BASIC ELECTRICAL REQUIREMENTS

SECTION 260010 - BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.01 SUMMARY

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B. Work included: This Section includes general administrative and procedural requirements for Division 26. The following administrative and procedural requirements are included in this Section to supplement the requirements specified in Division 01.

1. Quality assurance.
2. Definition of terms.
4. Coordination.
5. Record documents.
6. Operation and maintenance manuals.
7. Excavation.
8. Rough-in.
10. Cutting, patching, painting and sealing.
11. Field quality control.
12. Cleaning.
13. Project closeout.

1.02 QUALITY ASSURANCE

A. Reference to Codes, Standards, Specifications and recommendations of technical societies, trade organizations and governmental agencies shall mean that latest edition of such publications adopted and published prior to submittal of the bid. Such codes or standards shall be considered a part of this Specification as though fully repeated herein.

B. When codes, standards, regulations, etc. allow Work of lesser quality or extent than is specified under this Division, nothing in said codes shall be construed or inferred authority
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for reducing the quality, requirements or extent of the Contract Documents. The Contract Documents address the minimum requirements for construction.

C. Work shall be performed in accordance with all applicable requirements of the latest edition of all governing codes, rules and regulations including but not limited to the following minimum standards, whether statutory or not:


D. Standards: Equipment and materials specified under this Division shall conform to the following standards where applicable:

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<tr>
<th>Acronym</th>
<th>Description</th>
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<tr>
<td>ACI</td>
<td>American Concrete Institute</td>
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<tr>
<td>ANSI</td>
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</tr>
<tr>
<td>NEMA</td>
<td>National Electrical Manufacturer's Association</td>
</tr>
<tr>
<td>UL</td>
<td>Underwriters' Laboratories</td>
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</tbody>
</table>

E. All base material shall be ASTM and/or ANSI standards.

F. All electrical apparatus furnished under this Section shall conform to NEMA standards and the NEC and bear the UL label where such label is applicable.

1.03 DEFINITION OF TERMS

A. The following list of terms as used in the Division 26 documents shall be defined as follows:

1. "Provide": Shall mean furnish, install and connect unless otherwise indicated.
2. "Furnish": Shall mean purchase and deliver to Project site.
3. "Install": Shall mean to physically install the items in-place.
4. "Connect": Shall mean make final electrical connections for a complete operating piece of equipment.
5. "As directed": Shall be as directed by the Owner or their authorized Representative.

1.04 SUBMITTALS

A. Format: Furnish submittal data in PDF format for each Specification Section with a table of contents listing materials by Section and paragraph number.

B. Submittals shall consist of detailed Shop Drawings, Specifications, block wiring diagrams, "catalog cuts" and data sheets containing physical and dimensional information, performance data, electrical characteristics, materials used in fabrication and material finish. Clearly indicate by arrows or brackets precisely what is being submitted on and those optional accessories which are included and those which are excluded. Furnish quantities of each submittal as noted in Division 01.
C. Each submittal shall be labeled with the Specification Section Number and shall be accompanied by a cover letter or shall bear a stamp stating that the submittal has been thoroughly reviewed by the Contractor and is in full compliance with the requirements of the Contract Documents. Cover letters shall list in full the items and data submitted. Failure to comply with this requirement shall constitute grounds for rejection of data.

D. All resubmittals shall include a cover letter that lists the action taken and revisions made to each Drawing and equipment data sheet in response to Submittal Review Comments. Resubmittal packages will not be reviewed unless accompanied by this cover letter. Failure to include this cover letter will constitute rejection of the resubmittal package.

E. Substitutions:
   1. All requests for substitutions shall conform to the general requirements and procedure outlined in Division 01.
   2. Where items are noted as "or equal," a product of equal design, construction and performance will be considered. Contractor must submit to the Engineer all pertinent test data, catalog cuts and product information required substantiating that the product is in fact equal to that specified. Only one substitution will be considered for each product specified.
   3. Manufacturers' names and model numbers used in conjunction with materials, processes or equipment included in the Contract Documents are used to establish standards of quality, utility and appearance. Materials, processes or equipment, which in the opinion of the Engineer is equal in quality, utility and appearance, will be approved as substitutions to that specified.
   4. Whenever any material, process or equipment is specified in accordance with a Federal specification, an ASTM standard, an ANSI specification, UL rating or other association standard, the Contractor shall present an affidavit from the Manufacturer certifying that the product complies with the particular standard specification. When requested by the Engineer, support test data to substantiate compliance shall be submitted by the Contractor at no additional cost.
   5. Substitutions shall be equal, in the opinion of the Architect/Engineer, to the specified product. The burden of proof of such shall rest with the Contractor. When the Architect/Engineer in writing accepts a substitution, it is with the understanding that the Contractor guaranteed the substituted article or material to be equal to the one specified and dimensioned to fit within the construction. Approved substitutions shall not relieve the Contractor of responsibilities for the proper execution of the Work or from any provisions of the Specifications.
   6. The Contractor shall be responsible for all expenses in connection with the substitution materials, processes and equipment, including the effect of the substitution on the Contractor, Subcontractor's or other Contractor's Work. No substitution of material, processes or equipment shall be permitted without written authorization of the Architect/Engineer. Any assumptions on the acceptability of a proposed substitution prior to acceptance by the Engineer are at the sole risk of the Contractor.

1.05 COORDINATION

A. Discrepancies:
   1. In the event of discrepancies within the Contract Documents, the Engineer shall be so notified, within sufficient time, as delineated in Division 01, prior to the Bid Opening to allow the issuance of an Addendum.
2. If, in the event that time does not permit notification or clarification of discrepancies prior to the Bid Opening, the following shall apply: The Drawings govern in matters of quantity and the Specifications govern in matters of quality. In the event of conflict within the Drawings involving quantities or within the Specifications involving quantities or within the Specifications involving quality, the greater quantity and higher quality shall apply. Such discrepancies shall be noted and clarified in the Contractor's Bid. No additional allowances will be made because of errors, ambiguities or omissions that reasonably should have been discovered during the preparation of the Bid.

B. Project conditions:

1. Examination of Project site: The Contractor shall visit the Project site and thoroughly review the locale, working conditions, conflicting utilities and the conditions in which the Electrical Work will take place. Verify all existing conditions in the field. No allowances will be made subsequently for any costs that may be incurred because of any error or omission due to failure to examine the Project site and to notify the Engineer of any discrepancies between Contract Documents and actual Project site conditions.

2. Protection: Keep conduits, junction boxes, outlet boxes and other openings closed to prevent entry of foreign matter. Cover fixtures, equipment, devices and apparatus and protect them against dirt, paint, water, chemical or mechanical damage, before and during construction period. Prior to final acceptance, restore to original condition any fixture, apparatus or equipment damaged including restoration of damaged factory applied painted finishes. Protect bright finished surfaces and similar items until in service. No rust or damage will be permitted.

3. Supervision: Contractor shall personally or through an authorized and competent representative constantly supervise the Work from beginning to completion and, within reason, keep the same foreman and workmen on the Project throughout the Project duration.

C. Preparation:

1. Drawings:
   a. Layout: General layout indicated on the Drawings shall be followed except where other Work may conflict with the Drawings.
   b. Accuracy: Drawings for the Work under this Section are essentially diagrammatic within the constraints of the symbology applied.

1.06 RECORD DOCUMENTS

A. Provide Project Record Drawings as described herein:

1. Drawings shall fully represent installed conditions including correct conduit and wire sizing as well as routing and revised fixture schedule listing Manufacturers and products actually installed. Contractor shall record all changes in the Work during the course of construction on blue or black line prints. These prints shall be made subject of monthly review by the Owner's Representative to ascertain that they are current. If not current monthly payments may be withheld.

2. Record Drawings shall be the transfer of information on these prints to AutoCad files of the original Drawings by a professional draftsperson. The construction documents will be provided for the Contractor's use in reproducing at their cost the construction documents via computer aided drafting (CAD) process. A set of CAD files of the electrical documents will be provided to the Contractor in Autocad format.
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3. A single set of half size prints of the Record Drawings shall be submitted for review. Upon receipt of the Engineer's review comments, corrections shall be made and the Contractor shall provide the following:
   a. One set of full size prints.
   b. One set of half size prints.
   c. PDF files of Drawings.

1.07 OPERATION AND MAINTENANCE MANUALS

A. Prior to Project closeout furnish to the Owner, six (6) hard back 3-ring binders containing all bulletins, operation and maintenance instructions, part lists, service telephone numbers and other pertinent information as noted in each Section all equipment furnished under Division 26. Binders shall be indexed into Division Sections and labeled for easy reference. Bulletins containing more information than the equipment concerned shall be properly stripped and assembled.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.01 ROUGH-IN

A. Contractor shall verify lines, levels and dimensions indicated on the Drawings and shall be responsible for the accuracy of the setting out of Work and for its strict conformance with existing conditions at the Project site.

B. Verify final locations for rough-ins with field measurements and with the requirements for the actual equipment to be connected.

C. Refer to equipment specification in Divisions 22 through 33 for rough-in requirements.

3.02 ELECTRICAL INSTALLATION

A. Preparation, sequencing, handling and installation shall be in accordance with Manufacturer's written instructions and technical data particular to the product specified and/or accepted equal except as otherwise specified. Comply with the following requirements:
   1. Shop Drawings prepared by Manufacturer.
   2. Verify all dimensions by field measurements.
   3. Where mounting height is not detailed or dimensioned, contact the Architect for direction prior to proceeding with rough-in.
   4. Install systems, materials and equipment to conform with approved submittal data, including coordination Drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are indicated only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Architect.
   5. Install systems, materials and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.
   6. Install electrical equipment to facilitate servicing, maintenance and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.
   7. Coordinate electrical systems, equipment and materials installations with other building components.
8. Install systems, materials and equipment giving right-of-way priority to other systems that are required to maintain a specified slope.

9. Conform to the National Electrical Contractor's Association "Standard of Installation" for general installation practice.

3.03 CUTTING, PATCHING, PAINTING AND SEALING

A. Structural members shall in no case be drilled, bored or notched in such a manner that will impair their structural value. Cutting of holes, if required, shall be done with core drill and only with the approval of the Architect and Structural Engineer.

B. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.

3.04 FIELD QUALITY CONTROL

A. General testing requirements:

1. The purpose of testing is to ensure that all tested electrical equipment, both Contractor and Owner supplied, is operational and within industry and Manufacturer’s tolerances and is installed in accordance with design Specifications.

2. Tests and inspections shall determine suitability for energization.

3. Perform tests in presence of the Owner's Representative and furnish test equipment, facilities and technical personnel required to perform tests.

4. Tests shall be conducted during the construction period and at completion to determine conformity with applicable codes and with these Specifications.

B. Tests: In addition to specific system test described elsewhere, tests shall include:

1. Lighting control circuits: Test lighting circuits for correct operation through their control devices. The new fixtures are connecting to existing control systems, which shall be tested.

C. Testing safety and precautions:

1. Safety practices shall include the following requirements:

   a. Applicable State and Local safety operating procedures.

   b. OSHA.

   c. NSC.

   d. NFPA 70E.

2. All tests shall be performed with apparatus de-energized and grounded except where otherwise specifically required ungrounded by test procedure.

D. Coordinate with General Contractor regarding testing schedule and availability of equipment ready for testing.

E. Notify Owner one week in advance of any testing.

F. Any products which fail during the tests or are ruled unsatisfactory by the Owner's Representative shall be replaced, repaired or corrected as prescribed by the Owner's Representative at the expense of the Contractor. Tests shall be performed after repairs, replacements or corrections until satisfactory performance is demonstrated.

G. Include all test results in the maintenance manuals.
BASIC ELECTRICAL REQUIREMENTS

3.05 CLEANING

A. Prior to energizing of electrical equipment, the Contractor shall thoroughly clean the interior of enclosures from construction debris, scrap wire, etc. using Manufacturer's approved methods and materials.

B. Upon completion of Project, prior to final acceptance, the Contractor shall thoroughly clean both the interior and exterior of all electrical equipment per Manufacturers approved methods and materials. Remove paint splatters and other spots, dirt and debris.

C. Touch-up paint any marks, blemishes or other finish damage suffered during installation.

3.06 PROJECT CLOSEOUT

A. Special tools: Provide one of each tool required for proper operation and maintenance of the equipment provided under this Section. All tools shall be delivered to the Owner at the Project completion.

B. Keying: Provide two keys for each lock furnished under this Section and turn over to Owner.

END OF SECTION
PART 1 - GENERAL
1.01 SUMMARY
A. Work included: Labor, materials and equipment necessary to complete the installation required for the item specified under this Division, including but not limited to:
   1. Building wire.
   2. Wiring connections and terminations.
B. Related Work: Consult all other Sections, determine the extent and character of related Work and properly coordinate Work specified herein with that specified elsewhere to produce a complete installation.

1.02 REFERENCES
A. Comply with the latest edition of the following applicable Specifications and standards except as otherwise indicated or specified:
   1. Federal Specifications (FS):
      FS J-C-30A; Cable and Wire, Electrical (Power, Fixed Installation).
      FS W-S-610C; Splice Conductor.
      FS HH-I-595C; Insulation Tape, Electrical, Pressure-Sensitive Adhesive, Plastic.
   2. Underwriters Laboratories, Inc. (UL):
      UL 44; Thermoset-Insulated Wires and Cables.
      UL 83; Thermoplastic-Insulated Wires and Cables.
      UL 486A & B; Wire Connectors.
      UL 486C; Splicing Wire Connectors.
      UL 486D; Insulated Wire Connector Systems for Underground Use or in Damp or Wet Locations.
      UL 493; Thermoplastic-Insulated Underground Feeder and Branch Circuit Cables.
      UL 510; Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape.
      UL 1581; Reference Standard for Electrical Wires, Cables and Flexible Cords.
   3. National Electrical Manufacturer Association (NEMA):
      NEMA WC-5; Thermoplastic Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
      NEMA WC-7; Cross-Linked Thermosetting Polyethylene Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
   4. Institute of Electrical and Electronic Engineers (IEEE):
IEEE 82; Test Procedure for Impulse Voltage Tests on Insulated Conductors.

1.03 SUBMITTALS
A. Submit in accordance with the requirements of Section 260010: Basic Electrical Requirements, the following items:
   1. Data/catalog cuts for each product and component specified herein, listing all physical and electrical characteristics and ratings indicating compliance with all listed standards.
   2. Clearly mark on each data sheet the specific item(s) being submitted and the proposed application.
   3. Submit Manufacturer's installation instructions.
   4. Final test results.

1.04 QUALITY ASSURANCE
A. All materials, equipment and parts comprising the units specified herein shall be new, unused and currently under production.
B. Only products and applications listed in this Section may be used on the Project unless otherwise submitted.
C. Independent Testing Agency qualifications: Refer to Section 260010: Basic Electrical Requirements.

PART 2 - PRODUCTS

2.01 MANUFACTURERS
A. Products furnished by the following Manufacturers shall be acceptable if in compliance with all features specified herein and indicated on the Drawings.
   1. Building wire:
      a. Cerrowire
      b. General Cable
      c. Southwire Company
      d. Stabiloy (aluminum only)
      e. United Wire and Cable
   2. Wiring connectors and terminations:
      a. 3M Company.
      b. Ideal.
      c. Blackburn-Holub.
      d. Burndy.
      e. Thomas & Betts Corp.
      f. Beau Barrier.

B. Substitutions: Under provisions of Section 260010: Basic Electrical Requirements.

2.02 BUILDING WIRE
A. Conductor material:
1. Provide annealed copper for all wire, conductor and cable, unless otherwise indicated.
2. Copper wire AWG #8 and larger shall be stranded, unless otherwise indicated.
3. Copper wire AWG #10 and smaller may be solid or stranded as best suited for the installation.

B. Insulation material:
1. All insulated wire, conductor and cable shall be 600 volt rated unless otherwise noted on the Drawings.
2. Thermoplastic-insulated building wire: NEMA WC 5.
4. Copper feeders and branch circuits larger than #6 AWG: Type THW, XHHW or dual rated THHN/THWN.
5. Copper feeders and branch circuits #6 AWG and smaller: Type TW, THW, XHHW or dual rated THHN/THWN.
6. Identify system conductors as to voltage and phase connections by means of color-impregnated insulation.

2.03 METAL-CLAD CABLE (MC)
A. MC cable shall not be used on this project

2.04 WIRING CONNECTIONS AND TERMINATIONS
A. Bolted pressure connectors: Provide wide range-taking connectors with cast bronze compression bolts, designed for parallel taps, tees, crosses or end-to-end connections.

B. Electrical spring wire connectors:
1. Provide multi-part construction incorporating a non-restricted, zinc coated square cross-section steel spring enclosed in a steel sheet with an outer jacket of plastic and insulating skirt.
2. Self-stripping pigtail and tap U-contact connectors shall not be used.

C. Compression type terminating lugs:
1. Provide tin-plated copper high-compression type lugs for installation with hand or hydraulically operated circumference-crimping tools and dies as stipulated by the lug Manufacturer or as indicated on Drawings. Notch or single point type crimping is NOT acceptable.
2. Two hole, long barrel lugs shall be provided for size (4/0) and larger wire where terminated to bus bars. Use minimum of three crimps per lug, on sizes where possible.

D. Splicing and insulating tape: Provide black, ultraviolet proof, self-extinguishing, 7 mil thick vinyl general purpose electrical tape with a dielectric strength of 10,000 volts suitable for temperatures from minus 18 degrees C to 105 degrees C. Federal Spec. HH-I-595, Scotch 33+ or equal minimum.

E. Insulating resin:
1. Provide two-part liquid epoxy resin with resin and catalyst in pre-measured, sealed mixing pouch. Scotchcast 4 or equal for wet or underground vaults, boxes, etc. splices or terminations.
2. Use resin with a set up time of approximately 30 minutes at 21.1 degrees C and with thermal and dielectric properties equal to the insulating properties of the cables immersed in the resin.

F. Cable ties: Provide harnessing and point-to-point wire bundling with nylon cable ties. All cable ties shall be installed using tool supplied by Manufacturer of ties.

G. Wire lubricating compound:
   1. UL listed for the wire insulation and conduit type and shall not harden or become adhesive.
   2. Shall not be used on wire for isolated type electrical power systems.

H. Bolt termination hardware:
   1. Bolts shall be plated, medium carbon steel heat-treated, quenched and tempered equal to ASTM A-325 or SAE grade 5; or silicon bronze alloy ASTM B-9954 Type B.
   2. Nuts shall be heavy semi-finished hexagon, conforming to ANSI B18.2.2, threads to be unified coarse series (UNC), class 2B steel or silicon bronze alloy.
   3. Flat washers shall be steel or silicon bronze, Type A plain standard wide series, conforming to ANSI B27.2. SAE or narrow series shall not be used.
   4. Belleville conical spring washers shall be hardened steel, cadmium plated or silicon bronze.
   5. Each bolt connecting lug(s) to a terminal or bus shall not carry current exceeding the following values:
      a. 1/4" bolt - 125 amps
      b. 5/16" bolt - 175 amps
      c. 3/8" bolt - 225 amps
      d. 1/2" bolt - 300 amps
      e. 5/8" bolt - 375 amps
      f. 3/4" bolt - 450 amps

PART 3 - EXECUTION

3.01 EXAMINATION
   A. Contractor shall thoroughly examine Project site conditions for acceptance of wire and cable installation to verify conformance with Manufacturer and Specification tolerances. Do not commence with installation until all conditions are made satisfactory.

3.02 APPLICATION
   A. All wire, conductor and cable with their respective connectors, fittings and supports shall be UL listed for the installed application and ambient condition.
   B. Feeders and branch circuits in wet locations shall be rated 75 degree C.
   C. Feeders and branch circuits in dry locations shall be rated 90 degree C.
   D. Minimum conductor size:
      1. Provide minimum AWG #12 for all power and lighting branch circuits.
2. Provide minimum AWG #14 for all line voltage signal and control wiring unless otherwise indicated.

E. Color coding:
1. For 120/208 volt, 3 phase, 4 wire systems:
   a. Phase A - Black
   b. Phase B - Red
   c. Phase C - Blue
   d. Neutral - White
   e. Ground - Green
2. For 277/480 volt, 3 phase, 4 wire systems:
   a. Phase A - Brown
   b. Phase B - Orange
   c. Phase C - Yellow
   d. Neutral - Gray
   e. Ground - Green
3. Switch leg individually installed shall be the same color as the branch circuit to which they are connected, unless otherwise noted.
4. Travelers for 3-way and 4-way switches shall be a distinct color and pulled with the circuit switch leg or neutral.

3.03 WIRING METHODS
A. Install wires and cables in accordance with Manufacturer's written instructions, as indicated on Drawings and as specified herein.
B. Install all single conductors in raceway system, unless otherwise noted.
C. Parallel circuit conductors and terminations shall be equal in length and identical in all ways.
D. Provide adequate length of conductors within electrical enclosures and train the conductors to terminal points with no excess. Bundle multiple conductors, with conductors larger than #10 AWG cabled in individual circuits. Make terminations so there is no bare conductor at the terminal.
E. Provide #10 AWG pig tails on all 20A and 30A wiring devices served by #8 AWG conductors and larger.
F. Splice cables and wires only in outlet boxes, junction boxes, pull boxes, manholes or handholes. Group and bundle with tie wrap each neutral with its associated phase conductor where more than one neutral is present in a conduit.
G. Install cable supports for all vertical feeders in accordance with the NEC Article 300. Provide split wedge type fittings, which firmly clamp each individual cable and tighten due to cable weight.
H. Neatly form, train and tie the cables in individual circuits. For panelboards, cabinets, wireways, switches and equipment assemblies.
I. Provide UL-listed factory-fabricated, solderless metal connectors of size, ampacity rating, material, type and class for applications and for services indicated. Use connectors with temperature ratings equal to or greater than the wires that are being terminated.

J. Stranded wire shall be terminated using fitting, lugs or devices listed for the application. However, in no case shall stranded wire be terminated solely by wrapping it around a screw or bolt.

3.04 WIRING INSTALLATION IN RACEWAYS

A. Install wire in raceway after interior of building has been physically protected from the weather and all mechanical Work likely to injure conductors has been completed. Pull all conductors into a raceway at the same time. Exercise care in pulling conductors so that insulation is not damaged. Use UL listed, non-petroleum base and insulating type pulling compound as needed.

B. Completely mandrel all underground or concrete encased conduits prior to installing conductors.

C. Completely and thoroughly swab raceway system before installing conductors.

D. Do not use block and tackle, power driven winch or other mechanical means for pulling conductors of size smaller than AWG #1.

E. Wire pulling:
   1. Provide installation equipment that will prevent the cutting or abrasion of insulation during pulling of cables.
   2. Use rope made of nonmetallic material for pulling feeders.
   3. Attach pulling lines for feeders by means of either woven basket grips or pulling eyes attached directly to the conductors.
   4. Pull in together multiple conductors or cables in a single conduit.

F. Install and test all cables in accordance with Manufacturer's instructions and warranty.

3.05 WIRE SPLICES, JOINTS AND TERMINATION

A. Join and terminate wire, conductors and cables in accordance with UL 486A, C, NEC and Manufacturer's instructions.

B. Thoroughly clean wires before installing lugs and connectors.

C. Make splices, taps and terminations to carry full ampacity of conductors without perceptible temperature rise.

D. Splices and terminations shall be made mechanically and electrically secure.

E. Where it's determined that unsatisfactory splice or terminations have been installed, remove the devices and install approved devices at no addition cost.

F. Terminate wires in Terminal Cabinets, relay and contactor panels, etc. using terminal strip connectors.

G. Insulate spare conductors with electrical tape and leave sufficient length to terminate anywhere in the panel or cabinet.

H. Install cable ties and maintain harnessing.
I. Encapsulate splices in exterior outlets, pullboxes and junction boxes using specified insulating resin kits. Make all splices watertight for exterior equipment and equipment in pump rooms.

J. Make up all splices and taps in accessible junction or outlet boxes with connectors as specified herein. Pigtailed and taps shall be the same color as the feed conductor. Form conductor prior to cutting and provide at least six (6) inches of tail and neatly packed in box after splice is made up.

K. Branch circuits (#10 AWG and smaller):
   1. Connectors: Solderless, screw-on, reusable spring pressure cable type, 600 volt, 105-degree C. with integral insulation, approved for copper conductors.
   2. The integral insulator shall have a skirt to completely cover the stripped wires.
   3. The number, size and combination of conductors as listed on the Manufacturers packaging shall be strictly complied with.

L. Feeder circuits: (#6 to 750 MCM)
   1. Join or tap conductors from #6 AWG to 750 MCM using bolted pressure connectors or insulate mechanical compression (hi-press) taps with pre-molded, snap-on insulating boots or specified conformable insulating pad and over wrapped with two half-lapped layers of vinyl insulating tape starting and ending at the middle of the joint.
   2. Terminate conductors from size #6 AWG to 750 MCM copper using bolted pressure or mechanical compression lugs in accordance with Manufacturer recommendation or as specified elsewhere.
   3. Field installed compression connectors for cable sizes 250 MCM and larger shall have not less than two clamping elements or compression indents per wire.
   4. Insulate splices and joints with materials approved for the particular use, location, voltage and temperature. Insulate with not less than that of the conductor level that is being joined.

M. Termination hardware assemblies:
   1. AL/CU lugs connected to aluminum plated or copper buss, shall be secured using a steel bolt, flat washer (two per bolt), Belleville washer and nut.
   2. Copper lugs connected to copper bus, shall be secured using silicon bronze alloy bolt, flat washer (two per bolt), Belleville washer and nut.
   3. The crown of Belleville washers shall be under the nut.
   4. Bolt assemblies shall be torque to Manufacturer recommendation. Where manufacture recommendation are not obtainable, the following values shall be used:
      a. 1/4" - 20 bolt at 80-inch pounds torque.
      b. 5/16" - 18 bolt at 180-inch pounds torque.
      c. 3/8" - 16 bolt at 20-foot pounds torque.
      d. 1/2" - 13 bolt at 40-foot pounds torque.
      e. 5/8" - 11 bolt at 55-foot pounds torque.
      f. 3/4" - 10 bolt at 158-foot pounds torque.

3.06 IDENTIFICATION
A. Refer to Section 260553: Electrical Identification for additional requirements.
B. Securely tag all branch circuits. Mark conductors with specified vinyl wrap-around markers. Where more than two conductors run through a single outlet, mark each conductor with the corresponding circuit number.
C. Color code conductors size #8 and larger using specified phase color markers and identification tags.
D. Provide all terminal strips with each individual terminal identified using specified vinyl markers.
E. In manholes, pullboxes and handholes, provide tags of the embossed brass type and also show the cable type and voltage rating. Attach the tags to the cables with slip-free plastic cable lacing units.

3.07 FIELD QUALITY CONTROL
A. Prefunctional testing:
   1. Visual and mechanical inspection:
      b. Inspect exposed sections of wires and cables for physical damage and proper connections.
      c. Verify tightness of accessible bolted connections with calibrated torque wrench in accordance with Manufacturer’s published data.
      d. Inspect compression applied connectors for correct cable match and indentation.
      e. Verify visible cable bend meet or exceed ICEA and Manufacturer’s minimum allowable bending radius.
      f. If cables are terminated through window type current transformers, make an inspection to verify neutral and ground conductors are correctly placed for operation of protective devices.
      g. Ensure wire and cable identification has been installed as specified herein.
   2. Electrical testing:
      a. Contractor shall perform feeder and branch circuit insulation test after installation and prior to connection to utilization devices such as fixtures, motors or appliances. Testing shall be conducted on all the circuits on this project.
      b. Perform insulation-resistance test using megohm meter with applied potential of 1000V DC for a continuous duration of 60 seconds. Test conductors phase-to-phase and phase-to-ground. Conductors shall test free from short-circuit and ground faults.
      c. Perform continuity test of all feeder and branch circuits to ensure correct cable connections. Test all neutrals for improper grounds.
      d. Contractor shall furnish instruments, materials and labor for these tests.
   3. Test values: Investigate resistance values less than 50 megohms.
   4. Furnish test results in typewritten report form for review and inclusion in the operation and maintenance manuals.

END OF SECTION
GROUNDING AND BONDING

SECTION 260526 - GROUNDING AND BONDING

PART 1 - GENERAL

1.01 SUMMARY

A. Work included: Labor, materials and equipment necessary to complete the installation required for the item specified under this Division, including but not limited to:
   1. Power system grounding.
   2. Electrical equipment and raceway grounding and bonding.

1.02 REFERENCES

A. Comply with the latest edition of the following applicable Specifications and standards except as otherwise indicated or specified:
   1. Underwriters Laboratories, Inc. (UL):
      UL 467; Grounding and Bonding Equipment.
   2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
      IEEE No. 142; Recommended Practice for Grounding of industrial and Commercial Power Systems.

1.03 SYSTEM DESCRIPTION

A. Except as otherwise indicated, the complete electrical installation including the neutral conductor, metallic conduits and raceways, boxes, cabinets and equipment shall be completely and effectively grounded in accordance with all code requirements, whether or not such connections are specifically indicated or specified.

B. Resistance:
   1. Resistance from the main switchboard ground bus through the ground electrode to earth shall not exceed 5 OHMS unless otherwise noted.
   2. Resistance from the farthest panelboard, switchboard, etc. ground bus through the ground electrode to earth shall not exceed 20 OHMS

1.04 SUBMITTALS

A. Submit in accordance with the requirements of Section 260010: Basic Electrical Requirements, the following items:
   1. Data/catalog cuts for each product and component specified herein, listing all physical and electrical characteristics and ratings indicating compliance with all listed standards.
   2. Clearly mark on each data sheet the specific item(s) being submitted and the proposed application.
   3. Submit Manufacturer's installation instructions.

1.05 QUALITY ASSURANCE
GROUNDING AND BONDING

A. All materials, equipment and parts comprising the units specified herein shall be new, unused and currently under production.

B. Only products and applications listed in this Section may be used on the Project unless otherwise submitted.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Products furnished by the following Manufacturers shall be acceptable if in compliance with all features specified herein and indicated on the Drawings.

1. Ground Rods:
   a. Weaver.
   b. Erico "Cadweld" Products, Inc.

2. Ground Wells:
   a. Christy Concrete Products, Inc.
   b. Forni Corp.

3. Ground Bushings, Connectors, Jumpers and Bus:
   a. O-Z/Gedney.
   b. Thomas & Betts Corp.

B. Substitutions: Under provisions of Section 260010: Basic Electrical Requirements.

2.02 GROUND CONDUCTORS

A. Refer to Specification Section 260519: Building Wire and Cable for conductor specifications.

B. General purpose insulated:

   1. UL approved and code sized copper conductor, with dual rated THHN/THWN insulation, color identified green.

   2. Where continuous color-coded conductors are not commercially available, provide a minimum 4" long color band with green, non-aging, plastic tape in accordance with NEC/CEC.

C. Bonding pigtails: Insulated copper conductor, identified green, sized per code and provide with termination screw or lug. Provide solid conductors for #10 AWG or smaller and stranded conductors for #8 AWG or larger.

2.03 DRIVEN (GROUND) RODS

A. Copper clad steel, minimum 3/4-inch diameter by 8 feet long, unless otherwise noted.

2.04 GROUND WELL BOXES FOR GROUND RODS

A. Precast concrete box nominal 9" throat diameter x 14" deep with light duty concrete cover for non-traffic areas or steel plate for traffic areas. Cover shall be embossed or engraved with "GROUND ROD".

2.05 INSULATED GROUNDING BUSHINGS

A. Plated malleable iron or steel body with 150 degree Centigrade molded plastic insulating throat and lay-in grounding lug.
GROUNDING AND BONDING

PART 3 - EXECUTION

3.01 EXAMINATION
A. Contractor shall thoroughly examine Project site conditions for acceptance of grounding system installation to verify conformance with Manufacturer and Specification tolerances. Do not commence with installation until all conditions are made satisfactory.

3.02 INSTALLATION
A. Equipment bonding/grounding:
   1. Provide a NEC/CEC sized insulated copper ground conductor in all 120VAC through 600 VAC feeder and branch circuit distribution conduits and cables.

B. Site lighting grounding: Bond all metallic light poles and bollards. Provide ground rods where indicated on the Drawings.

END OF SECTION
SECTION 260529 - ELECTRICAL HANGERS AND SUPPORTS

PART 1 - GENERAL

1.01 SUMMARY

A. Work included: Labor, materials and equipment necessary to complete the installation required for the item specified under this Division, including but not limited to:

1. Conduit supports.
2. Equipment supports.
3. Fastening hardware.

1.02 REFERENCES

A. Comply with the latest edition of the following applicable Specifications and standards except as otherwise indicated or specified:

1. Underwriters Laboratories, Inc. (UL):
   UL 2239; Hardware for the Supports of Conduit, Tubing and Cable.

1.03 SYSTEM DESCRIPTION

A. Provide devices specified in this Section and related Sections for support of electrical equipment furnished and installed under Division 26.

B. Provide support systems that are adequate for the weight of equipment, conduit and wiring to be supported.

1.04 SUBMITTALS

A. Submit in accordance with the requirements of Section 260010: Basic Electrical Requirements, the following items:

1. Data/catalog cuts for each product and component specified herein.
2. Clearly mark on each data sheet the specific item(s) being submitted and the proposed application.
3. Submit Manufacturer's installation instructions.
1.05 QUALITY ASSURANCE

A. All materials, equipment and parts comprising the units specified herein shall be new, unused and currently under production.

B. Only products and applications listed in this Section may be used on the Project unless otherwise submitted.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Products furnished by the following Manufacturers shall be acceptable if in compliance with all features specified herein and indicated on the Drawings.

1. Concrete fasteners:
   a. Phillips "Red-Head".
   b. Remington.
   c. Ramset.

2. Concrete inserts and construction channel:
   a. Unistrut Corp.
   b. GS Metals "Globe Strut."
   c. Thomas & Betts "Kindorf" Corp.

3. Conduit straps:
   a. O-Z/Gedney.
   b. Erico "Caddy" Fastening Products.
   c. Thomas & Betts "Kindorf" Corp.

B. Substitutions: Under provisions of Section 260010: Basic Electrical Requirements.

2.02 CONCRETE FASTENERS

A. Provide expansion-shield type concrete anchors.

B. Provide powder driven concrete fasteners with washers. Obtain approval by Architect and Structural Engineer prior to use.
ELECTRICAL HANGERS AND SUPPORTS

2.03 CONCRETE INSERTS
   A. Provide pressed galvanized steel, concrete spot insert, with oval slot capable of accepting square or rectangular support nuts of ¼ inch to ½ inch diameter thread for rod support.

2.04 THREADED ROD
   A. Provide steel threaded rod, sized for the load unless otherwise noted on the Drawings or in the Specifications.

2.05 CONSTRUCTION CHANNEL
   A. Provide 1-1/2 inch by 1-1/2 inch, 12 gauge galvanized steel channel with 17/32-inch diameter bolt holes and 1-1/2 inch on center in the base of the channel.

2.06 CONDUIT STRAPS
   A. One hole strap, steel or malleable iron, with malleable iron clamp-back spacer for surface mounted wall and ceiling applications.
      1. Use malleable strap with spacers for exterior and wet locations.
      2. Use steel strap without spacers for interior locations.
   B. Steel channel conduit strap for support from construction channel.
   C. Steel conduit hanger for pendant support with threaded rod
   D. Steel wire conduit support strap for support from independent #12 gauge hanger wires.

PART 3 - EXECUTION

3.01 EXAMINATION
   A. Contractor shall thoroughly examine Project site conditions for acceptance of supporting device installation to verify conformance with Manufacturer and Specification tolerances. Do not commence with installation until all conditions are made satisfactory.

3.02 PREPARATION
   A. Coordinate size, shape and location of concrete pads with Division 03, Cast-in-place concrete.
   B. Layout support devices to maintain headroom, neat mechanical appearance and to support the equipment loads.
C. Where indicated on the Contract Documents, install freestanding electrical equipment on concrete pads.

3.03 INSTALLATION

A. Furnish and install supporting devices as noted throughout Division 26.

B. Electrical device and conduit supports shall be independent of all other system supports that are not structural elements of the building, unless otherwise noted.

C. Fasten hanger rods, conduit clamps, outlet and junction boxes to building structure using precast inserts, expansion anchors, preset inserts or beam clamps.

D. Use toggle bolts or hollow wall fasteners in hollow masonry, plaster or gypsum board partitions and walls.

E. Use expansion anchors or preset inserts in solid masonry walls.

F. Use self-drilling anchors, expansion anchor or preset inserts on concrete surfaces.

G. Use sheet metal screws in sheet metal studs and wood screws in wood construction.

H. Do not fasten supports to piping, ductwork, mechanical equipment, conduit or acoustical ceiling suspension wires.

I. Do not drill structural steel members unless first approved in writing by the Architect or Structural Engineer.

J. Fabricate supports from structural steel or steel channel, rigidly welded or bolted to present a neat appearance. Use hexagon head bolts with spring lock washers under all nuts.

K. Install surface-mounted cabinets and panelboards with minimum of four anchors. Provide additional support backing in stud walls prior to sheet rocking as required to adequately support cabinets and panels.

L. Bridge studs top and bottom with channels to support flush mounted cabinets and panelboards in stud walls.

3.04 ERECTION OF METAL SUPPORTS

A. Cut, fit and place miscellaneous metal fabrications accurately in location, alignment and elevation to support and anchor electrical materials and equipment.

B. Field Welding: Comply with AWS "Structural Welding Code."

3.05 ANCHORAGE
ELECTRICAL HANGERS AND SUPPORTS

A. All floor mounted, free standing electrical equipment etc. shall be securely fastened to the floor structure.

B. Anchorage of electrical equipment shall comply with the seismic requirements as outlined in Section 260010: Basic Electrical Requirements.

END OF SECTION 260529
SECTION 260531 - CONDUIT

PART 1 - GENERAL

1.01 SUMMARY

A. Work included: Labor, materials and equipment necessary to complete the installation required for the item specified under this Division, including but not limited to:

1. Rigid steel conduit and fittings.
2. PVC insulated rigid steel conduit and fittings.
3. Electrical metallic tubing and fittings.
4. Rigid non-metallic conduit and fittings.
5. Flexible metallic conduit and fittings.
6. Liquidtight flexible metallic conduit and fittings.
7. Miscellaneous conduit fittings and products.

1.02 REFERENCES

A. Comply with the latest edition of the following applicable Specifications and standards except as otherwise indicated or specified:

1. Federal Specifications (FS):
   FS WW-C-563; Electrical Metallic Tubing.
   FS WW-C-566; Specification for Flexible Metal Conduit.
   FS WW-C-581; Specification for Galvanized Rigid Conduit.
   FS W-C-1094A; Conduit and Conduit Fittings Plastic, Rigid.

2. American National Standards Institute, Inc. (ANSI):
   ANSI C80.1; Rigid Steel Conduit, Zinc-Coated.
   ANSI C80.3; Electrical Metallic Tubing, Zinc Coated.
   ANSI C80.5; Rigid Aluminum Conduit.

3. Underwriters Laboratories, Inc. (UL):
CONDUIT

UL 1; Flexible Metal Conduit.
UL 6; Rigid Metal Conduit.
UL 360; Liquid-Tight Flexible Steel Conduit.
UL 514B; Conduit, Tubing and Cable Fittings.
UL 635; Insulating Bushings.
UL 651; Schedule 40 and 80 Rigid PVC Conduit.
UL 797; Electrical Metallic Tubing - Steel.
UL 1242; Intermediate Metal Conduit - Steel.

4. National Electrical Manufacturer Association (NEMA):
   NEMA RN1; PVC Externally coated Galvanized Rigid Steel Conduit.
   NEMA TC 2; Electrical Plastic Tubing and Conduit.
   NEMA TC 3; PVC Fittings for use with Rigid PVC Conduit.

1.03 SUBMITTALS
   A. Submit in accordance with the requirements of Section 260010: Basic Electrical Requirements the following items:
      1. Data/catalog cuts for each product and component specified herein, listing all physical and electrical characteristics and ratings indicating compliance with all listed standards.
      2. Clearly mark on each data sheet the specific item(s) being submitted and the proposed application.
      3. Submit Manufacturer's installation instruction. Provide written instructions for raceway products requiring glues, special tools or specific installation techniques.

1.04 QUALITY ASSURANCE
   A. All materials, equipment and parts comprising the units specified herein shall be new, unused and currently under production.
   B. Only products and applications listed in this Section may be used on the Project unless otherwise submitted and approved.

PART 2 - PRODUCTS
2.01 MANUFACTURERS

A. Products furnished by the following Manufacturers shall be acceptable if in compliance with all features specified herein and indicated on the Drawings.

1. Metal conduit:
   a. Allied Tube and Conduit Co.
   b. Triangle PWC, Inc.
   c. Western Tube and Conduit Corp.
   d. Spring City Electrical Manufacturing Co.
   e. Occidental Coating Co. (OCAL).
   f. Alflex Corp.
   g. American Flexible Metal Conduit Co.
   h. Anaconda.

2. Nonmetallic conduit:
   a. Carlon.
   b. PW Pipe.

3. Fittings:
   a. Appleton Electric Co.
   b. OZ/Gedney.
   c. Thomas & Betts Corp.
   d. Spring City Electrical Manufacturing Co.
   e. Occidental Coating Co. (OCAL).
   f. Carlon.

B. Substitutions: Under provisions of Section 260010: Basic Electrical Requirements.

2.02 GALVANIZED RIGID STEEL CONDUIT (GRS)

A. Conduit: Full weight, threaded, hot-dip galvanized steel, conforming to ANSI C80.1 and UL 6.
CONDUIT

B. Standard threaded couplings, locknuts, bushings and elbows: Only materials of steel or malleable iron are acceptable. Locknuts shall be bonding type with sharp edges for digging into the metal wall of an enclosure.

C. Three piece couplings: Electroplated, cast malleable iron.

D. Insulating bushings: Threaded polypropylene or thermosetting phenolic rated 150 degree C minimum.

E. Insulated grounding bushings: Threaded cast malleable iron body with insulated throat and steel "lay-in" ground lug with compression screw.

F. Insulated metallic bushings: Threaded cast malleable iron body with plastic insulated throat rated 150 degrees C.

G. All fittings and connectors shall be threaded.

2.03 PVC INSULATED GALVANIZED RIGID STEEL CONDUIT (PVC GRS)

A. Conduit: Full weight, threaded, hot-dip galvanized steel, conforming to ANSI C80.1 and NEMA RN-1 with nominal 20 or 40 mil electrical tape wrap on the exterior of the conduit.

B. Fittings: Conduit couplings and connectors shall be as specified for galvanized rigid steel conduit and shall be factory PVC coated with an insulating jacket equivalent to that of the coated material.

2.04 ELECTRICAL METALLIC TUBING (EMT)

A. Conduit: Shall be formed of cold rolled strip steel, electrical resistance welded continuously along the longitudinal seam and hot dip galvanized after fabrication. Conduit shall conform to ANSI C80.3 Specifications and shall meet UL requirements.

B. Set screw type couplings: Electroplated, steel or cast malleable iron, UL listed concrete tight. Use set screw type couplings with four setscrews each of conduit sizes over 2 inches. Setscrews shall be of case hardened steel with hex head and cup point to firmly seat in wall of conduit for positive grounding.

C. Set screw type connectors: Electroplated steel or cast malleable iron UL listed concrete tight with male hub and insulated plastic throat, 150 degree C temperature rated. Setscrew shall be same as for couplings.

D. Raintight couplings: Electroplate steel or cast malleable iron; UL listed raintight and concrete tight, using gland and ring compression type construction.

E. Raintight connectors: Electroplated steel or cast malleable iron, UL listed raintight and concrete tight, with insulated throat, using gland and ring compression type construction.

2.05 RIGID NON-METALLIC CONDUIT (PVC)
CONDUIT

A. Conduit:
   1. Rigid polyvinyl chloride, Schedule 40 or 80 conforming to NEMA TC1 and UL 651, latest edition. UL listed for exposed and direct-burial applications and for 90 degrees C conductor insulation. Conduit shall include an integral bell fitting at one end.

B. Fittings: Couplings, adaptors, transition fittings, etc., shall be molded PVC, slip on, solvent weld type conforming to NEMA TC3 for Schedule 40 or 80.

2.06 FLEXIBLE METALLIC CONDUIT (FMC)

A. Conduit: Shall be fabricated in continuous lengths from galvanized steel strip, spirally wound and formed to provide an interlocking design and conforming to UL 1.

B. Fittings: Connectors shall be of the single screw clamp variety with steel or cast malleable iron bodies and threaded male hubs with insulated throats. Exception: Pressure cast screw-in connectors shall be acceptable for fixture connection in suspended ceilings and cut-in outlet boxes within existing furred walls.

2.07 LIQUIDTIGHT FLEXIBLE METALLIC CONDUIT (LFMC)

A. Conduit: Shall be fabricated in continuous lengths from galvanized steel strips, interlocking spirally wound, covered with extruded liquidtight jacket of polyvinyl chloride (PVC) and conforming to UL 360. Provide conduit with a continuous copper-bonding conductor wound spirally between the convolutions.

B. Fittings: Connector body and gland nut shall be of cadmium plated steel or cast malleable iron, with tapered, male, threaded hub; insulated throat and neoprene "O" ring gasket recessed into the face of the stop nut. The clamping gland shall be of molded nylon with an integral brass push-in ferrule.

2.08 MISCELLANEOUS CONDUIT FITTINGS AND PRODUCTS

A. Watertight conduit entrance seals: Steel or cast malleable iron bodies and pressure clamps with PVC sleeve, neoprene sealing grommets and PVC coated steel pressure rings. Fittings shall be supplied with neoprene sealing rings between the body and PVC sleeve.

B. Watertight cable sealing bushings: One piece, compression molded sealing ring with PVC coated steel pressure disks, stainless steel sealing screws and zinc plated cast malleable iron locking collar.

C. Expansion fittings: Multi-piece unit comprised of a hot dip galvanized malleable iron or steel body and outside pressure bussing designed to allow a maximum of 4" conduit movement (2" in either direction). Furnish with external braid tinned copper bonding jumper. Unit shall be UL listed for wet or dry locations.

D. Expansion/deflection couplings: Multi-piece unit comprised of a neoprene sleeve with internal flexible tinned copper braid attached to bronze end couplings with stainless steel bands.
Coupling shall accommodate .75-inch deflection, expansion or contraction in any direction and allow 30-degree angular deflections. Flexible, corrosion-resistant, watertight, moisture and heat resistant molded rubber jacket and stainless steel jacket clamps. Unit shall comply with UL467 and UL514. Manufacturer shall be OZ/Gedney Type DX, Steel City Type EDF or equal.

E. Fire rated penetration seals:
   1. UL building materials directory classified.
   2. Conduit penetrations in fire rated separation shall be sealed with a UL classified fill, void or cavity material.
   3. The fire rated sealant material shall be the product best suited for each type of penetration and may be a caulk, putty, composite sheet or wrap/strip.

F. Standard products not herein specified:
   1. Provide listing of standard electrical conduit hardware and fittings not herein specified for approval prior to use or installation, i.e. locknuts, bushings, etc.
   2. Listing shall include Manufacturers name, part numbers and a written description of the item indicating type of material and construction.
   3. Miscellaneous components shall be equal in quality, material and construction to similar items herein specified.

G. Hazardous area fittings: UL listed for the application.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Contractor shall thoroughly examine Project site conditions for acceptance of conduit system installation to verify conformance with Manufacturer and Specification tolerances. Do not commence with installation until all conditions are made satisfactory.

3.02 APPLICATION

A. Galvanized rigid steel conduit (GRS) shall be used in the following applications:
   1. For feeders and branch circuits located indoors, concealed or exposed above suspended ceilings, in damp/wet locations, in crawl spaces, in attics, chases, furred spaces, equipment rooms, loading docks or in hazardous locations in accordance with NEC and local Codes.
   2. For feeders and branch circuits concealed in concrete floors and walls when not in contact with earth.
3. For feeders and branch circuits located outdoors and exposed.

B. PVC insulated galvanized rigid steel conduit (PVC GRS) shall be used in the following applications:
   1. Use 40-mil for all below grade elbows and penetrations through floor slabs on grade or exterior walls.

C. Electrical metallic tubing (EMT): Shall be used exposed or concealed for interior electrical feeders 4" and smaller, interior power and lighting branch circuits and low tension distribution system where run above suspended ceilings, in concrete slabs and walls not in contact with earth; in stud walls, furred spaces and crawl spaces. EMT shall not be installed exposed below 6 feet above the finish floor except within electrical, communication or signal rooms or closets.

D. Rigid non-metallic conduit (PVC): Shall be used in the following applications:
   1. Schedule 40 for exterior branch circuits directly buried in earth, 24" minimum below grade.
   2. Schedule 80 below roads and paved surfaces, minimum 36-inches below finished grade.
   3. In general, PVC may not be run exposed in concrete walls or in floor slabs unless expressly indicated on the Drawings.

E. Flexible metallic conduit (FMC): Shall be used only in dry locations for connections from an adjacent outlet box or conduit to all motors, transformers, vibrating equipment or machinery, controllers, solenoid valves, float and flow switches or similar devices and to lighting fixtures installed in suspended ceilings, minimum sizes shall be 3/8" for lighting fixtures and control wiring and 1/2" for motor and transformer connections. U.O.N.

F. Liquidtight flexible metallic conduit (LFMC): Shall be used in wet or damp locations for connections from adjacent outlet box or conduit to all motors, transformers, vibrating equipment or machinery, controllers, solenoid valves, float and flow switches or similar devices. These areas are typically food preparation and dishwashing areas, sump wells, loading docks, pump rooms, exterior areas, etc. Minimum sizes shall be 1/2".

3.03 PREPARATION

A. Locations of conduit runs shall be planned in advance of the installation and coordinated with ductwork, plumbing, ceiling and wall construction in the same areas and shall not unnecessarily cross other conduits or pipe, nor prevent removal of ceiling tiles or panels, nor block access to mechanical or electrical equipment.

B. Where practical, install conduits in groups in parallel vertical or horizontal runs and at elevations that avoid unnecessary offsets.

C. All conduits shall be run parallel or at right angles to the centerlines of columns and beams, whether routed exposed, concealed above suspended ceiling or in concrete slabs.
D. Conduits shall not be placed closer than 12 inches to a flue, parallel hot water, steam line or other heat producing source or three inches from such lines when crossing perpendicular to the runs.

E. Exposed conduit installation shall not encroach into the ceiling height headroom of walkways or doorways. Where possible, install horizontal raceway runs above water and below steam piping.

F. The largest trade size conduits in concrete floor and wall slabs shall not exceed 1/3 the floor or wall thickness and conduits shall be spaced a minimum of three conduit diameters apart unless otherwise noted on the Drawings. All conduits shall be installed in the center of concrete slabs or wall and shall not be placed between reinforcing steel and the bottom of floor slabs.

G. In long runs of conduit, provide sufficient pull boxes inside buildings to facilitate pulling wires and cables, with spacing not to exceed 150 feet. Support pull boxes from structure independent of conduit supports. These pull boxes are not indicated on the Drawings.

H. Provide all reasonably inferred standard conduits fitting and products required to complete conduit installation to meet the intended application whether noted, indicated or specified in the Contract Documents or not.

I. Connect recessed lighting fixtures to conduit runs with maximum six feet of flexible metal conduit or MC cable extending from a junction box to the fixture or manufactured wiring system.

3.04 INSTALLATION

A. Install conduit in accordance with Manufacturer's written instructions, as indicated on Drawings and as specified herein.

B. Minimum Conduit Size: Unless otherwise noted herein or on Drawings, minimum conduit size shall be 1/2" for interior applications and 3/4" for exterior and underground applications.

C. All conduit sizes indicated on the Drawings are sized for copper conductors with THHN/THWN insulation. If conductor type or size is changed the Contractor shall be responsible for resizing conduits upward to meet Code.

D. In general, all conduit work shall be concealed where possible. Exceptions shall be electrical, communication and mechanical rooms, exposed ceiling areas, and parking garages.

E. Conduit connections to motors and surface cabinets shall be concealed, with the exception of electrical, communication and mechanical rooms, or unless exposed Work is clearly called for on the Drawings.

F. Install conduits in complete runs before pulling in cables or wires.

G. Install conduit free from dented, bruises or deformations. Remove and replace any damaged conduits with new undamaged material.
H. Conduits shall be well protected and tightly covered during construction using metallic bushings and bushing "pennies" to seal open ends.

I. In making joints in rigid steel conduit, ream conduit smooth after cutting and threading. Coat all field-threaded joints with UL approved conductive type compound to ensure low resistance ground continuity through conduit and to prevent seizing and corrosion.

J. Clean any conduit in which moisture or any foreign matter has collected before pulling in conductors. Paint all field-threaded joints to prevent corrosion.

K. In all empty conduits or ducts, install a “True Tape” conduit measuring tape line to provide overall conduit length for determining length of cables/conductors for future use.

L. Conduit systems shall be mechanically and electrically continuous throughout. Install code size, insulated, copper, green-grounding conductors in all conduit runs for branch circuits and feeders. This conductor is not indicated on the Drawings. Refer to Section 260526: Grounding and Bonding.

M. Metallic conduit shall not be in contact with other dissimilar metal pipes (i.e. plumbing).

N. Make bends with standard conduit bending hand tool or machines. The use of any item not specifically designed for the bending of electrical conduit is strictly prohibited.

O. A run of conduit between terminations at wire pulling points shall not contain more than the equivalent of four quarter bends (360 degrees, total).

P. Emergency power raceway system: Install entirely independent of other raceway systems, except where specifically allowed by NEC Article 517.

Q. Conduit for conductors above 600 volts use rigid steel.

3.05 PENETRATIONS

A. Cutting or holes:

1. Cut holes through concrete, masonry block or brick floors and floors of structure with a diamond core drill or concrete saw. Pneumatic hammer, impact electric, hand or manual hammer type drills are not allowed, except where permitted by the Architect as required by limited working space. Obtain the approval of the Architect prior to drilling through structural sections.

2. Cut holes for conduit penetrations through non-concrete and non-masonry walls, partitions or floors with a hole saw. The hole shall be only as large as required to accommodate the size of the conduit.

3. Provide single piece escutcheon plates around all exposed conduit penetrations in public places.

B. Sealing:
1. Non-rated penetrations: Pack opening around conduits with non-flammable insulating material and seal with gypsum wallboard taping compound.

2. Fire stop: Where conduits, wireways and other electrical raceways pass through fire rated partitions, walls, smoke partitions or floor; install a UL classified fire stop material to provide an effective barrier against the spread of fire, smoke and gases. Completely fill and seal clearances between raceways and openings with the fire stop material.

C. Waterproofing: At floor, exterior wall and roof conduit penetrations, completely seal clearances around the conduit and make watertight as specified in Division 07: Sealants and Caulking.

   1. Install specified watertight conduit entrance seals at all below grade wall and floor penetrations. Conduits penetrating exterior building walls and building floor slab shall be PVC coated rigid galvanized steel.

   2. For roof penetrations furnish and install roof flashing, counter flashing and pitch-pockets as specified under Roofing and Sheet Metal Sections of the Specifications.

   3. Provide membrane clamps and cable sealing fittings for any conduit that horizontally penetrates the waterproof membrane.

   4. Conduits that horizontally penetrate a waterproof membrane shall fall away from and below the penetration on the exterior side a minimum of two times the conduit diameters.

3.06 TERMINATIONS AND JOINTS

A. Use raceway fittings that are of types compatible with the associated raceway and suitable for the use and location. For intermediate steel conduit, use threaded rigid steel conduit fittings except as otherwise indicated.

B. Raceways shall be joined using specified couplings or transition couplings where dissimilar raceway systems are joined.

C. Conduits shall be securely fastened to cabinets, boxes and gutters using two locknuts and an insulating bushing or specified insulated connectors. Where joints cannot be made tight, use bonding jumpers to provide electrical continuity of the raceway system. Where terminations are subject to vibration, use bonding bushings or wedges to assure electrical continuity. Where subject to vibration or dampness, use insulating bushings to protect conductors. Install grounding bushings or bonding jumpers on all conduits terminating at concentric or eccentric knockouts.

D. Conduit terminations exposed at weatherproof enclosures and cast outlet boxes shall be made watertight using specified connectors and hubs.

E. Stub-up connections: Extend conduits through concrete floor for connection to freestanding equipment with an adjustable top or coupling threaded inside for plugs and set flush with the finished floor. Extend conductors to equipment with rigid steel conduit; flexible metal conduit may be used 6 inches above the floor. Where equipment connections are not made under this contract, install screwdriver operated threaded flush plugs with floor.
CONDUIT

F. Install specified cable sealing bushings on all conduits originating outside the building walls and terminating in switchgear, cabinets or gutters inside the building. Install cable sealing bushings or raceway seal for conduit terminations in all grade level or below grade exterior pull, junction or outlet boxes.

G. Install expansion couplings where any conduit crosses a building separation or expansion joint as follows:

1. Conduits three inches and larger, shall be rigidly secured to the building structure on opposite sides of a building expansion joint and provided with expansion or deflection couplings. Install the couplings in accordance with the Manufacturer's recommendations.

2. Conduits smaller than three inches shall be rigidly secured to the building structure on opposite sides of a building expansion joint with junction boxes on both sides of the joint. Connect conduits to junction boxes with 15 inches of slack flexible conduit. Flexible conduit shall have a copper green ground-bonding jumper installed. For concrete embedded conduit, use expansion and deflection couplings as specified above for three inches and larger conduits.

H. Use short length (maximum of 6ft) of the appropriate FMC or LFMC conduit for connections to motors and other electrical equipment subject to movement, vibration, misalignment, cramped quarters or noise transmission. Provide liquidtight flexible metal conduit for installation in exterior locations, moisture or humidity-laden atmosphere, corrosive atmosphere, water hose or spray wash-down operations and locations subject to seepage or dripping of oil, grease or water. Provide a green ground wire with FMC or LFMC conduit.

3.07 SUPPORTS

A. Provide supports for raceways as specified in Section 260529: Electrical Hangers and Supports.

B. All raceways systems shall be secured to building structures using specified fasteners, clamps and hangers spaced according to the NEC.

C. Support single runs of conduit using one-hole pipe straps. Where run horizontally on walls in damp or wet locations, install "clamp backs" to space conduit off the surface.

D. Multiple conduit runs shall be supported using "trapeze" hangers fabricated from specified construction channel, mounted to 3/8-inch diameter, threaded steel rods secured to building structures. Fasten conduit to construction channel with standard one-hole pipe clamps or the equivalent. Provide lateral seismic bracing for hangers.

E. Individual 1/2" and 3/4" conduits installed above suspended ceilings may be attached to the ceiling's hanger wire using spring steel support clips provided that not more than two conduits are attached to any single support wire.

F. Support exposed vertical conduit runs at each floor level, independent of cabinets or switches to which they run, by means of acceptable supports.

G. Fasteners and supports in solid masonry and concrete:
CONDUIT

1. Use steel or malleable iron concrete inserts set in place prior to placing the concrete.

2. After concrete installation:
   a. Steel expansion anchors not less than ¼ inch bolt size and not less than 1-1/8 inch embedment.
   b. Power set fasteners not less than ¼ inch diameter with depth of penetration not less than three inches.
   c. Use vibration and shock resistant anchors and fasteners for attaching to concrete ceilings.

H. Hollow masonry: Toggle bolts are permitted. Bolts supported only by masonry block are not acceptable.

I. Metal structures: Use machine screw fasteners or other devices specifically designed and approved for the application.

END OF SECTION 260531
UNDERGROUND DUCTS AND STRUCTURES

SECTION 260543 - UNDERGROUND DUCTS AND STRUCTURES

PART 1 - GENERAL

1.01 SUMMARY

A. Work included: Labor, materials and equipment necessary to complete the installation required for the item specified under this Division, including but not limited to:

1. Underground conduits and ducts.
2. Duct banks.
3. Handhole and pullboxes.
4. Vaults
5. Excavation, trenching and backfill.

B. Related Work: Consult all other Sections, determine the extent and character of related Work and properly coordinate Work specified herein with that specified elsewhere to produce a complete installation.

1. Division 31 - Earthwork: General requirements for Excavation and Backfill and related items for ducts, manholes, pullboxes and handholes.

1.02 REFERENCES

A. Comply with the latest edition of the following applicable Specifications and standards except as otherwise indicated or specified:

1. Federal Specifications (FS):
   FS W-C-1094A; Conduit and Conduit Fittings Plastic, Rigid.
2. American Concrete Institute (ACI):
   ACI 318; Building Code Requirements for Structural Concrete
3. American Society for Testing And Materials (ASTM):
   ASTM C31; Standard Practice for Making and Curing Concrete Test Specimens in the Field
   ASTM C39; Test Method for Compressive Strength of Cylindrical Concrete Specimens
   ASTM C172; Standard Practice for Sampling Freshly Mixed Concrete
   ASTM C192; Practice for Making and Curing Concrete Test Specimens in the Laboratory
   ASTM C231; Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
   ASTM C478; Specification for Precast Reinforced Concrete Manhole Sections
   ASTM C805; Test Method for Rebound Number of Hardened Concrete
UNDERGROUND DUCTS AND STRUCTURES

ASTM C857; Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures
ASTM C858; Specification for Underground Precast Concrete Utility Structures
ASTM C877; Specification for External Sealing Bands for Concrete Pipe, Manholes and Precast Box Sections
ASTM C891; Practice for Installation of Underground Precast Concrete Utility Structures
ASTM C990; Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants
ASTM C1037; Practice for Inspection of Underground Precast Concrete Utility Structures
ASTM C1064; Standard Test Method for Temperature of Freshly Mixed Concrete
ASTM C1231; Standard Practice for Use of Unbonded Caps in Determination of Compressive Strength of Hardened Concrete Cylinder
ASTM C1611; Standard Test Method for Slump Flow of Self-Consolidating Concrete

4. Underwriters Laboratories, Inc. (UL):
   UL 651; Schedule 40 and 80 Rigid PVC Conduit.

5. National Electrical Manufacturer Association (NEMA):
   NEMA TC 2; Electrical Plastic Tubing and Conduit.
   NEMA TC 3; PVC Fittings for use with Rigid PVC Conduit.

1.03 DEFINITIONS

A. Duct: Electrical conduit and other raceway, either metallic or nonmetallic, used underground embedded in earth.
B. Duct bank: Two or more conduits or other raceway installed underground in same trench.
C. Handhole: An underground junction box in a duct or duct bank.
D. Vault: An underground utility structure, large enough for a person to enter, connecting with ducts to afford facilities for installing, operating and maintaining equipment and wiring.

1.04 SUBMITTALS

A. Submit in accordance with the requirements of Section 260010: Basic Electrical Requirements, the following items:
   1. Data/catalog cuts for each product and component specified herein, listing all physical and electrical characteristics and ratings indicating compliance with all listed standards.
   2. Clearly mark on each data sheet the specific item(s) being submitted and the proposed application.
   3. Submit Manufacturer's installation instructions.
   4. Complete bill of material listing all components.

1.05 QUALITY ASSURANCE
A. All materials, equipment and parts comprising the units specified herein shall be new, unused and currently under production.

B. Only products and applications listed in this Section may be used on the Project unless otherwise submitted and approved.

C. Precast concrete vaults shall be designed and fabricated by an experienced and acceptable precast concrete manufacturer. The manufacturer shall have been regularly and continuously engaged in the manufacture of precast concrete units similar to that indicated in the project specifications or drawings for at least 10 years.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Products furnished by the following Manufacturers shall be acceptable if in compliance with all features specified herein and indicated on the Drawings.

1. Underground precast concrete utility structures:
   a. Oldcastle Enclosure Solutions.
   b. Jensen Precast.

2. Conduits, ducts and fittings:
   a. Prime Conduit.
   b. JM Eagle.
   c. Cantex.
   d. Occidental Coating Company (OCAL).

B. Substitution: Under provisions of Section 260010: Basic Electrical Requirements.

2.02 CONDUIT AND DUCT

A. Refer to specification section 260531.

B. Duct supports: Rigid PVC spacers selected to provide minimum duct spacing and concrete cover depths, while supporting ducts during concrete pour.

C. Duct sealing compound: Non-hardening, safe for human skin contact, not deleterious to cable insulation, workable at temperatures as low as 35 degree F, withstands temperature of 300 degrees F without slump and adheres to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, cable sheaths and jackets, etc.

2.03 PULLBOXES AND HANDHOLES

A. Construction: High densities precast reinforced concrete box, extension, base and cover. Furnish box with end and side knockouts and non-settling shoulders. Cover shall have tamper-proof hold-down bolts and two lifting eyes.

B. Size: As indicated on the Drawings.

C. Cover markings: Covers shall read "LIGHTING" or "SIGNAL" as appropriate.

D. Rated covers: Use cast iron lid with H20 traffic rating when subject to vehicular traffic.

2.04 VAULTS

A. Precast concrete: Concrete mix and reinforcing placement shall be in accordance with ACI 318. Design tops and wall structures for AASHTO H20 highway loading, with 30 percent loading added for impact. Walls shall withstand all soil pressures, taking into consideration
the soil encountered and ground water level present at the Project site. Assume ground water level three feet below ground surface unless a higher water table is indicated in soils report.

B. Construction:
1. Monolithic or modular assembled sections.
2. Assembled sections shall have mating edges with tongue and groove joints. Joints shall firmly interlock adjoining components and provide waterproof junctions. Seal joints watertight using preformed plastic strip conforming to FS SS-S-210.
3. Provide lifting devices cast into units for proper handling of units.
4. Identify all structures with Manufacturer's name embedded in or otherwise permanently attached to an interior wall face.
5. Include concrete knockout panels for conduit entrance and sleeve for ground rod.

C. Size and dimensions: As indicated on Drawings.

D. Accessories:
1. Frames and covers: Cast iron with cast-in legend "ELECTRIC" or "SIGNAL" as appropriate. Machine cover-to-frame bearing surfaces. Doors shall be secured with tamperproof bolts.
2. Sump frame and grate: Comply with FS RR-F-621, Type VII for frame and Type I for cover.
3. Pulling eyes in walls: Eyebolt with reinforcing bar fastening insert. 2-inch diameter eye, 1-inch by 4-inch bolt. Working load embedded in 6-inch, 4000-PSI concrete: 13,000 pounds minimum tension.
5. Bolting inserts for cable stanchions: Flared, threaded inserts of non-corrosive, chemical resistant, nonconductive thermoplastic material; 1/2-inch internal diameter by 2-3/4 inch deep, flared to 1-1/4 inch minimum at base. Tested ultimate pull-out strength: 12,000 pounds minimum.
6. Expansion anchors for installation after concrete is cast: Zinc-plated carbon steel wedge type with stainless-steel expander cup 1/2-inch bolt size, 5,300 pound rated pull-out strength and 6800 pound rated shear strength minimum.
7. Cable stanchions: Hot-rolled, hot-dipped, galvanized "T" section steel, 2 - 1/4 inches size, punched with 14 holes on 1-1/2 inch centers for cable arm attachment.
8. Cable arms: 3/16-inch thick hot-rolled, hot-dipped galvanized sheet steel pressed to channel shape, approximately two 12-inches wide by 14-inches long and arranged for secure mounting in horizontal position at any position on cable stanchions.
9. Cable support insulators: High glaze, wet-process porcelain arranged for mounting on cable arms.
11. Ground wire: Stranded bare copper conductor, #6 AWG.

2.05 CONSTRUCTION MATERIALS
A. Mortar: Conform to ASTM C270, Type M, except for quantities less than 2.0 Cu. Ft., where packaged mix complying with ASTM C387, Type M may be used.

B. Concrete: Conform to Division 03: Cast-in-place concrete for concrete and reinforcing.
   1. Strength: 3,000-PSI minimum 28-day compressive strength.

PART 3 - EXECUTION

3.01 EXAMINATION
A. Contractor shall thoroughly examine Project site conditions for acceptance of duct and manhole installation to verify conformance with Manufacturer and Specification tolerances. Do not commence with installation until all conditions are made satisfactory.

3.02 EARTHWORK
A. Excavation for underground electrical structures: Conform to elevations and dimensions indicated within a tolerance of plus or minus 0.10 foot; plus a sufficient distance to permit placing and removal of concrete formwork, installation or services, other construction and for inspection.
   1. Excavate, by hand, areas within drip-line of large trees. Protect the root system for damage and dry-out. Maintain moist conditions for root system and over exposed roots with burlap. Paint root cuts of 1 inch in diameter and larger with emulsified asphalt tree paint.
   2. Take care not to disturb bottom of excavation. Excavate by hand to final grade just before concrete reinforcement is placed.

B. Trenching: Excavate trenches for electrical installation as follows:
   1. Excavate trenches to the uniform width, sufficiently wide to provide ample working room and a minimum of 6 to 9 inches clearances on both sides of raceways and equipment.
   2. Excavate trenches to depth indicated or required.
   3. Limit the length of open trench to that in which installations can be made and the trench backfilled within the same day.
   4. Where rock is encountered, carry excavation below required elevation and backfill with a layer of crushed stone or gravel prior to installation of raceways and equipment. Provide a minimum of 6 inches of stone or gravel cushion between rock bearing surface and electrical installations.

C. Backfilling and filling: Provide a minimum of 3” of sand below, on the sides and on the top of the conduits.

3.03 CONDUIT AND DUCT INSTALLATION
A. Install duct lines in accordance with Manufacturer's written instructions, as indicated on the Drawings and as specified herein.

B. Application: Refer to specification section 260531.

C. Slope duct to drain towards handholes and away from building and equipment entrances. Pitch not less than 4-inches per 100-feet. Curved sections in duct lines shall consist of long sweep bends with a minimum radius of 25-feet in the horizontal and vertical directions. The use of manufactured bends is limited to building entrances and equipment stub-ups.
D. Make joints in ducts and fittings watertight according to Manufacturer's instructions. Stagger couplings so those of adjacent ducts do not lie in the same plane.

E. Terminate duct lines at handholes with end bells spaced 10-inches on center for 5-inch ducts and varied proportionately for other duct sizes. Change from regular spacing to end-bell spacing 10-feet from the end bell without reducing duct line slope and without forming trap in the line.

F. Separation between direct buried duct lines shall be 3-inches minimum for like systems and 6 inches minimum between power and signal ducts.

G. For direct burial installations install continuous warning strip of heavy gage plastic imprinted "electrical ducts below", approximately 12-inch wide at 12-inches above ducts.

H. Mandrel all ducts upon completion of installation and prior to pulling cables.

3.04 HANDHOLE AND PULL BOX INSTALLATION

A. Install handholes in accordance with Manufacturer's written instructions, as indicated on Drawings and as specified herein.

B. Handholes shall be installed flush with finished grade or surface. Install on a level 6-inch bed of well-tamped gravel or crushed stone.

C. Orientation of handholes shall be coordinated in advance with Landscape Architect and arranged to minimize connecting duct bends and deflections.

3.05 VAULT INSTALLATION

A. Install precast assembly in accordance with Manufacturer's written instructions, as indicated on Drawings and as specified herein.

B. Install cast iron frame and cover. Set frames in paved areas and traffic ways flush with finished grade. Set other frames 1-inch above finished grade.

C. Units shall be installed on a level 12-inch bed of well-tamped gravel or crushed stone.

D. Install removable hardware, including pulling eyes, cable stanchions, cable arms and insulators, as required for installation and support of cable and conductors and as indicated.

3.06 FIELD QUALITY CONTROL

A. Testing: Demonstrate capability and compliance with requirements upon completion of installation of underground duct and structures.

1. Duct integrity: Rod ducts with a mandrel 1/4-inch smaller in diameter than internal diameter of ducts. Where rodding indicates obstructions in ducts, remove the obstructions and retest.

3.07 CLEANING

A. Pull brush through full length of ducts. Use round bristle brush with a diameter 1/2-inch greater than internal diameter of duct.

B. Clean internal surfaces of handholes and vaults. Remove foreign material.

END OF SECTION
SECTION 260553 - ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.01 SUMMARY

A. Work included: Labor, materials, and equipment necessary to complete the installation required for the item specified under this Division, including but not limited to:

1. Electrical equipment nameplates.
2. Panelboard directories.
3. Wire and cable identification.
4. Buried electrical line warnings.
6. Inscribed device coverplates.

B. Related Work: Consult all other Sections, determine the extent and character of related Work and properly coordinate Work specified herein with that specified elsewhere to produce a complete installation.

1. Division 09: Painting.

1.02 SUBMITTALS

A. Submit in accordance with the requirements of Section 260010: Basic Electrical Requirements, the following items:

1. Data/catalog cuts for each product and component specified herein.
2. Schedules for nameplates to be furnished.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Products furnished by the following Manufacturers shall be acceptable if in compliance with all features specified herein and indicated on the Drawings.

1. Conduit and wire markers:
   a. Thomas & Betts Corp.
   b. Brady.
   c. Griffolyn.

2. Inscription Tape:
   a. Kroy.
b. Merlin.

B. Substitutions: Under provisions of Section 260010: Basic Electrical Requirements.

2.02 NAMEPLATES

A. Type NP: Engraved, plastic laminated labels, Signs and Instruction Plates. Engrave stock melamine plastic laminate 1/16-inch minimum thickness for signs up to 20 square inches or 8 inches in length; 1/8 inch thick for larger sizes. Engraved nameplates shall have white letters and be punched for mechanical fasteners.

B. Color and letter height as specified in Part 3: Execution.

2.03 PANELBOARD DIRECTORIES (400 AMP OR LESS)

A. Directories: A 6" x 8" minimum size circuit directory frame and card with clear plastic covering shall be provided inside the inner panel door.

B. Circuit numbering: Starting at the top, odd numbered circuits in sequence down the left hand side and even numbered circuits down the right hand side. Multi-section panelboards shall have continuous consecutive circuit numbers, i.e. Section 1 (circuit numbers 1-42), Section 2 (circuit numbers 43-84), Section 3 (circuit numbers 85-126).

2.04 WIRE AND TERMINAL MARKERS

A. Provide self-adhering, pre-printed, machine printable or write-on, self-laminating vinyl wrap around strips. Blank markers shall be inscribed using the printer or pen recommended by Manufacturer for this purpose.

2.05 CONDUCTOR PHASE MARKERS

A. Colored vinyl plastic electrical tape, 3/4" wide, for identification of phase conductors. Scotch 35 Brand Tape or equal.

2.06 UNDERGROUND CONDUIT MARKER

A. 6-inch wide, yellow polyethylene tape, with continuous black imprinting reading "Caution - Buried Electric Line Below".

2.07 INSCRIBED DEVICE COVERPLATES

A. Coverplate material shall be as specified in Section 262726: Wiring Devices.

B. Methods of inscription: (Unless otherwise noted)

1. Type-on-tape:
   a. Imprinted or thermal transfer characters onto tape lettering system.
   b. Tape trimmer.
   c. Matte finish spray-on clear coating.

PART 3 - EXECUTION

3.01 EXAMINATION
A. Contractor shall thoroughly examine Project site conditions for acceptance of identification device installation to verify conformance with Manufacturer and Specification tolerances. Do not commence with installation until all conditions are made satisfactory.

3.02 NAMEPLATES

A. Installation:

1. Degrease and clean surfaces to receive nameplates.

2. Install nameplates parallel to equipment lines.

3. Secure nameplates to equipment fronts using machine screws.

B. Provide type 'NP' color coded nameplates that present, as applicable, the following information:

1. Equipment or device designation:

2. Amperage, KVA or horsepower rating, where applicable.

3. Voltage or signal system name.

4. Source of power or control.

C. Nameplates for power system distribution equipment and devices are to be black.

D. Nameplates for signal systems equipment and devices are to be black except as follows:

1. Fire alarm and life safety - Red.


3. Clock, intercom, sound, MATV, CATV - Blue.

E. Minimum letter height shall be as follows:

1. For panelboards, etc.: ½ inch letters to identify equipment designation. Use ¼ inch letters to identify voltage, phase, wires, etc.

2. For individual circuit breakers, switches and motor starters in switchboards use 3/8-inch letters to identify equipment designation. Use 1/8-inch letters to identify all other.

3. For individual mounted circuit breakers, disconnect switches, enclosed switches and motor starters use 3/8-inch letters to identify equipment designation. Use 1/8" letters to identify all other.

4. For transformers use 1/2 inch letters to identify equipment designation. Use ¼ inch letters to identify primary and secondary voltages, etc.

5. For equipment cabinets, terminal cabinets, control panels and other cabinet enclosed apparatus use 3/8-inch letters to identify equipment designation.
3.03 PANELBOARD DIRECTORIES (400 AMP OR LESS)

A. Provide typewritten directories arranged in numerical order denoting loads served by room number or area for each circuit.

B. Verify room numbers or area designation with Project Manager.

C. Mount panelboard directories in a minimum 6” x 8” metal frame under clear plastic cover inside every panelboard.

3.04 WIRE AND CABLE IDENTIFICATION

A. Provide wire markers on each conductor in panelboards, pull boxes, outlet and junction boxes and at load connection. Identify with branch circuit or feeder number for power and lighting circuits and with control wire number as indicated on equipment Manufacturer's Shop Drawings for control wiring.

B. Provide colored phase markers for conductors as noted in Section 260519: Building Wire and Cable. Apply colored, pressure sensitive plastic tape in half-lapped turns for a distance of 3 inches from terminal points and in boxes where splices or taps are made. Apply the last two laps of tape with no tension to prevent possible unwinding. Do not cover cable identification markings by taping.

3.05 UNDERGROUND CONDUIT MARKERS

A. During trench backfilling, for exterior underground power, signal and communications lines, install continuous underground plastic line marker, located directly above line at 6 to 8 inches below finished grade. Where multiple lines installed in a common trench or concrete envelope, do not exceed an overall width of 16 inches; install a single line marker.

3.06 JUNCTION BOX IDENTIFICATION

A. The cover of junction, pull and connection boxes for both power and signal systems, located above suspended ceilings and below ceilings in non-public areas, shall be clearly marked with a permanent ink felt pen. Identify the circuit(s) (panel designation and circuit numbers) contained in each box, unless otherwise noted or specified.

3.07 INSCRIBED DEVICE COVERPLATE

A. General:

1. Lettering type: Helvetica, 12 point or 1/8" high.

2. Color of characters shall be black.

3. Locate the top of the inscription ½” below the top edge of the coverplate.

4. Inscription shall be centered and square with coverplate.

B. Application:

1. Provide inscribed coverplates for devices as outlined below:

   a. Receptacles.
b. Multi-ganged (four or more) switch arrangement.

c. Special purpose switches, i.e. projection screens, shades, exhaust fans, etc.

d. Telecommunication outlets.

2. Type-on-tape installation:

a. Tape shall be trimmed to the height of the letters.

b. Trim tape length to 1/4 inch back from each edge of coverplate.

c. Contractor hands shall be clean or covered with surgical type glove prior to application of tape. Tape installations with visible fingerprints or smudges will not be acceptable.

END OF SECTION
DRY TYPE TRANSFORMERS

SECTION 262213 - DRY TYPE TRANSFORMERS

PART 1 - GENERAL

1.01 SUMMARY

A. Work included: Labor, materials and equipment necessary to complete the installation required for the item specified under this Division, including but not limited to:

1. Dry type ventilated transformers.

B. Related Work: Consult all other Sections, determine the extent and character of related Work and properly coordinate Work specified herein with that specified elsewhere to produce a complete installation.


2. Division 09: Painting. Touch-up painted surfaces.

1.02 REFERENCES

A. Comply with the latest edition of the following applicable Specifications and standards except as otherwise indicated or specified.

1. American National Standards Institute (ANSI):
   
   ANSI C57; Pertaining to Power/Distribution Transformer.

2. Underwriter's Laboratories, Inc. (UL):
   
   UL 486E; Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors.

   UL 1561; Dry-Type General Purpose and Power Transformers.

3. National Electrical Manufacturers Association (NEMA):

   NEMA ST 20; Dry Type Transformers.

   NEMA TP-1; Guide for Determining Energy Efficiency for Distribution Transformers.

4. Department of Energy (DOE):

1.03 SUBMITTALS

A. Submit in accordance with the requirements of Section 260010: Basic Electrical Requirements, the following items:

1. Data/catalog cuts for each product and component specified herein, listing all physical and electrical characteristics and ratings indicating compliance with all listed standards.

2. Clearly mark on each data sheet the specific item(s) being submitted and the proposed application.

3. Shop Drawings: Include type and style, dimensions, insulation class, rated temperature rise, taps provided, voltage, kVA and impedance ratings and characteristics, loss data, efficiency at 25, 50, 75 and 100 percent rated load and sound level.

4. Submit energy efficiency compliance documentation.

5. Submit inrush current design limitation documentation.

6. Furnish structural calculations for equipment anchorage as described in Section 260010: Basic Electrical Requirements.

7. Submit Manufacturer's installation instructions.

8. Final test results.


1.04 OPERATION AND MAINTENANCE MANUAL

A. Supply operation and maintenance manuals in accordance with the requirements of Section 260010: Basic Electrical Requirements, to include the following:

1. Detailed explanation of operation of the system.

2. Instructions for routine maintenance.

3. Telephone numbers for the authorized parts and service distributors.

4. Include all service bulletins and torque Specifications for all terminations.

5. Final testing reports.
1.05 QUALITY ASSURANCE

A. All materials, equipment and parts comprising the units specified herein shall be new, unused and currently under production.

B. Only products and applications listed in this Section may be used on the Project unless otherwise submitted.

C. Independent Testing Agency qualifications: Refer to Section 260010: Basic Electrical Requirements.

1.06 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Delivery: Transformers shall not be delivered to the Project site until protected storage space is available. Storage outdoors covered by rainproof material is not acceptable. Equipment damaged during shipment shall be replaced and returned to Manufacturer at no cost to Owner. Components shall be properly packaged in factory-fabricated containers and mounted on shipping skids.

B. Storage: Store in a clean, dry, ventilated space free from temperature extremes. Maintain factory wrapping or provide a heavy canvas/plastic cover to protect units from dirt, water, construction debris and traffic. Provide heat where required to prevent condensation.

C. Handling: Handle in accordance with Manufacturer's written instructions. Be careful to prevent internal component damage, breakage, denting and scoring. Damaged units shall not be installed. Replace damaged units and return equipment to Manufacturer.

1.07 WARRANTY

A. Units and components offered under this Section shall be covered by a 1 year parts and labor warranty for malfunctions resulting from defects in materials and workmanship. Warranty shall begin upon acceptance by the Owner.

1.08 EXTRA MATERIAL

A. Provide one spray can of matching finish paint for touching up damaged surfaces after installation.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Products furnished by the following Manufacturers shall be acceptable if in compliance with all features specified herein and indicated on the Drawings.

1. ABB/ General Electric.
DRY TYPE TRANSFORMERS

2. Eaton.
3. Siemens.
4. Square D.

B. Substitutions: Under provisions of Section 260010: Basic Electrical Requirements.

2.02 DRY TYPE TRANSFORMER - GENERAL

A. Rating: Provide kVA rating, primary and secondary voltage, frequency and phase as indicated on the Drawings. The designated rating is for continuous duty without the use of cooling fans unless specifically noted otherwise on the Drawings.

B. Windings: Three phase dry type transformers shall be of the two-winding type.

C. Taps: All dry type transformers rated 15 kVA and larger shall have two 2 1/2 percent full capacity taps above normal (FCAN) and four 2 1/2 percent full capacity taps below normal (FCBN) rated primary voltage.

D. Noise attenuation:

1. Isolate core and coil unit from the enclosure by means of vibration absorbing mounts that preclude metal-to-metal contact between the core-coil and the enclosure.

2. Provide sound levels that do not exceed the following maximum levels in accordance with NEMA and ANSI standards:
   a. 10 to 50 kVA; 45 db
   b. 51 to 150 kVA; 50 db
   c. 151 to 300 kVA; 55 db

E. Impedance:

1. Transformer impedance shall conform to NEMA standards. Do not use low impedance type transformers unless the circuits and equipment affected by the larger short circuit currents through such transformers are increased in short circuit current ratings, as required, at no additional cost to the Owner.

2. The following impedance are used as our basis of design:
   a. Three phase transformers:
      1) 15 kVA: 6.4Z
      2) 25 kVA: 5.8Z
      3) 30 kVA: 5.2Z
DRY TYPE TRANSFORMERS

4) 37.5 kVA: 5.5Z
5) 45 kVA: 5.0Z
6) 75 kVA: 4.7Z
7) 112.5 kVA: 5.1Z
8) 150 kVA: 5.3Z
9) 225 kVA: 5.7Z

F. Basic impulse level (BIL): 10 kV for transformers less than 300 kVA, 30 kV for transformers 300 kVA and larger.

G. Transformers shall have an efficiency compliant with the U.S. Department of Energy (DOE) final rule for the Distribution Transformers Energy Conservation Standard Rulemaking, 78 FR 23335 (April 18, 2013). Transformers built prior to January 1, 2016 will not be considered acceptable unless efficiency compliance documentation is submitted verifying transformer efficiency meets or exceeds the January 1, 2016 energy efficiency levels listed in DOE 78 FR 23335 (April 18, 2013).

H. Transformers shall be designed to limit inrush current to 12-times (12x) the base rated full load current or less.

I. Grounding: Ground core and coil assembly to enclosure by means of a visible flexible copper strap.

J. Enclosures:
   2. Manufacturers nameplate: Include transformer connection data and overload capacity based on rated allowable temperature rise.
   3. Type: Provide NEMA type as indicated on Drawings or specified herein, drip-proof, self-bracing enclosure designed to prevent accidental contact with electrically energized parts unless otherwise noted.
   4. Mounting: Transformers 75 kVA and less shall be suitable for wall, floor, frame or trapeze mounting. Transformers larger than 75 kVA shall be suitable for floor mounting.
   5. Finish: Clean, degrease, zinc-phosphate, prime and finish paint steel parts with a baked-on synthetic enamel, ANSI 61 (light gray).
   6. Accessories: Provide accessories as indicated on the Drawings.
   7. Size: Dimensions and configurations shall conform to the spaces allocated on the Drawings.

2.03 DRY TYPE VENTILATED TRANSFORMERS
DRY TYPE TRANSFORMERS

A. General:
   1. Indoor or outdoor, convection air-cooled, dry type transformers with NEMA Type 1 enclosure unless otherwise noted. Provide NEMA Type 3R Enclosure for all exterior mounted transformers or where indicated on Drawings.
   2. Transformers shall have been tested to UL standards and constructed to NEMA standards.

B. Insulation:
   1. Insulation system and average winding temperature rise for kVA as follows unless otherwise indicated:

<table>
<thead>
<tr>
<th>KVA RATING</th>
<th>CLASS H</th>
<th>RISE IN DEGREES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 15</td>
<td>220c</td>
<td>115c</td>
</tr>
<tr>
<td>16 - 500</td>
<td>220c</td>
<td>150c</td>
</tr>
</tbody>
</table>

   2. Case temperature shall not exceed 40 degrees centigrade rise above ambient at its warmest point.
   3. Provide insulating materials that are in accordance with the latest addition of NEMA ST20 Standards for a 220-degree centigrade, UL component recognized insulation system for extended life.

C. Core construction: High grade, non-aging, silicon steel, clamped with structural angles and bolted to the transformer enclosure on vibration isolating pads.

D. Coil construction:
   1. Continuous wound with aluminum wire, without splices except for taps.
   2. Pressure type, primary, secondary and tap connections.
   3. End fillers or tie downs for maximum strength.
   4. Vacuum impregnated with non-hygroscopic, thermosetting varnish.
   5. All connections shall be accessible from the front of the transformer to allow rear of transformer to be positioned within six inches of the adjacent wall.
   6. Isolate core and coil from enclosure using vibration-absorbing mounts.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Contractor shall thoroughly examine Project site conditions for acceptance of transformer installation to verify conformance with Manufacturer and Specification tolerances. Do not commence with installation until all conditions are made satisfactory.
3.02 PREPARATION

A. Ensure all conduit stub-ups for bottom entry into transformer are in place and located as required per Shop Drawings.

3.03 INSTALLATION

A. Install transformer in accordance with Manufacturer's written instructions, as indicated on the Drawings and as specified herein.

B. Transformers shall be installed to provide adequate air circulation for the removal of the heat they produce, in accordance with Manufacturer recommendations.

C. Transformers not specifically designed for wall mounting, shall be spaced a minimum of 6" from adjacent walls, ceiling and equipment.

D. Transformers shall be anchored and braced to withstand seismic forces as calculated per Section 260010: Basic Electrical Requirements.

E. Loosen and/or remove all shipping bolts in accordance with Manufacturer's instructions.

F. Install the transformers on the noise and vibration isolation pads designed to suppress the transformer noise from the building structure. Select and arrange the pads in accordance with the weight and mounting of the transformers. These pads are in addition to any internal vibration pads. Provide a neoprene sleeve over the portion of the bolt that passes through the transformer base or mounting bracket. Provide a rubber washer between the bolt head and the mounting channel. Use Kinetics Model KIP or equal.

3.04 TERMINATIONS

A. Provide all transformers with lugs for both primary and secondary conductor sizes for conductors indicated on Drawing. Connect lug to termination point with appropriate size bolt, nut flat and Belleville washers.

B. Provide high-pressure compression lugs, for primary and secondary phase and neutral terminations for transformers 45 kVA and larger. Utilize only the tool and dies designed for uses in installing the lugs provided.

C. Use flexible conduit indoors in dry locations or liquidtight flexible conduit in damp/wet locations, two-foot minimum in length, for primary and secondary connections to transformer case. Make connections to side panels of enclosure, except for floor mounted transformers fed from directly below enclosure.

3.05 GROUNDING

A. Provide transformer with a dual rated four-barrel solderless grounding lug with a 5/8"-11 threaded hole. Drill transformer enclosure with 11/16" bit and attach lug to enclosure utilizing a torque bolt and Dragon Tooth transition washer. Connect the following:
DRY TYPE TRANSFORMERS

1. Primary feeder ground.
2. Secondary feeder ground.
3. Grounding electrode.
4. Main bond jumper to neutral (when present).

3.06 IDENTIFICATION

A. Provide transformer nameplate as described in Section 260533: Electrical Identification.

3.07 FIELD QUALITY CONTROL

A. Contractor shall perform all quality control electrical testing, calibration and inspection required herein. Testing shall meet the requirements as outlined in Section 260010: Basic Electrical Requirements. Testing objectives shall be to:

1. Assure transformer installation conforms to specified requirements and operates within specified tolerances.
2. Field test and inspect to ensure operation in accordance with Manufacturer's recommendations and Specifications.
3. Prepare final test report including results, observations, failures, adjustments and remedies.
4. Apply label on transformer upon satisfactory completion of tests and results.
5. Verify ratings and settings and make final adjustments.

B. Prefunctional testing:

1. Visual and mechanical inspection:
   a. Compare nameplate information and connections to Contract Documents.
   b. Inspect for physical damage, defects alignment and fit.
   c. Check tightness of all control and power connections.
   d. Check that all covers, barriers and doors are secure.
   e. Perform specific inspections and mechanical tests as recommended by Manufacturer.
   f. Verify seismic bracing is correct.
   g. Verify winding core, frame and enclosure grounding are correct.
   h. Verify tap connections are as specified.
DRY TYPE TRANSFORMERS

2. Electrical tests:
   a. Perform insulation-resistance tests winding-to-winding and winding-to-ground with test voltage in accordance with Manufacturer’s recommendation.
   b. Perform turn-ratio test on tap connections. Verify winding polarities are in accordance with nameplate.
   c. Verify correct secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.

3. Test values:
   a. Bolt-torque levels shall be in accordance with the Manufacturer’s written instructions.
   b. Insulation-resistance test values at one minute should not be less than 500 megohms at 1000 VDC.
   c. Turn-ratio test results should not deviate more than 0.5% from either adjacent coils or calculated ratio.

C. Contractor shall replace at no costs to the Owner all devices which are found defective or do not operate within factory specified tolerances.

D. Contractor shall submit the Testing Agency's final report for review prior to Project closeout and final acceptance by the Owner. Test report shall indicate test dates, devices tested, results, observation, deficiencies and remedies. Test report shall be included in the operation and maintenance manuals.

3.08 ADJUSTING

A. Adjust primary taps so that secondary voltage is above and within 2 percent of rated voltage.

3.09 CLEANING

A. Prior to energizing of transformer the Contractor shall thoroughly clean the interior of enclosure of all construction debris, scrap wire, etc. using Manufacturer's approved methods and materials.

B. Upon completion of Project prior to final acceptance the Contractor shall thoroughly clean both the interior and exterior of transformer per Manufacturers approved methods and materials. Remove paint splatters and other spots, dirt and debris.

C. Touch-up paint any marks, blemishes or other finish damage suffered during installation.

END OF SECTION
SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.01 SUMMARY

A. Work included: Labor, materials and equipment necessary to complete the installation required for the item specified under this Division, including but not limited to:

1. Branch circuit panelboard.

2. Distribution panelboards (400 amps to 800 amps).

B. Related Work: Consult all other Sections, determine the extent and character of related Work and properly coordinate Work specified herein with that specified elsewhere to produce a complete installation.

1.02 REFERENCES

A. Comply with the latest edition of the following applicable Specifications and standards except as otherwise indicated or specified.

1. Federal Specifications (FS):

   FS W-C-375; Circuit Breakers, Molded Case, Branch Circuit and Service.

   FS W-P-115; Power Distribution Panel.

2. National Electrical Manufacturers Association (NEMA):

   NEMA AB 1; Molded Case Circuit Breakers.

   NEMA PB 1; Panelboards.

   NEMA PB 1.1; Instructions for safety instruction, operation and maintenance of panelboard rated 600 volts or less.

3. Underwriters Laboratories, Inc. (UL):

   UL 67; Panelboards.

   UL 486E; Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors.

   UL 489; Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures.
1.03 SUBMITTALS

A. Submit in accordance with the requirements of Section 260010: Basic Electrical Requirements, the following items:

1. Data/catalog cuts for each product and component specified herein, listing all physical and electrical characteristics and ratings indicating compliance with all listed standards.

2. Clearly mark on each data sheet the specific item(s) being submitted and the proposed application.

3. Shop Drawings: Include elevations, cabinet dimensions, gutter sizes, layout of contactors, relays, time clocks, lug sizes, bussing diagrams; make, location and capacity of installed equipment; mounting style; finish and panelboard nameplate inscription.

4. Furnish structural calculations for equipment anchorage as described in Section 260010: Basic Electrical Requirements.

5. Submit Manufacturer's installation instructions.

6. Complete bill of material listing all components.

7. Warranty.

B. Dimensions and configurations of panelboards shall conform to the spaces allocated on the Drawings for their installation. The Contractor shall include with the submittal a layout of the electrical room if it differs from construction documents for review and approval by the Engineer prior to release of order.

1.04 OPERATION AND MAINTENANCE MANUAL

A. Supply operation and maintenance manuals in accordance with the requirements of Section 260010: Basic Electrical Requirements, to include the following:

1. A detailed explanation of the operation of the system.

2. Instructions for routine maintenance.

3. Pictorial parts list and parts number.

4. Telephone numbers for authorized parts and service distributors.

5. Final testing reports.

1.05 QUALITY ASSURANCE
PANELBOARDS

A. All materials, equipment and parts comprising the units specified herein shall be new, unused and currently under production.

B. Only products and applications listed in this Section may be used on the Project unless otherwise submitted.

1.06 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Delivery: Panelboard components shall not be delivered to the Project site until protected storage space is available. Storage outdoors covered by rainproof material is not acceptable. Equipment damaged during shipment shall be replaced and returned to Manufacturer at no cost to Owner.

B. Storage: Store in a clean, dry, ventilated space free from temperature extremes. Maintain factory wrapping or provide a heavy canvas/plastic cover to protect units from dirt, water, construction debris and traffic. Provide heat where required to prevent condensation.

C. Handling: Handle in accordance with NEMA PB1.1 and Manufacturer's written instructions. Be careful to prevent internal component damage, breakage, denting and scoring. Damaged units shall not be installed. Replace damaged units and return equipment to Manufacturer.

1.07 WARRANTY

A. Units and components offered under this Section shall be covered by a 1 year parts and labor warranty for malfunctions resulting from defects in materials and workmanship. Warranty shall begin upon acceptance by the Owner.

1.08 EXTRA MATERIAL

A. Turn over two (2) sets of panelboard keys to the Owner at completion of Project. All panelboards shall be keyed alike.

B. Provide one spray can of matching finish paint for touching up damaged surfaces after installation.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Products furnished by the following Manufacturers shall be acceptable if in compliance with all features specified herein and indicated on the Drawings.


2. General Electric.
3. Siemens/I-T-E.

4. Square D.

B. Substitutions: Under provisions of Section 260010: Basic Electrical Requirements.

2.02 PANELBOARDS - GENERAL

A. Enclosure:

1. Cabinets shall be NEMA Type 1 enclosure, door and trim of code gauge galvanized steel.

2. Panelboard covers shall be door-in-door construction such that inner door exposes the overcurrent protective devices and the outer door exposes the complete panelboard interior (i.e. branch circuit conductors, lugs, neutral and ground bus, overcurrent protective devices, etc.). Outer door shall have full-length piano hinge and inner door shall have two-point hinges.

3. Provide combination spring catch and lock on inside edge of the inner door trims with flush fitting joint between door and trim. Locks on all panelboards shall be keyed alike. Doors 36 inches and over in height shall be provided with three-point catch and lock. Provide quarter-turn captive bolts on the outer door.

B. Bus assembly and terminations:

1. Bus shall be bolted copper with taps arranged for distributed phase connections to branch circuit devices

2. Cross connectors shall be copper, drilled and tapped for bolt-on device connections, arranged for double row placement of device and designed to permit removal or addition of overcurrent protection devices without disturbing adjacent devices or removing main bus connections.

3. Neutral bus shall be 100 percent rated of phase bus bars and shall have lugs for each outgoing branch circuit or feeder requiring a neutral connection unless otherwise noted.

4. Ground bus shall be full size with lugs for each outgoing branch circuit and feeder.

5. Refer to panelboard schedules on Drawings for bus rating. Bus rating shall match or be greater than main device or main lug rating.

6. As a minimum, bus bars shall be rated 10,000 AIC for 120/208 volt panelboards, unless otherwise noted.

7. Provide full sized bussing in all sections of multi-section panelboards.

8. No panelboard section shall have greater than 84 poles.

10. All "SPACES" shall be ready for installation of future overcurrent protective device.

C. Miscellaneous requirements:

1. Circuit numbering: Starting at the top, indicate odd numbered circuits in sequence down the left hand side and even numbered circuits down the right hand side. Multi-section panelboards shall have continuous consecutive circuit numbers, i.e. Section 1 (circuit numbers 1-42), Section 2 (circuit numbers 43-84), Section 3 (circuit numbers 85-126). Provide metal embossed circuit identification of panelboards.

2. Directories: A 6" x 8" minimum size circuit directory frame and card with clear plastic covering shall be provided inside the inner panelboard door to reflect conditions at completion of Work. Directory shall be typewritten denoting loads served by room number or area for each circuit.

3. Nameplates: Provide engraved nameplate for each panelboard. See Section 260533: Electrical Identification for requirements.

D. Refer to Panelboard Schedules for the following:

1. Mounting style; service voltage; terminal lug size, location and quantity; bus ampacity; interrupting capacity of bus and breakers; quantity, poles and rating of overcurrent protective devices.

E. Overcurrent protective devices:

1. Refer to Section 262816: Overcurrent Protection Devices.

2. Overcurrent protective devices shall be molded case circuit breakers.

3. Main devices shall be hard bus connected to the panelboard bus bars.

4. In all cases, panelboards fed directly from a transformer shall have a main overcurrent protective device. If not indicated on the Drawings or Panelboard Schedules, provide this device sized to provide the full capacity of the transformer rating.

5. Main devices shall be vertically mounted and shall have their operating handle in the up position when energized. Main devices that are mounted in the same manner as the branch devices are NOT acceptable; i.e. main devices shall be individually mounted at the top or bottom of the phase bus bars.

6. Panelboards overcurrent protective devices layout shall conform to the layout indicated on the panelboard schedules.

7. Provide handle ties for single pole circuit breakers that share a neutral conductor.

F. Finish: Five step zinc phosphate pre-treatment, one coat of rust inhibiting dichromate primer and one coat of baked-on enamel finish, ANSI 61 (light gray).

2.03 DISTRIBUTION PANELBOARDS
PANELBOARDS

A. Enclosures shall be sized as required and shall meet the space restriction allocated on Drawings. Panelboard shall comply with NEMA PS 1 and FS W-P-115.

B. Enclosure shall be freestanding and mount on a concrete pad.

C. Provide necessary hardware to permit locking every overcurrent protective device handle in the "OFF" position.

D. Where "SPACE" is indicated on panelboard schedules or Drawings, install cross connectors and mounting hardware to match the frame size ampere rated noted.

2.04 BRANCH CIRCUIT PANELBOARDS

A. Enclosure shall be 20" wide x 5-3/4" deep, surface or flush mounted and shall comply with NEMA PB 1 and FS W-P-115.

B. Flush panelboards mounted adjacent to each other shall be same physical size.

C. Where "SPACE" is indicated on panelboard schedules or Drawings, install minimum 100-ampere branch circuit cross connectors and mounting hardware. For future device spaces larger than 100 amps, cross connectors shall match the frame size ampere rated noted.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Contractor shall thoroughly examine Project site conditions for acceptance of panelboard installation to verify conformance with Manufacturer and Specification tolerances. Do not commence with installation until all conditions are made satisfactory.

3.02 INSTALLATION

A. Install panelboards in accordance with Manufacturer's written instructions, as indicated on the Drawings and as specified herein.

B. Set panels plumb and symmetrical with building lines in conformance with PB1.1. Furnish and install all construction channel bolts, angles, etc., required to mount the equipment furnished under this Section.

C. Mounting height shall be 6 feet.

D. Panelboards shall be anchored and braced to withstand seismic forces as calculated per Section 260010: Basic Electrical Requirements.

E. Provide mounting hardware brackets, busbar drillings and filler pieces for all unused spaces.
PANELBOARDS

F. "Train" interior wiring; bundle and clamp, using specified plastic wire wraps specified under Section 260519: Building Wire and Cable.

G. Replace panel pieces, doors or trim exhibiting dents, bends, warps or poor fit that may impede ready access, security or integrity.

H. Conduits terminating in concentric, eccentric or oversized knockouts at panelboards shall have ground bushings and bonding jumpers installed interconnecting all such conduits and the panelboard.

I. Check and tighten all bolts and connections with a torque wrench using Manufacturer's recommended values.

J. Visually inspect panelboard for rust and corrosion. If signs of rust and corrosion are present, restore or replace panelboard to new condition.

K. In damp and wet locations, mount panelboards with a minimum one inch of air space between cabinet and the wall or other support material.

L. Provide close up plugs in all unused openings in the cabinet.

M. Field install handle ties on single pole circuit breakers that share a neutral conductor.

3.03 FIELD QUALITY CONTROLS

A. Contractor shall perform all quality control electrical testing, calibration and inspection required herein. Testing objectives shall be to:

1. Assure panelboard installation conforms to specified requirements and operates within specified tolerances.

2. Field test and inspect to ensure operation in accordance with Manufacturer's recommendations and Specifications.

3. Prepare final test report including results, observations, failures, adjustments and remedies.

4. Apply label on panelboards upon satisfactory completion of tests and results.

5. Verify ratings and settings and make final adjustments.

B. Testing of overcurrent protective devices shall be done only after all devices are installed and system is energized.

C. Prefunctional testing:

1. Visual and mechanical inspection:

   a. Inspect for physical damage, defects alignment and fit.
b. Perform mechanical operational tests in accordance with Manufacturer's instructions.

c. Compare nameplate information and connections to Contract Documents.

d. Check tightness of all power connections.

e. Check that all covers, barriers and doors are secure.

2. Electrical tests:

   a. Insulation resistance: 1000 volt DC tests for one minute on all 600 volt and lower rated equipment, components, buses, feeder and branch circuits and control circuits. Test phase-to-phase and phase-to-ground circuits showing less than 10 megohms resistance to ground shall be repaired or replaced.

   b. Circuit continuity: All feeders shall be tested for continuity. All neutrals shall be tested for improper grounds.

   c. Ground resistance: Test resistance to ground of system and equipment ground connection.

   d. Test overcurrent protection devices per Section 262816: Overcurrent Protective Devices.

D. In the event that the system fails to function properly during the testing as a result of inadequate pretesting or preparation. The Contractor shall bear all costs incurred by the necessity for retesting including test equipment, transportation, subsistence and the Engineer's hourly rate.

E. Contractor shall replace at no costs to the Owner all devices which are found defective or do not operate within factory specified tolerances.

F. Contractor shall submit the Testing Agency's final report for review prior to Project closeout and final acceptance by the Owner. Test report shall indicate test dates, devices tested, results, observation, deficiencies and remedies. Test report shall be included in the operation and maintenance manuals.

3.04 CLEANING

   A. Prior to energizing of panelboards the Contractor shall thoroughly clean the interior of enclosure of all construction debris, scrap wire, etc. using Manufacturer's approved methods and materials.

   B. Upon completion of Project prior to final acceptance the Contractor shall thoroughly clean both the interior and exterior of panelboards per Manufacturers approved methods and materials. Remove paint splatters and other spots, dirt and debris.

   C. Touch-up paint any marks, blemishes or other finish damage suffered during installation.

END OF SECTION 262416
OVERCURRENT PROTECTIVE DEVICES

SECTION 262816 - OVERCURRENT PROTECTIVE DEVICES

PART 1 - GENERAL

1.01 SUMMARY

A. Work included: Labor, materials and equipment necessary to complete the installation required for the item specified under this Division, including but not limited to:
   1. Molded case circuit breakers.

B. Related Work: Consult all other Sections, determine the extent and character of related Work and properly coordinate Work specified herein with that specified elsewhere to produce a complete installation.

1.02 REFERENCES

A. Comply with the latest edition of the following applicable Specifications and standards except as otherwise indicated or specified:
   1. Federal Specification (FS):
      FS W-C-375; Circuit Breakers, Molded Case, Branch Circuit and Service.
   2. Underwriters Laboratories, Inc. (UL):
      UL 489; Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures.
   3. National Electrical Manufacturer Association (NEMA):
      NEMA AB 1; Molded Case Circuit Breakers.

1.03 SUBMITTALS

A. Submit in accordance with the requirements of Section 260010: Basic Electrical Requirements, the following items:
   1. Data/catalog cuts for each product and component specified herein, listing all physical and electrical characteristics and ratings indicating compliance with all listed standards.
   2. Describe product operation, equipment and dimensions and indicate features of each component.
   3. Clearly mark on each data sheet the specific item(s) being submitted and the proposed application.
   4. Provide factory certification of trip characteristics for each type and rating of circuit breaker.
   5. Provide current let-through and melting time information for each type and rating of fuses.
   6. Confirmation in writing of compliance with Arc Energy Reduction per CEC Article 240.87.
   7. Submit Manufacturer's installation instructions.
   8. Complete bill of material listing all components.

1.04 OPERATION AND MAINTENANCE MANUAL
OVERCURRENT PROTECTIVE DEVICES

A. Supply operation and maintenance manuals in accordance with the requirements of Section 260010: Basic Electrical Requirements, to include the following:

1. A detailed explanation of the operation of the system.
2. Instructions for routine maintenance.
3. Parts list and part numbers.
4. Telephone numbers for authorized parts and service distributors.
5. Final testing reports.

1.05 QUALITY ASSUARANCE

A. All materials, equipment and parts comprising the units specified herein shall be new, unused and currently under production.

B. Only products and applications listed in this Section may be used on the Project unless otherwise submitted.

1.06 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Delivery: Overcurrent Protective Device components shall not be delivered to the Project site until protected storage space is available. Storage outdoors covered by rainproof material is not acceptable. Equipment damaged during shipment shall be replaced and returned to Manufacturer at no cost to Owner.

B. Storage: Store in a clean, dry, ventilated space free from temperature extremes. Maintain factory wrapping or provide a heavy canvas/plastic cover to protect units from dirt, water, construction debris and traffic. Provide heat where required to prevent condensation.

C. Handling: Handle in accordance with Manufacturer's written instructions. Be careful to prevent internal component damage, breakage, denting and scoring. Damaged units shall not be installed. Replace damaged units and return equipment to Manufacturer.

1.07 WARRANTY

A. Units and components offered under this Section shall be covered by a 1 year parts and labor warranty for malfunctions resulting from defects in materials and workmanship. Warranty shall begin upon acceptance by the Owner.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Products furnished by the following Manufacturers shall be acceptable if in compliance with all features specified herein and indicated on the Drawings.

1. Circuit breakers:
   a. ABB/ General Electric.
   b. Eaton.
   c. Siemens.
   d. Square D.

B. Substitutions: Under provisions of Section 260010: Basic Electrical Requirements.

2.02 MOLDED CASE CIRCUIT BREAKERS

A. Branch and feeder circuit breakers shall be molded case, bolt on and trip indicating.
OVERCURRENT PROTECTIVE DEVICES

B. Where stationary molded case circuit breakers are indicated on the Drawings to be current limiting type, they shall be current limiting as defined by UL 489 and shall not employ any fusible elements.

C. Circuit breakers shall have interrupting capacity not less than that indicated on the Drawings.

D. Covers shall be sealed on non-interchangeable breakers and trip unit covers shall be sealed on interchangeable trip breakers to prevent tampering. Circuit breaker ratings shall be clearly visible after installation or engraved nameplates shall be provided stating the rating. All ferrous parts shall be plated to minimize corrosion.

E. Circuit breakers shall be toggle, quick-make and quick-break operating mechanisms with trip-free feature to prevent contacts being held closed against overcurrent conditions in the circuit. Trip position of the breakers shall be clearly indicated by operating handles moving to a center position.

F. Multipole breakers shall have a single handle to open and close all contacts simultaneously in both manual operation and under automatic tripping. Interpole barriers shall be provided inside the breaker to prevent any phase-to-phase flashover. Each pole of the breaker shall have means for Arc extinguishing.

G. All terminals shall be dual rated for aluminum or copper wire.

H. Circuit breakers with frame ratings 100 amp and smaller shall be ambient temperature compensated, thermal magnetic type unless otherwise noted. Breakers shall be of full size, 1” per pole type. Panels with more than one branch breaker larger than 100 amps shall be installed in distribution type panels.

I. Circuit breakers with frame ratings above 100 amps through 400 amps shall have solid state electronic trips with true RMS reading through the 13th harmonic with 1% accuracy, interchangeable trip via front accessible current plug, adjustable instantaneous and short time be rated as indicated on Drawings at the voltage indicated.

J. Circuit breakers with frame ratings above 400 amps through 1600 amps shall have microprocessor–based RMS sensing trip units with the following characteristics:
   1. Interchangeable current rating plug or an adjustable trip setting to match the trip rating as indicated on Drawings.
   2. Adjustable long time pick-up setting. Minimum of five settings from 50% to 100%.
   4. Adjustable short time pick-up setting. Minimum of five settings from 200% to 800%.
   5. Adjustable short-time delay setting. Minimum of three delay bands with I2t IN and OUT curves.
   6. Adjustable instantaneous pick-up setting. Minimum of five settings from 200% to 1000%. Where the instantaneous feature is omitted on the Drawings, the trip unit shall have an instantaneous override feature.
   7. Zone selective interlocking (ZSI) for short-time delay and ground-fault delay trip functions, if indicated on the drawings.
   8. LED status indication to show “health” of trip unit.
   9. Three-phase ammeter, if indicated on the drawings.
  10. Trip indication targets on overload, ground fault and short circuit, if indicated on the drawings.
K. Accessories: Provide accessories as noted on the Drawings, i.e. shunt-trip, auxiliary contacts, undervoltage trip, alarm switch, etc.

L. Spaces in the boards shall be able to accept any combination of 1, 2 or 3 pole circuit breakers as indicated. Provide all necessary bus, device supports and mounting hardware sized for frame, not trip rating.

M. Series rated breakers are not acceptable unless specifically noted on the Drawings.

N. Breaker shall be rated to operate in an ambient temperature of 40 degrees C.

O. For circuit breakers rated or can be adjusted to 1200 amps (or higher), provide zone selective interlocking (ZSI) with downstream protective devices, if indicated on the drawings. If ZSI is not indicated on the drawings, provide a key interlock maintenance mode switch and blue LED indicating lamp in the same section, which shall allow an operator to manually enable temporary protective device maintenance settings to reduce the arc flash energy level. Key shall be held captive when maintenance mode signal is disabled and removable when maintenance mode signal is enabled. Maintenance mode switch positions shall be labeled “Enabled” and “Disabled”. Blue indicating lamp shall be push-to-test type.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Contractor shall thoroughly examine Project site conditions for acceptance of overcurrent protective device installation to verify conformance with Manufacturer and Specification tolerances. Do not commence with installation until all conditions are made satisfactory.

3.02 INSTALLATION

A. Install overcurrent protective devices in accordance with Manufacturer's written instructions, as indicated on the Drawings and as specified herein.

B. Tighten electrical connectors and terminals; including screws and bolts, in accordance with equipment Manufacturers published torque-tightening values for equipment connectors. Where Manufacturers torque requirements are not indicated tighten connectors and terminals to comply with tightening torque specified in UL Standard 486A.

C. Install overcurrent protective devices and accessories in accordance with Manufacturer's written instructions and with recognized industry practices to ensure that protective devices comply with requirements. All devices shall be installed in accordance with applicable CEC and NEMA standards for installation.

D. Circuit breakers serving "Fire Alarm Control Panel(s)" shall be red in color.

3.03 FIELD QUALITY CONTROL

A. Independent testing: Contractor shall arrange and pay for the services of an independent Testing Agency to perform all quality control electrical testing, calibration and inspection required herein. Testing Agencies objectives shall be to:

1. Assure overcurrent protective device installation conforms to specified requirements and operates within specified tolerances.

2. Field test and inspect to ensure operation in accordance with Manufacturer's recommendations and Specifications.

3. Prepare final test report including results, observations, failures, adjustments and remedies.

4. Verify ratings and settings and make final adjustments.
OVERCURRENT PROTECTIVE DEVICES

B. At least three weeks prior to any testing, notify the Engineer so that arrangement can be made for witnessing test, if deemed necessary. All pretesting shall have been tested satisfactorily prior to the Engineer's witnessed test.

C. The Contractor shall supply a suitable and stable source of electrical power to each test site. The Testing Agency shall specify the specific power requirements.

D. Testing of overcurrent protective devices shall be done only after all devices are installed and prior to system being energized.

E. Prefunctional testing:
   1. Provide Testing Agency with Contract Documents and Manufacturer instructions for installation and testing.
   2. Visual and mechanical inspection:
      a. Inspect for physical damage, defects alignment and fit.
      b. Perform mechanical operational tests in accordance with Manufacturer's instructions.
      c. Compare nameplate information and connections to Contract Documents.
      d. Check tightness of all control and power connections.
      e. Check that all covers, barriers and doors are secure.
   3. Electrical tests:
      a. Circuit continuity: All feeders shall be tested for continuity. All neutrals shall be tested for improper grounds.
      b. Test all circuit breakers with frame size 225 amps and larger in each panelboard, distribution board, switchboard, etc. unless otherwise noted via primary current injection testing. Testing shall verify the following:
         1) Determine that circuit breaker will trip under overcurrent conditions, with tripping time in conformance with NEMA AB 1 requirements.
         2) Circuit breaker pickup and delay measurements are within the manufacturers published tolerances for long time, short time, instantaneous, and ground fault.
         3) For circuit breakers rated or can be adjusted to 1200 amps (or higher), confirm ZSI protection is acceptable or the maintenance mode switch is operational (enabled and disabled) with reduced pickup and delay measurements when enabled.
   F. Contractor shall replace at no costs to the Owner all devices which are found defective or do not operate within factory specified tolerances.
   G. Contractor shall submit the Testing Agency's final report for review prior to Project closeout and final acceptance by the Owner. Test report shall indicate test dates, devices tested, results, observation, deficiencies and remedies. Test report shall be included in the operation and maintenance manuals.

3.04 ADJUSTING

A. Adjust circuit breaker trip settings for coordination with other overcurrent protective devices in system.

B. Adjust circuit breaker trip settings for adequate protection from overcurrent and fault currents.
OVERCURRENT PROTECTIVE DEVICES

3.05 CLEANING
   A. Upon completion of Project prior to final acceptance the Contractor shall thoroughly clean overcurrent protective devices per Manufacturer's approved methods and materials. Remove paint splatters and other spots, dirt and debris.

3.06 TRAINING
   A. Factory authorized service representative shall conduct a 4 hour training seminar for Owner's Representatives upon completion and acceptance of system. Instructions shall include safe operation, maintenance and testing of equipment with both classroom training and hands-on instruction.
   B. Contractor shall schedule training with a minimum of 7 days advance notice.

END OF SECTION