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. Project management and coordination services.
8. Rough-in.
10. Cutting, patching, painting and sealing.
11. Field quality control.
12. Cleaning.
13. Project closeout.

C. 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 and operable installation.

1. General and supplementary conditions: Drawings and general provisions of Contract and Division 01 of the Specifications, apply to all Division 26 Sections.
2. Selective demolition: Nondestructive removal of materials and equipment for reuse or salvage as indicated. Also dismantling electrical materials and equipment made obsolete by these installations.

3. Concrete Work: Include forming, steel bar reinforcing, cast-in-place concrete, finishing and grouting as required for underground conduit encasement, light pole foundations, pull box slabs, vaults, housekeeping pads.

4. Miscellaneous metal work: Include fittings, brackets, backing, supports, rods, welding and pipe as required for support and bracing of raceways, lighting fixtures, panelboards, distribution boards, switchboards, motor control centers, etc.

5. Miscellaneous lumber and framing work: Include wood grounds, nailers, blocking, fasteners and anchorage for support of electrical materials and equipment. Refer to Division 06, Rough Carpentry.

6. Moisture protection and smoke barrier penetrations: Include membrane clamps, sheet metal flashing, counter flashing, caulking and sealant as required for waterproofing of conduit penetrations and sealing penetrations in or through fire walls, floors, ceiling slabs and foundation walls. All penetrations through vapor barriers at slabs on grade shall be taped and made vaportight.

7. Access panels and doors: Required in walls, ceilings and floors to provide access to electrical devices and equipment.

8. Painting: Include surface preparation, priming and finish coating as required for electrical cabinets, exposed conduit, pull and junction boxes, etc. where indicated as field painted in this Division.

9. Lighting fixture supports: Provide slack fixture support wire for lighting fixtures installed in acoustical tile or lay-in suspended ceilings.

D. Work furnished and installed under another Division requiring connections under this Division includes but is not limited to:

1. Electric motors.

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 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:

- **ACI** American Concrete Institute
- **ANSI** American National Standards Institute
- **ASTM** American Society for Testing Materials
- **ETL** Electrical Testing Laboratories
- **FS** Federal Specification
- **IEEE** Institute of Electrical and Electronics Engineers, Inc.
- **IPCEA** Insulated Power Cable Engineer Association
- **NEMA** National Electrical Manufacturer's Association
- **UL** Underwriters' Laboratories

E. Independent Testing Agency qualifications:

1. Testing Agency shall be an independent testing organization that will function as an unbiased authority, professionally independent of Manufacturer, Supplier and Contractor, furnishing and installing equipment or system evaluated by Testing Agency.

2. Testing Agency shall be regularly engaged in the testing of electrical equipment, devices, installations and systems.

3. Testing Agency shall meet Federal Occupational Safety and Health Administration (OSHA) requirements for accreditation of independent testing laboratories, Title 9, Part 1907.

4. On-site technical personnel shall be currently certified by the International Electrical Testing Association in electrical power distribution system testing.

5. Testing Agency shall use technicians who are regularly employed by the firm for testing services.

6. Contractor shall submit proof of above Testing Agency qualifications with bid documentation upon request.

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

G. 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.

H. Certify that each welder performing Work has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone re-certification.

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.

6. "Utility Companies": Shall mean the company providing electrical, telephone or cable television services to the Project.

1.04 SUBMITTALS

MAY 8, 2013

BASIC ELECTRICAL REQUIREMENTS

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A. Format: Furnish submittal data neatly bound in an 8-1/2" x 11" folder or binder 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. The Contractor shall submit detailed Drawings of all electrical equipment rooms and closets if the proposed installation layout differs from the construction documents. Physical size of electrical equipment indicated on the Drawings shall match those of the electrical equipment that is being submitted for review, i.e.: switchboards, panelboards, transformers, control panels, etc. Minimum scale: 1/4" = 1'- 0". Revised electrical equipment layouts must be approved prior to release of order for equipment and prior to installation.

E. As part of the equipment submittals, the Manufacturer shall provide anchorage calculations for floor and wall mounted electrical equipment so that it shall remain attached to the mounting surface after experiencing forces in conformance with CCR, Title 24, Table 23P, Part II and with Section 2312 "Earthquake Regulations" of the "Uniform Building Code" for Seismic Zone 4 Area, Importance Factor of 1.25. Structural Calculations shall be prepared and signed by a California Registered Structural Engineer. Specify proof loads for drilled-in anchors, if used.

F. The Manufacturer shall recommend the method of anchoring the equipment to the mounting surface and shall provide the Contractor with the assembly dimensions, weights and approximate centers of gravity.

G. 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.

H. Independent Testing Agency report:
   1. Testing Agency shall provide 3 copies of the complete testing report.
   2. Test report shall include the following:
      a. Summary of Project.
      b. Description of equipment.
      c. Equipment used to conduct the test.
         1) Type.
         2) Manufacturer.
         3) Model number.
         4) Serial number.
5) Date of last calibration.
6) Documentation of calibration leading to NIST standards.

d. Description of test.
e. Test results, as compared to Manufacturers or industry accepted standards and tolerances.
f. Conclusion and recommendation.
g. Signature of responsible test organization authority.

3. Furnish completed test report to Engineer no later than 30 days after completion of testing, unless otherwise directed.

I. 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 actual locations of outlets, true panelboard connections following phase balancing routines, correct conduit and wire sizing as well as routing, revised fixture schedule listing Manufacturers and products actually installed and revised panel schedules. 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 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 either Autocad Release 2008 or DXF file format.

3. Record drawing submissions shall be provided to the Engineer to review upon the completion of the following phases of Work:
   a. Building electrical rough-in.
   b. Final electrical installation.

4. Include in the record drawing submission the following shop drawing submission with all updated installation information:
   a. Fire alarm system.
   b. Telecommunication cabling system

5. 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. Two sets of full size prints.
   b. Four sets of half size prints.
   c. DXF files of Drawings.

B. Panel schedules:
   1. Typewritten panel schedules shall be provided for panelboards indicating the loads served and the correct branch circuit number. Schedules shall be prepared on forms provided by the Manufacturer and inserted in the pocket of the inner door of each panelboard. See Section 262416: Panelboards for requirements.

2. A single set of the record panel schedules 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. Fold and insert one copy of the appropriate schedule in the pocket of the inner door of each panelboard.
   b. Three binders, each containing a full set of the panel schedules. Provide index listing all schedules and dividers for separation of schedules as follows:
      1) 277/480V normal.
      2) 277/480V emergency.
      3) 277/480V generator equipment.
      4) 120/208V normal.
      5) 120/208V emergency.
      6) 120/208V generator equipment.

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.

1.08  PROJECT MANAGEMENT AND COORDINATION SERVICES

A. Overview: Contractor shall provide a Project Manager/Engineer for the duration of the Project to coordinate the Division 26 Work with all other trades. Coordination services, procedures and documentation responsibility shall include, but shall not be limited to the items listed in this Section.

B. Review of Shop Drawings prepared by other Subcontractors:

1. Obtain copies of all Shop Drawings for equipment provided by others that require electrical service connections or interface with Division 26 Work.

2. Perform a thorough review of the Shop Drawings to confirm compliance with the service requirements contained in the Division 26 Contract Documents. Document any discrepancy or deviation as follows:
   a. Prepare memo summarizing the discrepancy.
   b. Provide a copy of the specific shop drawing, indicating via cloud, the discrepancy.

3. Prepare and maintain a shop drawing review log indicating the following information:
   a. Shop drawing number and brief description of the system/material.
   b. Date of your review.
   c. Indication if follow-up coordination is required.

C. Request for information (RFI):

1. Thoroughly review the Contract Documents prior to the preparation and submission of an RFI. If an RFI is submitted, attach 8 1/2” x 11” copies of all relevant documents to clarify the issue.

2. Prepare and maintain an RFI log indicating the following information:
   a. RFI number and brief summary of the issue.
   b. Date of issuance and receipt of response.

D. Clarification confirmation memo (CCM):

1. Either the Contractor will prepare CCM memos or the Engineer to confirm a decision clarifying the Contract Documents that does not impact cost or affect other trades.

2. Prepare and maintain a CCM log indicating the following information:
   a. CCM number: Use CCM-C1, C2, etc. for memos issued by the Contractor and CCM-E1, E2, etc. for memos issued by the Engineer.
   b. Brief summary of issue and date issued.

1.09  CONTRACT PRICING MODIFICATION PROCEDURES

A. Submission guidelines: This Section covers the criteria for direct costs, mark-ups and documentation requirements to be followed by the Contractor for any pricing modification to the Base Contract, where unit pricing has not already been established.

1. Change orders: Pricing for additions or deletions to the Base Contract Scope of Work upon acceptance of bid value and receipt of authorization to proceed.
2. Allowances: Cost allowances may be assigned for specific Scope of Work outlined within the Base Contract where design has not been fully delineated on the Contract Documents. When detailed information is available, the Contractor shall prepare and submit a price quotation for the Work. This price quotation will be compared to the allowance value and any adjustments necessary to the Base Contract value shall be made via change order.

B. Direct costs:

1. Labor:
   a. Hourly labor rates shall not exceed the prevailing wage for the County where the Work is being performed. The costs for all supervision, including general superintendents and foremen, shall be included in the mark-up defined herein. Working foremen will be considered a direct cost only if the individual is on the Project site physically installing Work under the change order.
   b. Labor burden shall be based on rates currently in effect at the time the Work under the change order is being performed and shall include only fringe benefits by governing trade organizations, Federal Insurance Contribution Act, Federal and State Unemployment taxes, payroll taxes and net actual premium paid for public liability, workers’ compensation, property damage and other forms of insurance required by the Owner. No other cost will be included as labor burden.
   c. NECA Manual of Labor Units will be utilized as the basis for determining labor productivity rates for Electrical Work as follows:
      1) 85% of NECA column 1 (normal) for change in scope issued well in advance of Work needing to be performed, so as not to cause slow-down or Work stoppage.
      2) 100% of NECA column 1 (normal) for Work being performed with other Base Contract Work, not out of sequence and with minimal slow-down or Work stoppage.
      3) 100% of NECA column 2 (difficult) for Work performed out of sequence, requiring Work stoppage and reconstruction in areas already complete. This Work may involve the removal of ceiling tiles or the cutting and patching of walls.
   d. No labor costs shall be included for the following items since the labor is already covered by the NECA labor units for conduit and construction channel:
      1) Conduit straps and clips.
      2) Construction channel accessories (nuts, washers, etc.).
      3) Screws.
      4) Conduit elbows ¾” and smaller.

2. Material:
   a. The cost of material shall be the direct cost, including sales tax and may include the cost of transportation from the Supplier to the Contractor, but charges for final delivery to the Project site will not be allowed.
   b. Electrical commodities priced based on most current Trade Service Book with a 15% discount. Non-commodities priced per invoice from Supplier.

3. Equipment rental:
a. Payment for equipment costs will be made at the rental rates listed for such equipment as specified in the current edition, at the time of the Work, of “Labor Surcharge and Equipment Rental Rates,” a Caltrans Publication. Such rental rates shall be adjusted as appropriate and will be used to compute payments for equipment; regardless of weather the equipment is under Contractor’s control through direct ownership, leasing, renting or other method of acquisition. Daily, weekly or monthly rates shall be used, whichever is lower. Hourly rates including operator shall not be used.

b. The actual time to be paid for equipment shall be the time the equipment is in productive operation on the Work. No payment will be made time while equipment is inoperative due to breakdown or for non-working days.

c. Individual pieces of equipment having a replacement value of $1,000 or less shall be considered small tools or small equipment and no payment will be made since the costs of these tools and equipment are included as part of the Contractor’s mark-up for overhead and profit.

d. Payment to Contractor for use of equipment as set forth herein shall constitute full compensation to Contractor for the cost of fuel, power, oil, lubricants, supplies, small equipment, necessary attachments, repairs and maintenance of any kind, depreciation, storage, insurance, labor (except for equipment operators) and any and all costs to Contractor for incidental use of the equipment.

4. Performance bond: Only the actual cost of insurance and bond premiums, with no mark-up for overhead and profit, will be allowed.

C. Mark-up for overhead and profit on direct costs:

1. Costs to be included as part of mark-up:
   a. Field and home office personnel including, but not limited to, Principals, Project Managers, Superintendents, Supervisory Foremen, Estimators, Project Engineers, Detailers, Draftspersons, Schedulers and Administrative Assistants.
   b. All field and home office expenses including, but not limited to, field trailers, parking, storage sheds, office equipment and supplies, telephone service at the Project site, long-distance telephone calls, fax machines, computers and software, temporary utilities, sanitary facilities, etc.
   c. Administrative functions including, but not limited to, reviewing, coordinating, distributing, processing, posting, recording, estimating, negotiating, scheduling, schedule updating and revising, expediting, detailing, revising Shop Drawings and preparing Record Drawings.
   d. Vehicles required for the transportation of Contractor’s staff and field personnel.

2. Maximum mark-up values:
   a. For Work performed by the Contractor, the overhead mark-up shall equal a maximum of 10 percent of the direct costs, as defined herein.
   b. Mark-up for profit shall equal a maximum of 5 percent of combined direct and overhead costs.
   c. For Work performed by a Subcontractor shall equal a maximum of 5 percent mark-up for profit. Subcontractor shall follow the same guidelines above for their mark-up allowance. No consideration shall be given for more mark-ups then this two tier arrangement whereas the mark-up could exceed 20%.
d. For Work scope changes that result in a net decrease in cost to the Contractor or a Subcontractor, the Owner shall receive a credit based on the actual net decrease in direct cost figured in the same manner as an add cost. It is understood that the mark-up value applied at bid time will not be credited back. Although, if this is a change to a previous change order, then mark-up values shall be included in credit back to Owner.

e. There will be no mark-ups on the cost of performance bond.

D. Documentation:

1. Project change order request submission:
   a. Provide copies of all take-off sheets showing material and labor charges in line item format.
   b. Provide recap sheet showing all direct costs and mark-ups.
   c. Provide copies of invoices for Subcontracted Work.

2. Allowance account tracking:
   a. Contractor shall prepare and maintain a spreadsheet for each allowance account to track and monitor the requested and approved charges.
   b. Copies of these spreadsheets, along with the summary spreadsheets, shall be submitted to the Owner’s Representative twice a month.

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. Arrange for chases, slots and openings in other building components during progress of construction, to allow for electrical installations.

4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.

5. Sequence, coordinate and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
6. Where mounting height is not detailed or dimensioned, contact the Architect for direction prior to proceeding with rough-in.

7. Coordinate connection of electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies and controlling agencies. Provide required connection for each service.

8. 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.

9. Install systems, materials and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.

10. 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.

11. Coordinate electrical systems, equipment and materials installations with other building components.

12. Provide access panel or doors where devices or equipment are concealed behind finished surfaces. Furnish and install access doors per the requirements of Division 08.

13. Install systems, materials and equipment giving right-of-way priority to other systems that are required to maintain a specified slope.


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.

C. Cut, remove and legally dispose of selected electrical equipment, components and materials as indicated, including but not limited to removal of electrical items indicated to be removed and items made obsolete by the new Work.

D. Protect the structure, furnishings, finishes and adjacent materials not indicated or scheduled to be removed.

E. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.

F. Patch existing surfaces and building components using experienced installers and new materials matching existing materials and the original installation. For installers' qualifications refer to the materials and methods required for the surface and building components being patched.

G. Application of joint sealers:
1. General: Comply with joint sealer Manufacturers' printed application instructions applicable to products and applications indicated, except where more stringent requirements apply.

2. Installation of fire-stopping sealant: Install sealant, including forming, packing and other accessory materials, to fill openings around electrical services penetrating floors and walls, to provide fire-stops and fire-resistance ratings indicated for floor or wall assembly in which penetration occurs. Comply with installation requirements established by testing and inspecting agency.

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. Equipment operations: Test motors for correct operation and rotation.

2. Alarm and interlock systems: Produce malfunction symptoms in operating systems to test alarm and interlock systems. In addition, all specific tests described in the fire alarm system shall be performed.

3. Circuit numbering verification: Select on a random basis various circuit breakers in the panelboards and cycle them on and off to verify compliance of the typed panel directories with actual field wiring.

4. Voltage check:
   a. At completion of job, check voltage at several points of utilization on the system that has been installed under this Contract. During test, energize all installed loads.
   b. Adjust taps on transformers to give proper voltage, which is 118 to 122 volts for 120 volt nominal systems and proportionately equivalent for higher voltage systems. If proper voltage cannot be obtained, inform the Owner and the serving Utility Company.

C. Contractor shall provide test power required when testing equipment before service energization and coordinate availability of test power with General Contractor after service energization. The Contractor shall provide any specialized test power as needed or specified herein.

D. 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.

E. Calibration of test equipment:
1. Testing Agency shall have calibration program that assures test instruments are maintained within rated accuracy.

2. Instruments shall be calibrated in accordance with the following frequency schedule:
   a. Field instruments: Analog, 6 month maximum; Digital, 12 months maximum.
   b. Laboratory instruments: 12 months.
   c. Leased specialty equipment: 12 months where accuracy is guaranteed by lessor.

3. Dated calibration labels shall be visible on test equipment.

4. Records, which show date and results of instruments calibrated or tested, must be kept up-to-date.

5. Up-to-date instrument calibration instructions and procedures shall be maintained for test instrument.

6. Calibration standards shall be of higher accuracy than instrument tested.

7. Equipment used for field testing shall be more accurate than instrument being tested.

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

G. Notify Owner and Engineer one week in advance of any testing.

H. 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.

I. Testing Agency shall maintain written record of tests and shall assemble and certify final test report.

J. Include all test results in the maintenance manuals.

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. Training: At the time of completion, a period of not less than 4 hours shall be allotted by the Contractor for instruction of building operating and maintenance personnel in the use of all systems. This 4 hours training is in addition to any instruction time called out in the Specifications for specific systems, i.e., Fire Alarm, Generator, etc. All personnel shall be instructed at one time, the Contractor making all necessary arrangements with Manufacturer’s
Representative. The equipment Manufacturer shall be requested to provide product literature and application guides for the users' reference. Costs, if any, for the above services shall be paid by the Contractor.

B. 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.

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

END OF SECTION
SECTION 260090
ELECTRICAL DEMOLITION

PART 1 - GENERAL
1.01 SUMMARY
A. Work included: Labor and equipment necessary to complete the demolition required for the item specified under this Division, including but not limited to:
   1. Selective Electrical demolition

1.02 SYSTEM DESCRIPTION
A. Disconnection, removal and relocation of all wiring, light fixtures, outlets, conduit and all other types of electrical equipment as described on Drawings.
B. Purpose is to remove, relocate and extend existing installations to accommodate new construction.

PART 2 - PRODUCTS
2.01 MATERIALS AND EQUIPMENT
A. Materials and equipment necessary for patching and extending Work, as specified in other Sections.

PART 3 - EXECUTION
3.01 EXAMINATION
A. Contractor shall thoroughly review conditions in the area of demolition prior to commencing Work to ensure complete understanding of existing installation in relationship to demolition Work.

3.02 GENERAL REQUIREMENTS
A. Remove all wiring, light fixtures, outlets, conduit and all other types of electrical equipment indicated to be removed. Devices that are to be removed may require reworking conduit and wiring in order to maintain service to other devices. If removed devices are on walls or ceilings that are to remain, blank coverplates are to be installed on outlet boxes.
B. Where remodeling interferes with circuits in areas that are otherwise undisturbed, circuits shall be reworked as required.
C. Existing devices and circuiting that are indicated are indicated only for informational purposes. Contractor shall visit the Project site and shall verify conditions as they exist and shall remove, relocate and/or rework any electrical equipment or circuits affected (whether indicated or not) due to removal of existing walls, ceilings, etc. Coordinate all Work with that of other trades.
D. All equipment, fixtures, devices, etc., which are removed shall be delivered to the Owner for disposition. All items which are removed and not wanted by the Owner and which are not reused shall become the property of the Contractor and shall be legally removed from the Project site.
E. Cutting and patching necessary for the removal of Electrical Work shall be included.
F. Remove and replace lighting fixtures, rework, relocate or replace conduit and wiring and do other Work required by the installation of new ductwork, piping, etc., above the ceiling. Coordinate with other trades and verify the extent of the Work.

3.03 LIGHT FIXTURES
A. Disconnect and remove abandoned light fixtures. Remove conduits, wiring, boxes, brackets, stems, hangers and other accessories.

3.04 OUTLETS
A. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit servicing them is abandoned and removed. Provide blank cover for abandoned outlets that are not removed.

3.05 CONDUIT
A. Remove abandoned conduit, including abandoned conduit above accessible ceiling finishes. Cut conduit flush with walls and floors and patch surfaces.

3.06 WIRING
A. Removed abandoned wiring to source of supply.

3.07 EXISTING SYSTEMS
A. Electrical distribution system: Disable system only to make switchovers and connections. Obtain permission from Owner's designated representative at least 24 hours before partially or completely disabling system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to Work area.
B. Fire alarm system: Maintain the existing system in service. Disable system only to make temporary connections to maintain service in areas adjacent to Work area(s). Notify Owner and Fire Supervisory Service at least 24 hours before partially or completely disabling the system.
C. Telephone system: Maintain the existing system in service throughout construction. Disable system only to make temporary connections where necessary to maintain service in areas adjacent to Work area(s). Notify Owner and Telephone Utility at least 24 work week hours before partially or completely disabling the system.

3.08 CLEANING AND REPAIR
A. Clean and repair existing materials and equipment that shall remain.
B. Panelboards: Clean exposed surfaces and check tightness of electrical connections. Replace damaged circuit breakers and provide closure plates for vacant positions. Provide typed circuit directory showing revised circuiting arrangement.

END OF SECTION
SECTION 260519
BUILDING WIRE AND CABLE

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 183; Manufactured Wiring Systems.
   UL 310; Electrical Quick-Connect Terminals.
   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 854; Service-Entrance Cables.
   UL 1569; Metal-Clad Cables.
   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. America Insulated Wire Corp.
      b. Rome Cable.
      c. Southwire Company.
   2. Metal-Clad or Armored Cable:
      a. American Cable Systems.
   3. Flexible Cords and Cables:
      a. Carol Cable Company.
      b. PWC Corp.
      c. ITT Royal Electric.
   4. 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. Wire AWG #8 and larger shall be stranded, unless otherwise indicated.  
   3. 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. Feeders and branch circuits larger than 6 AWG: Type THW, XHHW or dual rated THHN/THWN.  
   5. Feeders and branch circuits 6 AWG and smaller: Type TW, THW, XHHW or dual rated THHN/THWN.  
   6. Control Circuits: Type THW or dual rated THHN/THWN.  
   7. 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 be an armored assembly of two or more dual rated THHN/THWN conductors. A full sized green insulated ground wire.  
B. MC cable sheath shall be fabricated in continuous lengths from galvanized steel strip, spirally wound and formed to provide an interlocking design.  
C. Conductors shall be color-coded for the correct phase and voltage as specified herein.  
D. Fittings: Connectors shall be of the single screw clamp variety with steel or cast malleable iron bodies and threaded male hubs with insulated throats. Fittings shall be UL listed for use with MC cable type specified.  

2.04 ARMORED CABLE (AC)  
A. AC cable shall be an armored assembly of two or more dual rated THHN/THWN conductors. A full sized green insulated ground wire and a bare wire metal sheath bond conductor.  
B. AC cable sheath shall be fabricated in continuous lengths from galvanized steel strip, spirally wound and formed to provide an interlocking design.  
C. Conductors shall be color-coded for the correct phase and voltage as specified herein.
D. Fittings: Connectors shall be of the single screw clamp variety with steel or cast malleable iron bodies and threaded male hubs with insulated throats. Fittings shall be UL listed for use with AC cable type specified.

2.05 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. Push-in wire connectors:
   1. Multi-port push-in wire connectors for a maximum of 8-wires, as required for specific application. Connectors are manufactured to accommodate a wide range of sizes with either solid or stranded conductors, up to a maximum wire size of #10 AWG. Low insertion force required for ease of installation.
   2. Housing shall be 105 degrees C and transparent for visual connection verification.
   3. 600 volt maximum rating with copper contacts.
   4. UL Listed to 486C and UL 467 Listed for grounding and bonding applications.

D. Compression type terminating lugs:
   1. Provide tin-plated copper high-compression type lugs for installation with hand or hydraulically operated circumference-cramping 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.

E. 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.

F. Insulating putty:
   1. Provide pads or rolls of non-corrosive, self-fusing, one-eighth inch thick rubber putty with PVC backing sheet. Scotch vinyl mastic pads and roll or equal.
   2. Use putty suitable for temperatures from minus 17.8 degrees C to 37.8 degrees C with a dielectric strength of 570-volts/mil minimum.

G. 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.
H. Terminal strips:
   1. Provide box type terminal strips in the required quantity plus 25% spare. Install in continuous rows in terminal cabinets.
   2. Use the box type terminal strips with barrier open backs and with ampere ratings as required.
   3. Identify all terminals with numbering sequence being used for a particular system.
I. Crimp type connectors:
   1. Provide insulated fork or ring crimp terminals with tinned electrolytic copper-brazed barrel with funnel wire entry and insulation support
   2. Fasten crimp type connectors or terminals using a crimping tool recommended by the connector Manufacturer.
   3. Provide insulated overlap splices with tinned seamless electrolytic copper barrel with funnel wire entry and insulation support.
   4. Provide insulated butt splices with tinned seamless electrolytic copper barrel with center stop, funnel wire entry and insulation support.
J. 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.
K. 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.
L. 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, confirming 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. 20 amp power and lighting branch circuit containing no more than four (4) current carrying conductors (phases and neutrals). Use #10 AWG conductor for 120/208 volt circuits located outside a 75 foot radius of panel source and for 277 volt branch circuits located outside a 200 foot radius of panel source, unless otherwise noted.

F. 20 amp power and lighting branch circuits containing no more than eight (8) current carrying conductors (phases and neutrals). Use #10 AWG conductors for 120/208 volt circuits located outside a 65 foot radius of panel source and for 277/480 volt circuits located outside a 150 foot radius of panel source.

G. Provide #10 AWG pig tails on all 20A and 30A wiring devices served by #8 AWG conductors and larger.

H. Splice cables and wires only in outlet boxes, junction boxes, pull boxes, manholes or handholes. Group and bundle with tie wrap each neutral with it's associated phase conductor where more then one neutral is present in a conduit.

I. 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.

J. Neatly form, train and tie the cables in individual circuits. For panelboards, cabinets, wireways, switches and equipment assemblies.

K. Seal cable or wire, entering a building from underground, between the wire or cable and conduit, where it exits the conduit, with a non-hardening approved compound, i.e. duct seal or equal.

L. 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.

M. 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.

N. Flexible cords and cables supplied, as part of a pre-manufacturer fixture or unit assembly shall be installed according to Manufacturers published installation instructions.

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 MC CABLE INSTALLATION

A. Install MC cable in accordance with Manufacturer's instructions and in strict accordance with NEC Article 334. Follow Manufacturer's explicit instructions when connecting the cable to fittings and boxes. Connectors shall be firmly secured to the cable, but not over-tightened. Connector shall be firmly attached to the metal boxes.

B. Support cables every 6 feet and within 12 inches of boxes, per NEC Article 334, using separate spring metal clip or metal cable ties (not steel tie wire) for each cable. Cables shall not be bundled together.

C. Suspended ceiling drop wire may be used to directly support a maximum of two separate MC cables.

D. Provide separate drop wire above accessible ceiling, to support more than (2) two MC cables.

E. Do not rest cables on ceiling tiles or allow contact with mechanical piping systems.

F. Bend the cable per NEC Article 334.

G. Provide separate sleeves and/or fire barriers where cable penetrated firewalls, unless cable is UL listed for the application.

3.06 AC CABLE – INSTALLATION

A. The Drawings indicate above suspended ceiling power distribution junction boxes for conversion from hardwire to AC cable wiring system. Install these boxes such that they are accessible from below. AC cable shall be run to each device as described in documents. AC cable runs have not been indicated. Refer to Shop Drawings for installation.

B. Install AC cable in accordance with Manufacturer instructions and in strict accordance with NEC Article 333. Follow Manufacturer's explicit instructions when connecting the cable to fittings and boxes. Connectors shall be firmly secured to the cable, but not over-tightened. Connector shall be firmly attached to the metal boxes.

C. Support cables every 4 1/2 feet and within 12 inches of boxes, per NEC Article 333, using separate spring metal clip or metal cable ties (not steel tie wire) for each cable. Cables shall not be bundled together.

D. Suspended ceiling drop wire may be used to directly support a maximum of two separate AC cables.

E. Provide separate drop wire above accessible ceiling, to support more than (2) two AC cables.

F. Do not rest cables on ceiling tiles or allow contact with mechanical piping systems.

G. Bend the cable per NEC Article 333.

H. Provide separate sleeves and/or fire barriers where cable penetrated firewalls, unless cable is UL listed for the application.
3.07 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. Pigtails 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.

3.08 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.

3.09 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 required herein. Independent Testing Agency shall meet the requirements as outlined in Section 260010: Basic Electrical Requirements.

B. 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 as follows:
      1) 100% of all feeders 100 amp rated and above.
      2) 50% of all feeders smaller than 100 amps.
      3) 10% of all branch circuits at each individual panelboard.
   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
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.
   3. Safety ground grid and/or mat.

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 05: Building Steel.
   2. Division 22: Cold Water Piping.

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. Ground the electrical service system neutral at service entrance equipment as described herein and indicated on Drawings.

B. Ground each separately derived system neutral as described herein and indicated on Drawings.

C. Provide a safety ground grid and/or mat beneath all electrical switchgear operating at 1000 volts and above, and at emergency generator. Grid/mat shall be poured in the concrete floor slab and constructed as specified herein.

D. 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.

E. 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

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. Bare conductors in direct contact with earth or encased in concrete: #2/0 AWG copper minimum, U.O.N.

D. 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.

2.06 CONNECTIONS TO PIPE
A. For cable to pipe: UL and NEC/CEC approved bolted connection.

2.07 CONNECTIONS TO STRUCTURAL STEEL, GROUND RODS OR SPLICES
A. Where required by the Drawings, grounding conductors shall be spliced together, connected to ground rods or connected to structural steel using exothermic welds or high pressure compression type connectors.
   1. Exothermic welds shall be used for cable-to-cable and cable-to-ground rod and for cable to structural steel surfaces. Exothermic weld kits shall be as manufactured by Cadweld or equal. Each particular type of weld shall use a kit unique to that type of weld.
   2. High-pressure compression type connectors shall be used for cable-to-cable and cable-to-ground rod connections.

2.08 EXTRA FLEXIBLE, FLAT BONDING JUMPERS
A. Where required by Code, indicated on the Drawing, and specified herein.

2.09 BUILDING GROUND BUS REQUIREMENTS
A. Main building power system ground bus:
   1. Provide one 24" wide x 4" high x 1/4" thick copper bus bar as a minimum. Mount on wall in main electrical room utilizing insulating stand-offs at 18" above finished floor.
   2. Furnish complete with cast copper alloy body lugs for connecting grounding system conductors. Attach lugs to bus with appropriate size cadmium bronze bolt, flat washer and Belleville washer. Torque all lug connections.
   3. All holes shall be drilled and tapped for single-hole lugs. Provide 6 spare lugs and lug spaces.

B. Building power system reference ground bus:
   1. The reference ground bus is furnished as part of the main electrical switchboard for the building, along with neutral disconnect and bus, and is in addition to the main building power system ground bus outlined above. The building grounding electrode shall make a direct connection to the building referenced ground bus in the main switchboard.
2. Provide a #2/0 AWG copper ground conductor connection between the building reference ground bus in switchboard and the main building ground bus wall mounted in main electrical room.

C. Telecommunication system ground bus requirements:

1. Main telecommunication system ground bus: Provide one 18” wide x 4” high x 1/4” thick copper bus bar as a minimum. Mount on wall in MDF room utilizing insulating stand-offs at 18” above finished floor.

2. Telecommunication system ground bus: Provide one 12” wide x 4” high x 1/4” thick copper bus bar as a minimum. Mount on wall in each IDF room and in the MPOE room utilizing insulating stand-offs at 18” above finished floor.

3. Furnish complete with cast copper alloy body lugs for connecting grounding system conductors. Attach lugs to bus with appropriate size cadmium bronze bolt, flat washer and Belleville washer. Torque all lug connections.

4. All holes shall be drilled and tapped for single-hole lugs. Provide 3 spare lugs and lug spaces.

2.10 SAFETY GROUND GRID AND/OR MAT

A. Provide prefabricated or field constructed wire mesh consisting of #6 AWG bare copper conductors forming a 24” x 24” grid. Prefabricated wire mesh shall be constructed with silver brazing at all cross intersections. Field constructed wire mesh shall utilize either exothermic welds or high pressure compression connectors at all cross intersections.

B. Provide #1/0 AWG bare copper conductor installed in the center of grid and run parallel the length of the mesh, leaving 8 foot pigtails at both ends for bonding with electrical switchgear.

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. Grounding electrodes:

1. Metal underground water pipe: Cold water metal piping system: Where the underground cold water service line is metal, indirect contact with the earth for 10 feet or more, the Contractor shall install a grounding electrode conductor from the main incoming cold water line ahead of the meter and extend to the main building reference ground bus in the main electrical room. The electrode shall be sized per NEC/CEC Article 250. Electrode connection should be accessible.

2. Concrete encased grounding electrode (UFER ground): Provide a #2/0 AWG minimum bare copper conductor encased along the bottom of concrete foundation or footings which are in direct contact with the earth and where there is no impervious water-proofing membrane between the footing and the soil. The electrode shall extend through a horizontal length of 30 feet minimum and shall be encased in not less than 2 or more than 5 inches of concrete separating it from surrounding soils. The electrode shall emerge from the concrete slab through a protective non-metallic sleeve and shall be extended to the main building reference ground bus.
3. Supplementary grounding electrode (ground ring, grid and driven rods): Provide, as indicated on the Drawings, driven ground rod(s) installed in listed ground well box(s) and filled with gravel after connection is made. Interconnect ground rod with structural steel and adjacent rods with minimum #4 AWG bare copper conductor. Ground rod shall not be less than 10 foot from any other electrode of another electrical system or from adjacent ground rod(s).

B. Grounding electrode conductor: Provide grounding electrode conductor as indicated on the Drawings or sized per NEC/CEC Article 250, whichever is greater.

C. Power system grounding:
   1. Provide, unless otherwise indicated, a main building power system ground bus mounted on the wall in the main electrical room. Connect the following items using NEC/CEC sized copper grounding conductors to lugs on the main building ground bus:
      a. Grounding conductor from building reference ground bus in main service switchboard.
      b. Bonding conductor to metallic cold water piping system.
      c. Bonding conductor to building structural steel.
      d. Separately derived system grounding conductors in same room.

   2. At the building power system reference ground bus in the main service switchboard, connect the grounding electrode conductor from concrete encased UFER ground or other grounding electrode systems as indicated on the Drawing or herein.

D. Separately derived electrical system grounding:
   1. Ground each separately derived system per requirements in NEC/CEC Article 250 as a minimum, unless greater requirements are required elsewhere in the Contract Documents.

   2. Transformers: Provide a dual rated four or six-barrel grounding lug with a 5/8"-11 threaded hole. Drill enclosure with 11/16" bit and attach lug to enclosure utilizing a torque bolt and a dragon tooth transition washer or equal. Connect the following when present:
      a. Grounding electrode conductor from supplemental ground rods.
      b. Building steel.
      c. Cold water pipe.
      d. Primary feeder ground.
      e. Secondary feeder ground.
      f. Main bond jumper.
      g. Isolated ground conductor.

   3. Where construction of the building does not allow for easy connections to building steel, i.e. concrete constructed building structural system, a separate ground riser system shall be installed within the building. System shall consist of the following:
      a. From main building power system ground bus provide a #2/0 THHN ground conductor in a 1-1/4" conduit to each electrical riser closet and extend up through building to top floor electrical rooms.
b. Pullbox shall be a minimum of 14” x 14” x 6” deep and shall house a 12” wide x 4” high x ¼” thick bus bar on stand-off, mounted to back of pullbox. Furnish complete with cast copper alloy body lugs for connecting grounding system conductors. Attach lugs to bus with appropriate size cadmium bronze bolt, flat washer and Belleville washer. Torque all lug connections.

E. 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.

2. Provide a separate grounding bus at panelboards, switchboards, motor control centers. Connect all metallic enclosed equipment so that with maximum fault current flowing, shall be maintained at not more than 35 volts above ground.

3. Conduit terminating in concentric, eccentric or oversized knockouts at panelboards, cabinets, gutters, etc. shall have grounding bushings and bonding jumpers installed interconnecting all such conduits.

4. Provide bonding jumpers across expansion and deflection couplings in conduit runs, pipe connections to water meters, dielectric couplings in metallic cold water piping system.

5. Provide internal ground wire in flexible conduit connected at each end via grounding bushing.

6. Provide external ground wire wrapped around flexible conduit and terminate to connectors designed for the purpose.

F. Switchgear operating at over 1000 volts, unit substations and generators:

1. Provide a safety grid and/or mat encased in the middle of the concrete pad or floor beneath the switchgear or equipment with bare copper conductor pigtails extending up through slab at both ends of switchgear/equipment, within footprint of gear.

2. The grid/mat shall extend a minimum of 48” beyond the footprint of the equipment on both ends and at the back side of switchgear.

3. The grid/mat shall extend a minimum of 72” beyond the footprint on the front side of switchgear.

4. Terminate the safety grid/mat #1/0 AWG bare copper conductor pigtails to the electrical equipment ground bus within sections at each end of equipment lineup.

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 required herein.

B. Prefunctional testing:

1. Provide Testing Agency with Contract Documents for their review prior to the commencement of ground testing.

2. Visual and mechanical inspection:

a. The Testing Agency shall inspect the grounding electrode and connections prior to concrete encasement, burial or concealment.

b. Check tightness and welds of all ground conductor terminations.

c. Verify installation complies with the intent of the Contract Documents
3. Obtain and record ground resistance measurements both from electrical equipment ground bus to the ground electrode and from the ground electrode to earth. Furnish and install additional bonding and add grounding electrodes as required complying with resistance limits specified under this Section of the Specification.

4. A typewritten record of measured resistance values shall be submitted for review and included with the operation and maintenance manual furnished to the Owner at the time of Project closeout and before certificate of final payment is issued.

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.

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 03: Cast-in-place concrete. Concrete equipment pads.
   2. Division 05: Miscellaneous metals. Hangers for electrical equipment.
   3. Division 09: Ceiling suspension systems. Slack fixture support wires.

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.

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 WOOD SUPPORTS
A. Cut, fit and place wood grounds, nailers, blocking and anchorage accurately in location, alignment and elevation to support and anchor electrical materials and equipment.

3.06 ANCHORAGE

A. All floor mounted, free standing electrical equipment such as transformers, switchboards, distribution boards, motor control centers, 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
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. Intermediate metal conduit and fittings.
4. Electrical metallic tubing and fittings.
5. Flexible metallic conduit and fittings.
6. Liquidtight flexible metallic conduit and fittings.
7. Miscellaneous conduit fittings and products.

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 01: Cutting and patching.
2. Division 07: Sheet metal flashing and trim.

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.

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

3. Underwriters Laboratories, Inc. (UL):
   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.
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. Alflex Corp.
      f. American Flexible Metal Conduit Co.
      g. Anaconda.
   2. Fittings:
      a. Appleton Electric Co.
      b. OZ/Gedney.
      c. Thomas & Betts Corp.
      d. Spring City Electrical Manufacturing Co.
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.
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 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.

2.04 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.

2.05 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.

2.06 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.

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.
B. PVC insulated galvanized rigid steel conduit shall be used in the following applications:
   1. Use 40-mil coating for feeders and branch circuits in damp or wet locations.
   2. Use 20 or 40 mil for feeders and branch circuits concealed in concrete walls or slabs in contact with earth.
   3. Use 20 or 40-mil for runs beneath floor slabs on grade.
   4. Use 40-mil for all below grade penetrations through floor slabs on grade or exterior walls.

C. Intermediate metal conduit (IMC): Shall be used for the same application as galvanized rigid steel conduit as specified herein, except for hazardous locations prohibited by CEC, NEC or Local Codes.

D. 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.

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.

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

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

3.05 PENETRATIONS

A. Locate penetrations and holes in advance where they are proposed in the structural sections such as footings, beams, wall, etc. Penetrations are acceptable only when the following occurs:
   1. Where indicated on the Structural Drawings.
   2. As approved by the Structural Engineer prior to construction and after submittal of Drawing showing location, size and position of each penetration.

B. 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 Structural Engineer as required by limited working space. Obtain the approval of the Structural Engineer prior to drilling through structural sections.
   2. Provide sleeves or “can outs” for cast-in-place concrete floors and walls. Following conduit installation, seal all penetrations using non-iron bearing, chloride free, non-shrinking, dry-pack grouting compounds; or fire rated penetration-sealing materials.
   3. 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.
   4. Provide single piece escutcheon plates around all exposed conduit penetrations in public places.

C. 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.

D. 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 CONCEALED IN CONCRETE

A. Install conduits approximately in the center of the slab so that there will be a minimum of 3/4-inch of concrete around the conduits.

B. Installation of conduit in structural concrete that is less than three inches thick is prohibited. Topping slabs, maintenance pads and curbs are exempted.

C. Tie conduits to reinforcing rods or otherwise secure them to prevent sagging or shifting during concrete placement. Run conduit larger than 1-inch trade size, parallel with or at right angles to the main reinforcement; where at right angles to the reinforcement, the conduit shall be close to one of the supports of the slab.

D. Where nonmetallic conduit or tubing is used, raceways must be converted to PVC coated rigid steel conduit before rising above floor.

E. Make couplings and connections watertight.

F. Protect stub-ups from damage where conduits rise from floor slabs. Arrange so curved portion of bends is not visible above the finished slab.

3.07 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.

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.

3.08 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:

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
SECTION 260533

BOXES

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. Wall and ceiling outlet boxes.
   2. Pull and junction boxes.

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 08: Access doors. Wall and ceiling access doors.

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/National Electrical Manufacturer Association:
      ANSI/NEMA OS-1; Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports.
      ANSI/NEMA OS-2; Nonmetallic Outlet Boxes, Device Boxes, Covers and Box Supports.
      NEMA 250; Enclosures for Electrical Equipment (1000 volts maximum).
   2. Underwriters Laboratories (UL):
      UL 50; Enclosures for Electrical Equipment.
      UL 514A; Metallic Outlet Boxes.
      UL 1773; Termination Boxes.

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.

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.
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. Outlet and junction boxes:
      a. Spring City Electrical Manufacturing Co.
      b. Thomas & Betts Corp.
      c. Raco, Inc.
   2. Cast boxes:
      a. Appleton Electric Co.
      b. Crouse-Hinds.
   3. Pullboxes:
      a. Circle AW Products.

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

2.02 OUTLET BOXES

A. Standard outlet box:
   1. Provide galvanized, one-piece die formed or drawn steel, knockout type box of size and configuration best suited to the application indicated on the Drawings.
   2. 4-inch square by 1-1/2 inch deep shall be minimum box size.
   3. ANSI/NEMA OS 1.

B. Concrete box:
   1. Provide galvanized steel, 4-inch octagon rings with mounting lugs, backplate and adapter ring as required.
   2. Select height as necessary to position knockouts above concrete reinforcing steel.
   3. ANSI/NEMA OS 1.

C. Tile box:
   1. Provide outlet boxes for installation in tile or concrete block walls.
   2. Standard outlet boxes with raised, square corners and device covers are acceptable.
   3. ANSI/NEMA OS 1.

D. Cast metal outlet body:
   1. Provide four inch round, galvanized cast iron alloy with threaded hubs and mounting lugs as required.
   2. Provide boxes with cast cover plates of the same material as the box and neoprene cover gaskets.

E. Conduit outlet body: Provide Cadmium plated cast iron alloy, oblong conduit outlet bodies with threaded conduit hubs and neoprene gasket, cast iron covers.
PULL AND JUNCTION BOXES

A. Sheet metal pull and junction box:
   1. Provide standard outlet or concrete ring boxes wherever possible; otherwise use minimum 16 gauge galvanized sheet metal, NEMA 1 boxes, sized to Code requirements with covers secured by cadmium plated machine screws located 6 inches on centers.
   2. ANSI/NEMA OS 1.

B. Cast metal pull and junction box: Provide standard cast malleable iron outlet or device boxes wherever possible; otherwise use cadmium plated, cast malleable iron boxes with bolt-on, interchangeable conduit hub plates with neoprene gaskets.

C. Flush mounted pullboxes and junction boxes: Provide overlapping covers with flush head cover retaining screws, prime coated.

PART 3 - EXECUTION

3.01 EXAMINATION

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

3.02 PREPARATION

A. Install all outlet boxes flush with building walls, ceilings and floors except where boxes are installed in mechanical and electrical rooms, in cabinetry, above accessible ceilings or where exposed Work is called for on the Drawings.

B. Locate pullboxes and junction boxes in concealed locations above removable ceilings or exposed in electrical rooms, utility rooms or storage areas.

C. Install outlet boxes at the locations and elevations indicated on the Drawings or specified herein. Make adjustments to locations as required by structural conditions and to suit coordination requirements of other trades.

D. Locate switch outlet boxes on the latch side of doorways unless otherwise indicated.

E. Locate outlet boxes above hung ceilings having concealed suspension systems, adjacent to openings for removable recessed lighting fixtures.

F. Do not install outlet boxes back-to-back, separate boxes by at least 6". In fire rated walls separate boxes by at least 24" and wall stud.

G. Adjust position of outlet boxes in finished masonry walls to suit masonry course lines. Coordinate cutting of masonry walls to achieve neat openings for boxes.

3.03 INSTALLATION

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

B. Locate electrical boxes as indicated on Drawings and as required for splices, taps, wire pulling, equipment connections and Code compliance.

C. Install junction or pullboxes where required to limit bends in conduit runs to not more than 360 degrees or where pulling tension achieved would exceed the maximum allowable for the cable to be installed. Note that these boxes are not indicated on the Drawings.
D. Install raised covers (plaster rings) on all outlet boxes in stud walls or in furred, suspended or exposed concrete ceilings. Covers shall be of a depth to suit the wall or ceiling finish.

E. Leave no unused openings in any box. Install close-up plugs as required to seal openings.

F. Provide cast metal boxes with gasketed cast metal cover plates where boxes are exposed in damp or wet locations.

G. Provide an access panel in permanent ceiling or wall where boxes are installed and will be inaccessible.

H. For boxes mounted in exterior walls, make sure that there is insulation behind outlet boxes to prevent condensation in boxes.

I. For outlets mounted above counters, benches or backsplashes, coordinate location and mounting heights with built-in units. Adjust mounting height to agree with required location for equipment served.

J. Use conduit outlet bodies to facilitate pulling of conductors or to make changes in conduit direction only. Do not make splices in conduit outlet bodies.

K. Add additional sheet rock as necessary to maintain original fire rating of walls where boxes are installed.

L. Install galvanized steel coverplates on boxes in unfinished areas, above accessible ceilings and on surface mounted outlets.

3.04 SUPPORTS

A. Provide boxes installed in metal stud walls with brackets designed for attaching directly to the studs or mount boxes on specified box supports.

B. Mount boxes, installed in suspended ceilings of gypsum board or lath and plaster construction, to 16 gauge metal channel bars attached to main ceiling runners.

C. Support boxes independently of conduit system.

D. Support boxes, installed in suspended ceilings supporting acoustical tiles or panels, directly from the structure above wherever pendant mounted lighting fixtures are to be installed from the box.

E. Support boxes, mounted above suspended acoustical tile ceilings, directly from the structure above.

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. Warning and caution signs.
7. 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 LEGEND PLATES
A. Type LP: Die-stamped metal legend plate with mounting hole and positioning key for panel mounted operator devices, i.e. motor control pilot devices, hand-off-auto switches, reset buttons, etc.
B. Stamped characters to be paint filled.

2.04 BRASS TAGS
A. Type BT: Metal tags with die-stamped legend, punched for fastener.
B. Dimensions: 2" diameter 19 gauge.

2.05 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).

2.06 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.

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

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

2.09 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.
   2. Engraving:
      a. 1/8" high letters.
b. Paint filled letters finished in black.

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:
   a. Equipment designations shall conform to the following:
      1) Power source:
         a) Normal - __
         b) Emergency – E
         c) UPS – U
      2) Equipment description:
         a) Primary substation – PS
         b) Secondary substation – SS
         c) Main switchboard – MS
         d) 277/480 volt distribution board – HD
         e) 277/480 volt panelboard – H
         f) 120/208 volt distribution board – LD
         g) 120/208 volt panelboard – L
         h) Transformer – TX
         i) Motor control center – MCC
      3) Floor number where equipment is located – 3
      4) Equipment designation – B
   b. Example: EHD2A
      1) Emergency source.
      2) 277/480 volt distribution board.
      3) 2nd floor.
      4) Board designation A
2. Amperage, KVA or horsepower rating, where applicable.

3. Voltage or signal system name.

4. Source of power or control.

5. Examples:
   a. Boards: EHD2A; 1200A; 277/480V, 3PH, 4W; Served from: ATS1A
   b. Transformers: ETX2A; 150KVA; 480V pri. - 120/208V, 3PH, 4W sec.; Served from: 06EHD2A; Load Served: 06EL2A
   c. Motor Control Centers:
      1) Main nameplate: MCC1A; 600A Main Bus; 480V,3PH,3W; Served from HD1A
      2) Each compartment: EF-1; 20 HP; 100A Switch; Size 1 Starter
   d. Disconnects or Individual Motor Starters: EF-1; 20HP; 480V,3PH,3W; Served from MCC1A

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.

E. Minimum letter height shall be as follows:
   1. For panelboards, switchboards, battery panels motor control center, 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 panelboards, switchboards and motor control centers 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 LEGEND PLATES
   A. Provide panel-mounted operators devices such as pilot lights, reset buttons, “HAND-OFF-AUTO” switches, etc.

3.04 BRASS TAGS
   A. Provide type BT tags for individual ground conductors to exposed ground bus indicating connection i.e. "UFER", "Cold water bond", etc.
   B. Provide tags for all feeder cables in underground vaults and pull boxes.
   C. Provide tags for empty conduits in underground vault, pull boxes and stubs.

3.05 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.

3.06 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.

3.07 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.

3.08 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.

3.09 WARNING, CAUTION AND INSTRUCTION SIGNS
A. Provide warning, caution or instruction signs where required by NEC, where indicated or where reasonably required to assure safe operation and maintenance of electrical systems and of the items to which they connect. Install engraved plastic laminated instruction signs with approved legend where instructions or explanations are needed for system or equipment operation. Install butyrate signs with metal backing for outdoor items.
B. Emergency Operating Signs: Install engraved laminate signs with white letters on red background with minimum 3/8 inch high lettering for emergency instructions on power transfer, load shedding or other emergency operations.

3.10 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. Outlets in surface raceways.
c. Multi-ganged (four or more) switch arrangement.
d. Special purpose switches, i.e. projection screens, shades, exhaust fans, etc.
e. Telecommunication outlets.

2. Type-on-tape inscriptions shall be provided for the following devices:
   a. Receptacles.
   b. Outlets in surface raceways.
   c. Telecommunication outlets.

3. Engraved inscriptions shall be provided for the following devices:
   a. Multi-ganged switches.
   b. Special purpose switches.

4. 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
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 panelboards.
   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.
   FS W-S-865; Enclosed Knife Switch.

2. National Electrical Manufacturers Association (NEMA):
   NEMA AB 1; Molded Case Circuit Breakers.
   NEMA KS 1; Enclosed Switches.
   NEMA PB 1; Panelboards.
   NEMA PB 1.1; Instructions for safety instruction, operation and maintenance of panelboard rated 600 volts or less.
   NEMA PB 1.2; Application Guide for Ground-Fault Protective Devices for Equipment.

3. Underwriters Laboratories, Inc. (UL):
   UL 67; Panelboards.
   UL 363; Knife Switches.
   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.
   UL 870; Wireways, Auxiliary Gutters and Associated Fittings.

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

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.
   4. Riser gutter shall be sized for feeder and requirements of NEC. Refer to feeder schedule on Drawings for conductor sizes and quantities.
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 and 14,000 AIC for 277/480 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 42 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.

2. If indicated on the Panelboard Schedules and/or Electrical Drawings provide contactors, relays, time clocks, etc. mounted within panelboard enclosure. Enclosure shall be fabricated such that circuit breaker portion of panel and contactor section shall have separate, lockable, hinged doors.

E. Overcurrent protective devices:

1. Refer to Section 262816: Overcurrent Protection Devices.

2. Overcurrent protective devices shall be molded case circuit breakers assemblies where indicated on panelboard schedules or Electrical Drawings.

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

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

C. 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.

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. Provide four 3/4” spare conduits stubbed-out of flush mounted panelboards to nearest accessible ceiling space.

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

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

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

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

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

3.03 FIELD QUALITY CONTROLS

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 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. 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 system is 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 power connections.
   e. Check that all covers, barriers and doors are secure.

3. 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.

F. 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.

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

H. 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
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. Hinged cover enclosures.
   2. Cabinets.
   3. Terminal blocks and accessories.

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. National Electrical Manufacturer's Association (NEMA):
      - NEMA 250; Enclosures for Electrical Equipment.
      - NEMA ICS 1; Industrial Control and Systems.
      - NEMA ICS 4; Terminal Blocks and Industrial use.
      - NEMA ICS 6; Enclosures for Industrial Controls and Systems.
   2. Underwriters Laboratories (UL):
      - UL 50; Enclosures for Electrical Equipment.
      - UL 65; Standards for Wired Cabinets.
      - UL 1059; Terminal Blocks.
      - UL 1773; Termination Boxes.

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 Project construction, material, finish and any specific features of each component.
   3. Clearly mark on each data sheet the specific item(s) being submitted and the proposed application.
   4. Submit Manufacturer's installation instructions.
   5. Shop Drawings: Indicating wiring diagrams and equipment arrangement within cabinets.
6. Furnish structural calculations for equipment anchorage as described in Section 260010: Basic Electrical Requirements.

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.

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. Circle AW Products.

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

2.02 CABINETS AND ENCLOSURES

A. Construction: Shall be code gauge galvanized steel with standard concentric knockouts for conduit terminations. Size shall be as indicated on Drawings. Cabinet shall be NEMA 250 Type 1.

B. Finish: Manufacturer's standard gray baked enamel finish.

C. Covers: Continuous hinged steel door, lockable and keyed to match panelboard locks.

D. Mounting:
   1. Flush cabinets shall be furnished with concealed trim clamps and shall be not less than 4 inches deep.
   2. Surface cabinets shall be furnished with screw cover trim, flush hinged door and shall not be less than 6 inches deep.

2.03 BACKBOARDS

A. Furnish cabinet with 3/4-inch fire retardant plywood mounting backboard on interior unless otherwise indicated on Drawings.

2.04 TERMINAL BLOCKS AND ACCESSORIES

A. Terminal blocks: NEMA ICS 4; UL listed.

B. Power terminals: Unit construction type, closed-back with tubular pressure screw connections, rated 600 volts.

C. Signal and control terminals: See terminal strips in Section 260519: Building Wire and Cable.

D. Identification: Identify terminal strips with permanent numbers.

E. Wiring diagram: Provide wiring diagram in protective pocket on inside front cover of cabinet. Diagram shall indicate control wiring, connections and layout of components within enclosure.

PART 3 - EXECUTION
3.01 EXAMINATION
   A. Contractor shall thoroughly examine Project site conditions for acceptance of cabinets and enclosures installation to verify conformance with Manufacturer and Specification tolerances. Do not commence with installation until all conditions are made satisfactory.

3.02 INSTALLATION
   A. Set cabinets and enclosures plumb and symmetrical with building lines. Furnish and install all construction channel bolts, angles, etc. required to mount all equipment furnished under this Section of the Specifications.
   B. Cabinets and enclosures shall be anchored and braced to withstand seismic forces calculated in accordance with that referenced in Section 260010: Basic Electrical Requirement.
   C. "Train" interior wiring, bundle and clamp using specified plastic wire wraps.
   D. Replace doors or trim exhibiting dents, bends, warps or poor fit that may impede ready access, security or integrity.
   E. Terminate conduit in cabinet with lock nut and grounding bushing.
   F. Terminate wiring on terminal blocks and identify each with heat shrink tags.

3.03 CLEANING
   A. Touch-up paint any marks, blemishes or other finish damage suffered during installation.
   B. Vacuum clean cabinet on completion of installation.

   END OF SECTION
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. Fuses.
   2. Fused switches.

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.
   FS W-F-870; Fuseholders (for Plug and Enclosed Cartridge Fuses).
   FS W-S-865; Enclosed Knife Switch.

2. Underwriters Laboratories, Inc. (UL):
   UL 98; Dead-Front Switches.
   UL 248(1-16); Low-Voltage Fuses.
   UL 489; Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures.
   UL 512; Fuseholders.

3. National Electrical Manufacturer Association (NEMA):
   NEMA AB 1; Molded Case Circuit Breakers.
   NEMA KS 1; Enclosed Switches.

4. Pacific Gas & Electric (PG&E) – Section G2 – Protection and Control Requirements for Generation Entities - Power Generation Interconnection Handbook:
   Paragraph G2.14; Emergency Generator Requirements
   Table G2-5; Section G2 – Protection and Control Requirements for Generation Entities document.

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. Submit Manufacturer's installation instructions.

7. Complete bill of material listing all components.

8. Warranty.

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. Parts list and part numbers.

4. Telephone numbers for authorized parts and service distributors.

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.

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. Fuses:
   a. Bussmann Division, Cooper Industries.
   b. Gould Shawmut Co.

2. Fused switches switches:
   b. General Electric.
   c. Siemens/I-T-E.
   d. Square D.

3. Circuit breakers:
   b. General Electric.
   c. Siemens/I-T-E.
   d. Square D.

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

2.02 FUSES

A. General: All power fuses shall be time-delay, high interrupting (300 K AIC), current limiting type, unless otherwise noted on the Drawings. All fuses shall be the product of a single Manufacturer and shall be selectively coordinated when applied in 2:1 ratios. Types of fuses shall be as follows:

1. 0 - 600 amperes: UL Class J, dual element, time delay type fuse with separate overload and short-circuit elements. The fuse shall hold 500% of rated current for a minimum of 10 seconds.

2. 601 - 4000 amperes: UL Class L, time delay type fuses with 99.9% pure silver fuse links and "O-rings" to seal between the end bells and the fuse barrel. Fuses shall hold 500% of rated current for a minimum of 4 seconds, clear 20 times rated current in 0.01 seconds or less.

3. Motor branch circuit fuses (0-600 amperes): UL Class J dual element, time delay type fuse. Motor branch circuit fuses shall be sized for Type 2 coordination for the motor controller and back-up motor overload protection and shall be coordinated with motor starter overload relay heaters. See Section 262900: Motor Controls.

B. Control and instrument fuses shall be suitable for installing in blocks or fuseholders. Exact type and rating shall be as recommended by the Manufacturer of the equipment being protected.

C. Fuses for installation in current limiting circuit breakers or motor circuit protectors shall meet the specific requirements of the Manufacturers of that equipment to ensure compatibility.

2.03 FUSED SWITCHES
A. General: This Section covers fused switches for mounting in switchboards and distribution boards for sizes 30 amp through 800 amp.

B. Fusible switches shall be quick-make, quick-break of the sizes indicated on the Drawings. The units shall be listed and approved by Underwriters' Laboratories and, where applicable shall be dual horsepower rated for both standards one-time or dual element uses.

C. Fusible switches shall be group mounted in switchboards. Each switch is to be enclosed in a separate steel enclosure. The enclosure shall employ a hinged cover for access to the fuses. Incorporate safety cover interlocks to prevent opening the cover with the switch in the "ON" position or prevent placing the switch in the "ON" position with the cover open. This interlock shall be constructed so that it can be released with a standard electrician's tool for testing fuses without interrupting service.

D. Provide handles with provisions for padlocking and shall clearly indicate the "ON" and "OFF" positions. Provide front cover doors capable of being padlocked in the closed position.

E. Switches shall pass industry standard I2t withstand tests and fuse race tests.

F. Fusible switches shall be suitable for use on circuits having available fault currents as of 200,000 RMS symmetrical amperes.

G. Furnish fusible switches 30 amperes through 600 amperes frames with rejection type fuse clips. Furnish fusible switches 800 amperes through 1200 amperes with Class L fuse clips.

H. Switches 400 amperes through 1200 amperes shall be designed to accommodate UL listed shunt trip. Where indicated on the Drawings, provide the following accessories:
   1. UL listed 120 VAC shunt trip.
   2. Zero sequence ground protection system including test panel. Ground fault shall include separate time and current pick-up adjustments.

2.04 MOLDED CASE CIRCUIT BREAKERS

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

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 or if not indicated, not less than 14,000 RMS symmetrical amps for 480 volt systems and 10,000 RMS symmetrical amps for 208 volt systems.

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 rated for aluminum or copper wire.

H. Circuit breakers with trip 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 trip ratings 101 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 trip ratings 401 amps through 1200 amps shall have electronic trips with the following characteristics:
   1. Electronic true RMS sensing trip, adjustable via current plug.
   2. Adjustable long time setting and delay.
   3. Adjustable short time pick-up and delay.
   4. Adjustable instantaneous pick-up.
   5. Mechanical targets on overload, ground fault and short circuit.

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.

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. A fuse identification label shall be placed inside the door of each fused switch. Each label shall show fuse type, ampere rating and Manufacturer.

C. 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.

D. 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 NEC and NEMA standards for installation.

E. 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.

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 system is 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. Determine that circuit breaker will trip under overcurrent condition, with tripping time in conformance with NEMA AB 1 requirements.
   c. Test all circuit breakers with frame size 225 amps and larger and 10 percent of all circuit breakers with frame sizes less than 225 amps in each panelboard, distribution board, switchboard, etc. unless otherwise noted.

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.

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
SECTION 262819

DISCONNECT SWITCHES

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. Disconnect Switches.

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 on specified:
   1. Federal Specifications (FS):
      FS W-F-870; Fuseholders (for plug and enclosed cartridge fuses).
      FS W-S-865; Switch, Box (enclosed), Surface-Mounted.
   2. National Electrical Manufacturer Association (NEMA):
      NEMA KS 1; Enclosed Switches.
   3. Underwriters Laboratories, Inc. (UL):
      UL 512; Fuseholders.

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. As a minimum the following characteristics shall be indicated:
      a. NEMA types.
      b. Current rating.
      c. Number of poles.
      d. Fuse provisions.
      e. Enclosure dimensions.
      f. Voltage.
      g. Horsepower rating (if applicable).
      h. Short circuit rating.
   3. Clearly mark on each data sheet the specific item(s) being submitted and the proposed application.
4. Submit Manufacturer's installation instructions.

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.

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 DISCONNECT SWITCHES

A. Description: Provide NEMA heavy-duty type switches with dead front construction and padlock provisions for up to three locks in the “OFF” position.

B. Switch interior: Provide switch with switchblades that are fully visible in the “OFF” position when the door is open. Provide UL listed lugs for copper conductors, lugs to be front removable. Provide plated current carrying part.

C. Switch mechanism: Provide switches with a quick-make, quick-break, position indicating, operating handle and mechanism and a dual cover interlock to prevent unauthorized opening of the switch door in the “ON” position or closing of the switch mechanism with the door open. Furnish an electrical interlock to de-energize control wiring when the disconnect switch is opened.

D. Enclosures: Provide switches with hinged cover in NEMA 1 general purpose, sheet steel enclosure for dry locations and NEMA 3R weatherproof galvanized enclosures for exterior, damp or wet locations, unless otherwise noted on the Drawings. Provide an enclosure treated with a rust-inhibiting phosphate primer and finished in gray baked enamel.

E. Ratings: Provide switches that are horsepower rated for 240 VAC or 600 VAC as required for the circuit involved and that meet “I-SQUARED-T” requirements. Fusible switches to have provisions for the types of fuses specified in Section 262816: Overcurrent Protective Devices. UL listed short circuit rating, when equipped with fuses to be 200,000 amperes RMS symmetrical. Furnish with provisions for RK-1 fuses for switches up to 600 amps. 800 amp switches and larger to have provisions for Class L fuses.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Contractor shall thoroughly examine Project site conditions for acceptance of disconnects switch 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 locations of switches and equipment in the field to provide code required clearances in front of switches and to ensure that switches are insight of the controller as described in NEC Article 430.

3.03 INSTALLATION
A. Install disconnect switches where indicated on the Drawings.
B. Install fuses in fusible disconnect switches.
C. Include construction channel and mounting hardware as required to support disconnect switch.

3.04 IDENTIFICATION
A. Provide engraved, machine screw retained type 'NP' nameplate on each disconnect switch. See Section 260553: Electrical Identification.

3.05 CLEANING
A. Upon completion of Project prior to final acceptance the Contractor shall thoroughly clean both the interior and exterior of enclosure of all construction debris, scrap wire, paint splatters, dirt, etc.

END OF SECTION
SECTION 263633

AUTOMATIC STATIC TRANSFER SWITCH

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. Automatic Static Transfer Switch (ASTS).

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. American National Standards Institute, Inc. (ANSI):

2. Federal Specifications (FS):

3. National Electrical Manufacturer Association (NEMA):
   NEMA ICS 1; General Standards for Industrial Control and Systems.
   NEMA ICS 2; Standards for Industrial Control Devices, Controllers and Assemblies.
   NEMA ICS 4; Terminal Blocks.
   NEMA ICS 6; Enclosures for Industrial Controls and Systems.

4. Underwriters Laboratories, Inc. (UL):
   UL 467; Grounding and Bonding Equipment.
   UL 468A; Wire Connectors and Wiring Lugs for Use with Copper Conductors.

1.03 SYSTEM DESCRIPTION

A. System operation:

1. The ASTS shall be a three-pole, double-throw, solid-state, automatic transfer switch that is fed from two AC power sources. One source shall be designated as the preferred source while the other is the alternate source. Selection of which input source is preferred shall be user selectable from the operator control panel. All transfers shall be a fast break-before-make with no overlap in conduction from one source to the other. All transfers, including sense and transfer times, shall have less than a 1/4 cycle interruption in power to the load.

2. Normal mode:
   a. In normal operation, the load shall be connected to the preferred source as long as all phases of the preferred source are within the acceptable limits. Upon failure of the
preferred source, the load shall be transferred to the alternate source until such time as the preferred source returns to within the acceptable limits.

b. Transfer voltage limits shall be +/- 10% of the nominal input voltage for steady state conditions, with low voltage transfer limits having an inverse time relationship that is within the IEEE Std. 446 computer voltage tolerance envelope.

c. After the preferred source returns to within the acceptable voltage limits for at least the preset adjustable retransfer time delay (typically 3 seconds) and is in phase with the alternate source, the load shall be retransferred automatically to the preferred source. The automatic retransfer to the preferred source can be disabled if so selected by the user from the operator control panel. When the automatic retransfer is disabled, emergency transfer from the alternate source to the preferred source shall not be disabled upon alternate source failure.

3. Load current inhibit:
   a. The ASTS shall sense the load current and, if the load current exceeds an adjustable preset level deemed to represent a load inrush or fault condition, the ASTS shall disable the automatic transfer even if the voltage on the selected source exceeds the transfer limits.

   b. The load current transfer inhibit shall be automatically reset after the current returns to normal to allow for continued protection against a source failure.

4. Manual transfer:
   a. The ASTS shall allow manually initiated transfers between the two sources, providing the alternate source is within acceptable voltage limits and phase tolerances with the preferred source. Allowable phase differences between the sources for manually initiated transfers shall be adjustable from the operator control panel.

   b. The ASTS shall be capable of tolerating transfers up to 180 degrees out of phase for emergency conditions. However, the user-adjustable phase synchronization window shall be limited to +/- 30 degrees.

   c. If the transfer is manually initiated, the ASTS shall transfer between the two sources without interruption of power to the load greater than 1 millisecond provided that both sources are available and synchronized within the user-adjustable phase synchronization window.

   d. For sources where the two frequencies are not exactly the same, as would be the case between a utility and standby generator source, manually initiated transfers shall be delayed by the ASTS until the two sources are within the user-adjustable phase synchronization window.

5. Emergency transfer: In an effort to maintain power to the load, upon loss of the source that the load is connected to, the ASTS shall automatically transfer to the other source in less than 1/4 cycle, overriding any retransfer time delays or other inhibits except load overcurrent providing that the other source is available.

6. SCR failure:
   a. The ASTS shall continuously monitor the status of the SCR switching devices for proper operation.

   b. In the event of a shorted SCR on the source powering the load, the ASTS shall automatically alarm the condition and trip open the other source isolation breaker.
c. In the event of a shorted SCR on the other source, the ASTS shall automatically alarm the condition and trip open the other source isolation breaker.

d. In the event of an open SCR, the switch shall automatically alarm the condition, transfer to the other source and trip open the previous source isolation breaker.

e. All open and shorted SCR alarm conditions shall be latched and require the system to be repaired and reset to restore normal operation.

7. Maintenance bypass:
   a. The ASTS shall be furnished with key-interlocked maintenance bypass breakers which allow the ASTS electronics to be bypassed to either input source for maintenance without interruption of power to the load.
   b. The packaging of the ASTS shall have all electronics isolated from the input, output and bypass connections to allow safe servicing of any components without access to hazardous voltages when the unit is in maintenance bypass.

B. Electrical requirements:
   1. Nominal input voltage: 480 volts three phase, 60 Hz, 3-wire-plus-ground.
   2. Maximum continuous current: 400 amp or 600 amp as indicated on Drawings.
   3. Load power factor range: 0.5 to 1.0, leading or lagging.
   4. Load crest factor: Up to 3.5.
   5. Source voltage distortion: Up to 10% THD with notches and ringing transients.
   6. Overload capability: 125% for 2 hours, 150% for 15 minutes, 1000% for 2 cycles minimum.
   7. Short circuit withstand capability: Up to 65,000 symmetrical amps at 480 volts.

C. Environmental requirements:
   1. Storage temperature range: -40° to +80°C
   2. Operating temperature range: 0° to 40°C.
   3. Relative humidity: 0 to 95% without condensation.
   4. Operating altitude: Up to 4000 feet above sea level without derating.
   5. Storage/transport altitude: Up to 40,000 feet above sea level.
   6. Audible noise: Less than 55 dBA at 5 feet (with audible alarm off).

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. Describe system 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. Shop Drawings to include:
a. Provide one line diagram showing all interconnections of major components.
b. Schematic wiring diagrams of all control and alarm systems.
c. Front, plan and side view elevations with overall dimensions.
d. Conduit entrance locations and requirements.
e. Electrical characteristics including voltage, frame size and trip rating and withstand ratings.

5. Submit Manufacturer's installation instructions.
6. Complete bill of materials listing all components.
7. Warranty.

B. Dimensions and configurations of ASTS components shall conform to the space allocated on the Drawings. The Contractor shall submit a revised layout if the equipment furnished varies in size from that indicated on Drawings for Engineer's approval.

1.05 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 part numbers.
4. Pictorial and schematic Electrical Drawings of wiring systems, including operating and safety devices, control panels, instrumentation and annunciators.
5. Telephone numbers for the authorized parts and service distributors.
6. Include all service bulletins and torque Specifications for all terminations.
7. Final testing report.

1.06 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.

1.07 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Delivery: ASTS 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 shipping 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 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 components damage, breakage, denting and scoring. Damaged units shall not be installed. Replace damaged units and return equipment to Manufacturer.
1.08 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.
B. This warranty is part of the pre-purchasing agreement and is in addition to the Contractor's warranties.

1.09 SYSTEM START-UP
A. Upon completion of installation, a factory trained dealer service representative shall perform initial start-up of the ASTS’s. Sufficient time shall be allowed to properly check the system out and perform required minor adjustments before the Engineer's witnessed test shall begin.

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

2.02 COMPONENTS
A. Frame and enclosure:
   1. The complete ASTS shall be housed in a free-standing, NEMA 1 enclosure consisting of a welded steel frame with removable exterior panels of the same depth, height and construction as the PDU’s. This to allow direct attachment to the PDU frame without intermediate side panels and utilize the side panel of the PDU for the ASTS side panel. A tool shall be required to remove exterior panels that expose hazardous voltages. All removable panels shall be grounded to the frame for safety and EMI/RFI protection. The frame shall include four heavy duty swivel castors for ease of installation and four permanent leveling feet for final installation. The frame shall be protected with a paint process to provide superior protection against rust or corrosion. Exterior panels shall be powder-painted with a textured enamel finish. The color of the exterior panels shall match the PDU paint finish.
   2. The ASTS shall utilize convection air cooling for the enclosure with forced air cooling of the heat sinks. All fans shall be redundant. Heat rejection shall be through screened protective openings in the top and bottom of the unit. Removable conduit termination plates shall be provided in the top and bottom of the unit for termination of the two source input conduits or raceways and/or the output conduits or raceways.
   3. The complete ASTS shall have maximum dimensions of 18” up to 200 amps, 30” up to 480 amps and 74” up to 960 amps in width by 32” in depth by 68” in height. The distributed floor weight shall be less than 250 lbs per square feet. The required service access shall be at the front and rear of the unit only.
B. Disconnect switches:
   1. The ASTS shall be equipped with 6 molded case, plug-in, non-automatic circuit breakers. The breakers shall be UL listed for use up to 600 VAC. The plug-in feature of the
breaker shall include an interlock which prevents the breaker from being unplugged without being in the “Off” (open) position.

2. Two of the breakers shall provide input power to the solid-state switching devices. Two parallel output breakers shall be provided. Two of the breakers shall provide for maintenance bypassing of the solid-state switching devices to either input source.

3. Kirk-Key interlocks shall be provided on the breakers to prevent improper maintenance bypassing of the solid-state switch. A bypass breaker can not be closed unless the solid-state switch is connected to the same input source and only one bypass breaker can be closed at a time.

4. All breakers shall be equipped with N.O. and N.C. auxiliary contact switches for monitoring of the breaker positions. The two input breakers for the solid-state switching devices also shall be equipped with 48 VDC shunt trips to allow for control by the ASTS logic.

C. Input surge suppression:

1. The ASTS shall be equipped with two high energy, UL 1449 and UL 1283 listed, Transient Voltage Surge Suppressors (TVSS), one connected to each input for maximum surge suppression.

2. Each TVSS shall consist of multiple metal oxide varistor (MOV) arrays with the MOV’s having their clamping voltages matched to within 1% and arranged for surge current sharing.

3. Each MOV shall be individually fused to protect against MOV failure while still allowing rated surge current to flow without fuse operation. The fuses shall have an interrupting capacity of at least 100 kA at 480 VAC.

4. Each array shall withstand at least 1250 IEEE C62.41 category C3 surges (20 kV, 10 kA) without failure.

5. Each TVSS shall have a total surge current capacity of 80 kA per phase based on a standard 8 x 20 microsecond surge waveform.

6. Each TVSS shall also provide electrical noise attenuation of 50 dB from 100 kHz to 100 MHz based on MIL 220A and 50 ohm impedance.

D. Operator control panel:

1. A mimic/control panel shall be provided for operator interface with the ASTS. The mimic/control panel shall be located on the front of the unit behind the hinged front door. A menu-driven, backlit, 640 x 200 full graphics Liquid Crystal Display (LCD) shall be used to display system information, status information, a one-line diagram of the ASTS, active alarms and alarm history information.

2. The mimic panel screen shall indicate the power flow, the status of all molded case disconnect switches, the preferred source, the ASTS position (connected to source 1 or 2) as well as active alarms. The voltages and currents of all three phases of both sources, both source frequencies, output kVA, output kW, the number of switch transfers and active alarms shall be monitored and displayed simultaneously as part of the mimic panel screen.

3. All voltages and currents shall be measured using true-RMS techniques for accurate representation of non-sinusoidal waveforms associated with computers and other electronic loads.
4. The following alarm conditions shall be monitored and annunciated by the monitoring system. An audible alarm shall be activated when any of the alarms occurs. All alarms shall be displayed in text form:

<table>
<thead>
<tr>
<th>Alarm Condition</th>
<th>Source 1</th>
<th>Source 2</th>
<th>Source 1</th>
<th>Source 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source 1 Failure</td>
<td>Shorted SCR1</td>
<td>Source 1 Breaker Open</td>
<td>Source 1 Breaker Open</td>
<td>Source 1 Breaker Open</td>
</tr>
<tr>
<td>Source 2 Failure</td>
<td>Shorted SCR2</td>
<td>Source 2 Breaker Open</td>
<td>Source 2 Breaker Open</td>
<td>Source 2 Breaker Open</td>
</tr>
<tr>
<td>Sources Out of Sync</td>
<td>Open SCR1</td>
<td>Output Breaker 1 Open</td>
<td>Output Breaker 2 Open</td>
<td>Output Breaker 2 Open</td>
</tr>
<tr>
<td>Over/Under Frequency</td>
<td>Open SCR2</td>
<td>Bypass Breaker 1 Closed</td>
<td>Bypass Breaker 2 Closed</td>
<td>Bypass Breaker 2 Closed</td>
</tr>
<tr>
<td>Fan Failure</td>
<td>Auto Retransfer Failed</td>
<td>Bypass Breaker 2 Closed</td>
<td>Bypass Breaker 2 Closed</td>
<td>Bypass Breaker 2 Closed</td>
</tr>
<tr>
<td>Unit Overtemp</td>
<td>Output Overload</td>
<td>Transfer Inhibit</td>
<td>Transfer Inhibit</td>
<td>Transfer Inhibit</td>
</tr>
<tr>
<td>Power Supply Fault</td>
<td>Source 1 Overload Xfr Inhibit</td>
<td>Logic Failure</td>
<td>Logic Failure</td>
<td>Logic Failure</td>
</tr>
<tr>
<td>Control Fuse Open</td>
<td>Source 2 Overload Xfr Inhibit</td>
<td>Logic Failure</td>
<td>Logic Failure</td>
<td>Logic Failure</td>
</tr>
</tbody>
</table>

5. Pushbutton switches shall be provided for operator interface to the LCD control panel for menu selection, control of the preferred source, manual transfer initiation, auto/manual retransfer selection and other system setpoints. In addition, switches shall be provided for the audible alarm silence and reset. To facilitate ASTS operation, step-by-step start-up, transfer and maintenance bypass procedures shall be displayed on the LCD screen. For manual transfers, a synescoppe shall display the leading or lagging real-time phase difference between the two input sources.

6. To facilitate diagnostics, an event history log of the last 128 alarm events and 64 frames of unit status frozen upon alarm conditions shall be stored in non-volatile memory and displayable on the LCD. A system calendar and clock shall be included to time-stamp all stored events. Monitored parameters shall be acquired two times per 4 millisecond frame.

7. For remote monitoring by the BMS system, a serial RS-232 port shall provide present switch status information, alarm history information and the history of status screens that are triggered upon a major alarm event.

2.03 SOURCE QUALITY CONTROL

A. Verification of performance:

1. The ASTS shall be inspected and tested in the Manufacturer's plant to demonstrate achievement of the system's objectives and for full compliance with the requirements of the Contract Documents.

2. The acceptance test shall be conducted in accordance with a detailed in-plant test procedure, which shall be approved by the Engineer. Tests shall include those specified below and such other tests as are deemed necessary to assure a satisfactory and compliant system. Furnish two certified copies of all test data and results. Give minimum of 15 days advance notice of the test schedule. The Engineer reserves the right to witness the tests. All equipment, devices and instrumentation required for conducting the tests shall be furnished.

3. Voltage and frequency measuring instruments shall be of the recording type and shall provide permanent strip chart records. Strip charts shall be properly identified and annotated and photocopied of it shall be included with the test data submittal.

4. The inspection and functional no-load test shall be conducted to determine that switches, status lights, LCD, alarm lights, audible alarm and all other operational characteristics of the ASTS are functioning and are in accordance with Specification requirements.

PART 3 - EXECUTION
3.01 EXAMINATION
   A. Contractor shall thoroughly examine Project site conditions for acceptance of ASTS 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 ASTS in accordance with Manufacturer's written instructions, as indicated on the Drawings and as specified herein.
   B. All equipment will be constructed to withstand forces generated by earthquake motions. As a minimum, equipment and equipment frames shall be designed to withstand a force of 50% of the weight of the equipment and frame acting at its center of gravity. Anchorage of the equipment and/or frame to the structure will be for a force of 100% gravity also acting at the center of gravity.
   C. Capacitors shall be mounted in frames with necessary spacers and hold-down clips to withstand a .5G lateral force without shifting of capacitors or damage to termination fittings.

3.03 FIELD QUALITY CONTROL
   A. Manufacturer's field service: Contractor shall arrange and pay for the services of a factory-authorized service representative to supervise the initial start-up, pretesting and adjustment of the UPS system.
   B. Services included in Pre-Purchasing Agreement:
      1. Manufacturer's field service: Contractor shall coordinate the services of a factory-authorized service representative to supervise the initial start-up, pretesting and adjustment of the ASTS. Cost for this service are included in the Owner’s pre-purchase agreement.
      2. Infrared scans shall be performed by Liebert under the pre-purchasing agreement.
      3. Manufacturer shall provide all tools, labor, load bank and load bank cables to perform the performance tests on the ASTS as described below.
   C. 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 ASTS 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. Field test all circuit breakers.
      4. Prepare final test report including results, observations, failures, adjustments and remedies.
      5. Apply label on ASTS upon satisfactory completion of tests and results.
      6. Verify ratings and settings and make final adjustments.
   D. At least three weeks prior to any testing, notify the Engineer so that arrangements can be made for witnessing tests, if deemed necessary. All pretesting shall have been tested satisfactorily prior to the Engineer's witnessed test.
E. 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.

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

G. Prefunctional testing:
   1. Provide Testing Agency with Contract Documents and Manufacturer instructions for installation and testing.
   2. Pretesting:
      a. Upon completing system installation, align and adjust the system and perform complete pretesting to determine conformance with the requirements of the Contract Documents. Correct any deficiencies observed in the pretesting. Replace all malfunctioning or damaged items and retest until satisfactory results are achieved.
      b. Insulation resistance tests of all buses, components, feeders, branch circuits and control circuits.
      c. Continuity tests of circuits.
      d. Provide Testing Agency with Contract Documents and Manufacturer's instructions for installation and testing.
   3. 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.
      f. Verify that overcurrent protective devices meet specified requirements.
      g. Verify key interlock operation.
   4. Electrical tests:
      a. Operational test: Perform an operational test to verify conformance of system performance and conditions to Contract Document within Manufacturer's tolerances.
      b. Insulation resistance: 1000 volt DC tests for one minute on all 600 volt and lower rated equipment, components, buses, feeders, 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.
      c. Ground resistance: Test resistance to ground of system and equipment ground connections.
      d. Test overcurrent protective devices.

H. Functional performance testing:
   1. ASTS Manufacturer’s field service representative shall provide all tools, labor and load bank to perform the performance tests on the ASTS system listed below.
   2. Test and cycle all alarm and annunciation circuits to verify proper operation.
3. With ASTS system operating from prime AC power source at full power load, (from load bank) and in the presence of the Engineer perform and document the following tests:
   a. Transfer to alternate power source.
   b. Return to prime power source.

I. 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.

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

K. Contractor shall submit the Testing Agency's final report to the Engineer for review prior to Project closeout and final acceptance by the Owner. Test report shall indicate test dates, devices tested, results, observations, deficiencies and remedies. Include a copy of the test report in the Owner’s operation and maintenance manuals.

3.04 TRAINING

A. Provisions shall be made for an on-site 1 day training program, one of the days shall be concurrent with the field testing program. The training shall include, but not be limited to, a theoretical presentation of the ASTS system and a thorough explanation and training in general operating procedures including system level troubleshooting. The classes shall be for 3 to 6 students at the discretion of the Owner.

B. The vendor shall furnish all materials, books and other aids for each student at no charge to Owner.

C. Contractor shall schedule training with a minimum of 7 days advance notice.

END OF SECTION