

SECTION 16131

CONDUIT AND FITTINGS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes

1. The Section includes the requirements pertaining to conduits and fittings used to contain electrical conductors and cables.
2. All conductors and cables shall be installed in conduit or approved raceways regardless of which Division the conductors or cables are specified.

1.2 REFERENCES

A. The following is a list of standards which may be referenced in this Section.

1. American National Standards Institute (ANSI).
 - a. C80.1, Rigid Steel Conduit-Zinc Coated.
2. American Society for Testing Materials (ASTM).
 - a. A123 E1, Standard Specification for Zinc-Coated (Galvanized) Coatings on Iron and Steel Products.
3. National Electrical Contractors Association (NECA).
 - a. National Electrical Installation Standards (NEIS).
4. National Electrical Manufacturers Association (NEMA).
 - a. RN 1, Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Coated and Intermediate Metal Conduit.
 - b. TC 3, PVC Fittings for use with Rigid PVC Conduit and Tubing.
 - c. TC 6, PVC and ABS plastic Utilities Duct for Underground Installation.
5. Nation Fire Protection Association (NFPA).
 - a. 70, National Electrical Code (NEC).
6. Underwriters Laboratories, Inc. (UL).
 - a. 6, Standard for Safety Rigid Metal Conduit.
 - b. 514B, Standards for Safety Fittings for Conduit and Outlet Boxes.
 - c. 651, Standard for Safety Schedule 40 and 80 PVC Conduit.
 - d. 651A, Standard for Safety Type EB and Rigid PVC Conduit and HDPE Conduit.
 - e. 1660, Standard for Safety Liquid-Tight Flexible Nonmetallic Conduit.
 - f. 360, Standard for Safety Liquid-Tight Flexible Metallic Conduit.
 - g. 797, Standard for Safety Electrical Metallic Conduit.

1.3 SUBMITTALS

- A. Contractor shall submit all the product data in Division 16 at the same time. Piecemeal submittals will be rejected as incomplete.

APPENDIX A: ELECTRICAL TECHNICAL SPECIFICATIONS

1. The product data shall be bound in a three ring binder with tabs for each Section. The tabs shall be numbered to match the specification Section numbers. Submittals not bound and labeled as specified will be rejected as incomplete.
2. A submittal is required for each product specified. Each individual product submittal shall have the corresponding Reference Keynote Number (example - 16131.C01) typewritten in the upper right hand corner of the submittal. The submittals within each Section tab shall be in the same sequential order as they are listed in the specification Section. Submittals not containing the Reference Keynote Number will be rejected as incomplete.
3. No typical submittals will be accepted. Each submittal shall be project specific and clearly identify specifically which components or parts are being submitted for approval. Any product submittals, such as a catalog sheet, which do not clearly identify which components or parts are being submitted for approval, will be rejected as incomplete.

B. Product data

1. Pursuant to Section 01300 - Submittal Procedures.
2. Manufacturer's data including materials of construction, equipment weight and related information for each item specified in PART 2 PRODUCTS.

PART 2 PRODUCTS

2.1 MATERIALS

A. **Galvanized Rigid Steel Conduit (GRC) (16131.C01).**

1. Shall be mild steel, hot dipped galvanized inside and out.
2. Shall be manufactured in accordance with ANSI C80.1 – Rigid Steel Conduit, Zinc Coated, and UL-6.
3. Conduit fittings shall be hot dipped galvanized malleable iron.
4. Condulets shall form 7 type.
5. The use of three-piece couplings shall be incorporated only when unavoidable and not simply due to poor planning and layout.
6. The use of compression, setscrew and split conduit fittings is unacceptable.
7. Gaskets shall be installed on all conduit covers regardless of the environment they are installed in.
8. Conduit straps shall be hot dipped galvanized malleable iron and incorporate matching conduit spacers when attached directly to walls, ceilings and floors.
9. LTV steel, Triangle PWC, or approved equal.

B. **Rigid Non-metallic Conduit (PVC) (16131.C30).**

1. Shall be schedule 40 PVC unless specifically called out otherwise on the Drawings.
2. Shall be sunlight resistant.
3. Shall be manufactured in accordance with UL-651 Standard.
4. Conduit and fittings shall be securely glued.
5. Provide conduit bell ends at vaults unless specifically called out otherwise on the Drawings.

6. Provide PW Pipe, Carlon, or approved equal.

2.2 ACCESSORIES

A. Conduit Sealing Bushing (16131.S90)

1. Shall be suitable for installing on conduit type shown on the Drawings.
2. OZ Gendey, or approved equal.

B. Conduit Thread Lubricant (16131.L01).

1. Shall be an electrically conductive with copper particles suspended in the product.
2. Provide Kopr-Shield Catalog number CP8-TB, or approved equal.

C. Glue (16131.G01).

1. Glue shall be the wet/dry rated cement commonly referred to as “Blue Glue”.

D. Cord Grip (CGB) (16131.C89).

1. Provide stainless steel bodied cord grips with NPT mounted in conduit couplings as identified on the Drawings.
2. Provide Hubbell, Kellems, or approved equal.

E. Conduit Measuring Tape (Pulling Twine) (16131.T32).

1. Provide 1250 pound tensile strength tape in spare conduits and as called out elsewhere on the Drawings.
2. Greenlee Catalog number 39243, or approved equal.

F. Cord Connector (16131.C90).

1. Provide stainless steel cord grip with integrated stainless steel mesh.
2. Provide Hubbell SCH1000 Series, or approved equal.
3. Provide cord grip with stainless steel integrated mesh for any unsupported cord longer than 59 inches to provide adequate support of the cord.

G. Bushing Plug (16131.P90).

1. Provide OZ Gedney type PPC bushing plug, or approved equal.

PART 3 EXECUTION

3.1 INSTALLATION

A. General Requirements

1. All identification labeling shall be in compliance with Section 16075 Electrical and Control Identification
2. Install conduit runs in accordance with the schematic representation shown on the Drawings.
3. Minimum conduit size shall be .75 inch unless specifically called out otherwise on the drawings.

APPENDIX A: ELECTRICAL TECHNICAL SPECIFICATIONS

4. Where raceways are indicated, but the routing is not identified, the routing shall be the CONTRACTOR'S choice and in accordance with the rest of the Contract Documents and the National Electrical Code (NEC).
5. Raceways shall be electrically and mechanically complete before the conductors are installed.
6. Routing of conduits may be adjusted to avoid obstructions. Coordinate with other trades prior to installation of raceways. Lack of such coordination shall not be justification for extra compensation and removal and reinstallation to resolve conflicts shall be at the CONTRACTOR's expense.
7. Conduit joints shall be wrench tight, thoroughly grounded, secure and free of obstructions.
8. Conduits shall be reamed.
9. Metallic threads shall all be coated with conduit thread lubricant before assembly. Failure to install the lubricant will result in removal of all conduit and reassembly with the conduit lubricant.
10. Exposed conduits shall be installed parallel or perpendicular to the structural members and surfaces and shall be level and or plumb.
11. When two or more conduits are routed in the same general direction their routing shall be parallel with symmetrical bends.
12. Conduits shall be bent with equipment specifically designed for this purpose and for the specific size and type of conduit.
13. Conduits that are creased or crushed shall be replaced.
14. Install conduits such that they do not interfere with the proper and safe operation of equipment and do not block or otherwise interfere with the ingress and egress and installation of removable hatches and covers.
15. Install expansion joints as needed across expansion joints in the structure and at other locations where necessary to compensate for thermal or mechanical expansion or contraction.
16. Conduits shall be routed at least six (6) inches from high temperature piping, ducts and flues.
17. Conduits installed in exposed areas indoors shall be GRC type unless the area contains potentially corrosive elements.
18. Conduits that terminate at an enclosure that does not have a threaded hub shall be installed with a Myers type hub and ground ring. No exceptions shall be permitted without prior written approval for specific locations issued by the ENGINEER. Conduits that are permitted to terminate without a Myers type hub or a threaded hub shall have a ground bushing installed. A separate bonding conductor shall be routed to all ground bushings within an enclosure and be bonded to the enclosure and grounding conductor if present.
19. All conduits shall be capped throughout construction to prevent entrance of dirt, trash, water, etc.
20. Spare conduits shall be provided with a coupling and threaded male plug that matches the makeup of the conduit for the area they are installed in. The conduit shall terminate at an enclosure when one is called out and exists as part of the Work. Where the spare conduit is stubbed up in a concrete slab for future equipment, it shall be installed flush with the finished floor. Where spare conduits

APPENDIX A: ELECTRICAL TECHNICAL SPECIFICATIONS

are routed to other areas such as outside a building envelope, in an attic, to a vault, etc., the conduit shall have a female conduit cap installed.

B. Underground Conduit Installation.

1. Underground conduits shall be PVC except as specifically noted differently elsewhere.
2. Underground conduits shall be routed as shown on the Drawings.
3. Power conduits shall be separated from all other conduits by a minimum of 12 inches and when required to cross other conduits it shall be done at a 90 degree angles.
4. Conduits routed in structural concrete shall be routed in such a manner as to not interfere with the structural integrity of the concrete. The ENGINEER shall approve CONTRACTOR's proposed conduit routing before installation. It is the CONTRACTOR's responsibility to coordinate conduit routing with the ENGINEER well before it is scheduled to be installed. Conduits shall be stubbed up directly under the enclosure or device their will serve. The CONTRACTOR is responsible to coordinate with the other trades prior to installation of raceways. Lack of coordination shall not be justification for extra compensation and removal and re-installation of conduits to resolve conflicts shall be done at the CONTRACTOR's expense.
5. Underground conduit shall have a minimum of 24 inches of cover unless specifically called out differently on the Drawings.

C. Miscellaneous

1. Provide cord grip for any unsupported cord.

END OF SECTION

SECTION 16135

BOXES AND ENCLOSURES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes.

1. This Section includes requirements for electrical device boxes, enclosures, in-ground boxes and vaults.

1.2 REFERENCES

A. The following is a list of Standards that may be referenced in the Section.

1. American Society for Testing and Materials (ASTM).
 - a. A123 E1 Standard Specifications for Zinc-Coated Coatings on Iron and Steel Products.
2. National Electrical Contractors Association, Inc. (NECA).
 - a. 5055 National Electrical Installation Standard.
3. National Fire Protection Association (NFPA).
 - a. 70 National Electrical Code (NEC)
4. Underwriters Laboratory, Inc. (UL).
 - a. 514C Standard for Safety Non-Metallic Outlet Boxes, Flush Device Boxes and Covers.
 - b. 50 Enclosures for Electrical Equipment.

1.3 SUBMITTALS

A. Contractor shall submit all the product data in Division 16 at the same time. Piecemeal submittals will be rejected as incomplete.

1. The product data shall be bound in a three ring binder with tabs for each Section. The tabs shall be numbered to match the specification Section numbers. Submittals not bound and labeled as specified will be rejected as incomplete.
2. A submittal is required for each product specified. Each individual product submittal shall have the corresponding Reference Keynote Number (example - 16135.B01) typewritten in the upper right hand corner of the submittal. The submittals within each Section tab shall be in the same sequential order as they are listed in the specification Section. Submittals not containing the Reference Keynote Number will be rejected as incomplete.
3. No typical submittals will be accepted. Each submittal shall be project specific and clearly identify specifically which components or parts are being submitted for approval. Any product submittals, such as a catalog sheet, which do not clearly identify which components or parts are being submitted for approval, will be rejected as incomplete.

B. Product Data.

APPENDIX A: ELECTRICAL TECHNICAL SPECIFICATIONS

1. Pursuant to Section 01300 Submittal Procedures.
2. Manufacturer's data including materials of construction, equipment weight and related information for each item specified in PART 2 PRODUCTS.

PART 2 PRODUCTS

2.1 DEVICE BOXES

A. **Cast Iron Boxes (16135.B01).**

1. Shall be cast iron galvanized boxes, have tapered threaded hubs and be the deep FD type in all cases.
2. Boxes shall have internal grounding screw.
3. Shall have external mounting tabs.
4. Whichever manufacturer is submitted and approved, all like boxes on Project shall be of the same manufacturer.
5. Provide OZ Gedney, Crouse-Hinds, or approved equal.

PART 3 EXECUTION

3.1 INSTALLATION

A. General.

1. All identification labeling shall be in compliance with Section 16075 Electrical and Control Identification.
2. Install boxes and enclosures in accordance with the schematic representation as indicated on the Drawings.
3. Boxes and enclosures shall be mounted level and plumb.
4. Boxes and enclosures shall not be altered, holes drilled, etc. in any way that may compromise the NEMA rating of the enclosure or box.
5. Boxes and enclosures shall be mounted with hot dipped galvanized hardware.
6. Boxes and enclosures shall be bonded the equipment grounding conductor.
7. Surface mounted enclosures and boxes shall be spaced off the surface at least ¼ inch in damp or wet locations.
8. Boxes and enclosures with threaded hubs or punched holes shall have the opening match the conduit size. The use of reducing bushings or reducing washers is unacceptable.
9. Galvanized cast iron boxes are permitted only where GRC conduit is permitted.
10. Enclosures shall be provided whenever a junction or pull box larger than 4 inches square is required.
11. Provide a divider whenever a box contains conductors of different potentials that the code requires separation.

END OF SECTION

SECTION 16210

ELECTRICAL UTILITY SERVICES

PART 1 GENERAL

1.1 SUMMARY

- A. The Section includes electrical utility requirements and contact information.

1.2 SYSTEM DESCRIPTION

A. Electrical Service

1. The CONTRACTOR shall coordinate all work and inspections with the ENGINEER, the local jurisdiction having authority, AND Pacific Power (PP&L) (electric utility).
2. The OWNER is responsible for all costs for this work including fees for permits, and fees for the electric utility.
3. The CONTRACTOR shall provide all necessary installation services that are not provided by the electric utility.
4. The CONTRACTOR shall provide all necessary components that are not provided by the electric utility. All components shall be as specified by the electric utility. Components include conduits, pull rope, vaults, pull boxes, transformer pads, current transformer cabinets, meter socket enclosures, bollards, and ancillary items.
5. The CONTRACTOR shall comply with the electric utility's electric service requirements.

PART 2 PRODUCTS

2.1 MATERIALS

A. **Meter Base** (262116.B01)

1. Contact Pacific Power for exact requirements.
2. Reference PP&L standard documents for additional information.

PART 3 INSTALLATION

3.1 QUALITY CONTROL

- A. All work shall comply with the electric utility's electrical service requirements, electric utility's specifications, and the Contract Documents.

APPENDIX A: ELECTRICAL TECHNICAL SPECIFICATIONS

- B. CONTRACTOR shall coordinate work with other trades to avoid conflicts, delays and unnecessary interference with operation of the facility during construction.
- C. CONTRACTOR shall provide all materials and incidentals required for a complete and operable system, even if not indicated explicitly by the Contract Documents.
- D. The routing of the conduit is critical and shall be coordinated with the utility, ENGINEER and OWNER.

END OF SECTION 26 21 16