Attachment 1 – Electrical Specifications

FOR

COUNTY OF NEVADA
STATE OF CALIFORNIA

Electric Bus Charging Project
Nevada County Operations Center (NCOC) Phase-1

COUNTY PROJECT NO. 889830

California Air Resources Board (CARB) Grant No. G20-NS-001

A sub-grant of U.S. Environmental Protection Agency 2019 and 2020 Targeted Air Shed Grant Program #TA98T15301-0 with CARB

SECTION 260010

BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.01 SUMMARY

A. Table of Contents, Division 26 - Electrical:

SECTION NO.	SECTION TITLE
260010	BASIC ELECTRICAL REQUIREMENTS
260060	POWER SYSTEM STUDY
260519	BUILDING WIRE AND CABLE
260526	GROUNDING AND BONDING
260529	ELECTRICAL HANGERS AND SUPPORTS
260531	CONDUIT
260533	BOXES
260543	UNDERGROUND DUCTS AND STRUCTURES
260553	ELECTRICAL IDENTIFICATION
262413	SWITCHBOARDS
262816	OVERCURRENT PROTECTIVE DEVICES
270010	BASIC COMMUNICATION REQUIREMENTS
270528	COMMUNICATION PATHWAYS
271500	COMMUNICATION HORIZONTAL CABLING

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 1, “General Provisions”.

1. Quality assurance.
2. Definition of terms.
3. Submittals.
4. Coordination.
5. Record documents.
6. Operation and maintenance manuals.
7. Rough-in.
8. Electrical installation.
9. Cutting, patching, painting, and sealing.
10. Field quality control.
11. Cleaning.
12. 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 1, “General Provisions” of the Specifications, apply to all Division 26 Sections.
2. Earthwork: Include trenching, backfilling, boring and soil compaction as required for the installation of underground conduit, in-grade pull boxes, vaults, lighting pole foundations, etc. Refer to Caltrans Standard Specifications 2018 and County Special Provisions.
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, etc. Refer to Caltrans Standard Specifications 2018 and County Special Provisions.

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:

1. California Electrical Code (CEC).
2. California Building Code (CBC).
3. California Fire Code (CFC).
4. California Mechanical Code (CMC).

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
CBM	Certified Ballast Manufacturers
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 CEC 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

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

B. Submittals shall consist of detailed Shop Drawings, Specifications, block wiring diagrams, "catalog cuts" and data sheets containing physical and dimensional information, performance data, electrical characteristics, materials used in fabrication and material finish. Clearly indicate by arrows or brackets precisely what is being submitted on and those optional accessories which are included and those which are excluded. Furnish quantities of each submittal as noted in Division 1, “General Provisions”.

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 or provide a Specification Section line-by-line compliance response statement with detailed exception/ deviation response statements for all applicable provisions for the applicable Specification Section. Any Specification Section lines without a detailed exception/ deviation response statement shall be treated as the Contractor or Vendor is submitting in full compliance with the applicable Specification Section requirements. 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 and fixture submittals, the Contractor shall provide anchorage calculations for floor and wall mounted electrical equipment and fixtures, distribution conduits and raceways, in conformance with the latest edition of the California Building Code (CBC) and ASCE 7. Use the Occupancy Category, Ground Accelerations, Site Class, Seismic Design Category, and Seismic Importance Factor as noted in the structural drawings. For components required for Life Safety or containing hazardous materials use Ip=1.5. Structural Calculations shall be prepared, stamped, 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. Review of submittals is for general conformance to design concept and general compliance with the Specification Sections. Submittal Review Comments do not imply waiver of Specifications Section requirements unless specifically noted.

H. 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.

I. 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.

J. Substitutions:

1. All requests for substitutions shall conform to the general requirements and procedure outlined in Division 1, “General Provisions”.

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 1, “General Provisions”. 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

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 luminaire schedule listing Manufacturers and products 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). A set of CAD files of the electrical construction documents will be provided to the Contractor by the Engineer
3. Record drawing submissions shall be provided to the Engineer to review upon the completion of the following phases of Work:
    a. All underground installation.
    b. Building electrical rough-in.
    c. Final electrical installation.
4. 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. Electronic files of Drawings in PDF and CAD.

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 262413: Switchboards for requirements.

C. Field labels, markings, and warning signs: Provide in accordance and as required by:
    1. General: CEC Article 110.21.
    2. Arc-Flash Hazard Warning: CEC Article 110.16 (A).
    3. Service Equipment: CEC Article 110.16 (B).
    4. Identification of Disconnecting Means: CEC Article 110.22 (A).
    5. Available Fault Current: CEC Article 110.24.
    6. Depth of Working Space in Existing Buildings: CEC Article 110.26 (A)(1)(c).
    7. Guarding of Live Parts: CEC Article 110.27 (C).
    8. Manholes: CEC Article 110.75 (E).
    9. Identification for Branch Circuits: CEC Article 210.5.
    10. Identification for Feeders: CEC Article 215.12.
    11. Switchboard, Switchgear, and Panelboard Identification: CEC Article 408.3.
    12. Field Identification Required: CEC Article 408.4.
    13. Short-Circuit Current Rating: CEC Article 408.6.

1.07 OPERATION AND MAINTENANCE MANUALS

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

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.01 ROUGH-IN

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

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

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. Direction prior to proceeding with rough-in.
4. Coordinate connection of electrical systems with exterior underground utilities and services. Comply with requirements of governing regulations, franchised service companies and controlling agencies. Provide required connection for each service.
5. 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.
6. Install systems, materials, and equipment level and plumb, parallel, and perpendicular to other building systems and components, where installed exposed in finished spaces.
7. 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.
8. Coordinate electrical systems, equipment, and materials installations with other building components.

9. Install systems, materials and equipment giving right-of-way priority to other systems that are required to maintain a specified slope.
10. Conform to the National Electrical Contractors Association "Standard of Installation" for general installation practice.

3.03 CUTTING, PATCHING, PAINTING AND SEALING

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

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.
3. Circuit numbering verification: Select on a random basis, various circuit breakers within 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.

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-months 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-hour training is in addition to any instruction time called out in the Specifications for specific systems. 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 type 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 260060

POWER SYSTEM STUDY

PART 1 - GENERAL

1.01 SUMMARY

A. Work included: Services necessary to complete the system analysis studies required for the item specified under this Division, including but not limited to:

1. Short circuit study.
2. Protective device evaluation study.
3. Protective device coordination study.
4. Arc flash and shock risk assessment.

B. Related Work: Consult all other Sections, determine the extent and character of related Work, and properly coordinate Work specified herein with equipment specified elsewhere to perform a complete analysis study.

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):

   ANSI Z535.4; Product Safety Signs and Labels

2. Institute of Electrical and Electronic Engineers (IEEE):

   IEEE 1584; Guide for Performing Arc-Flash Hazard Calculations

3. National Fire Protection Association (NFPA):

   NFPA 70E; Standard for Electrical Safety in the Workplace

1.03 SUBMITTALS

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

1. The results of the Power System Study shall be summarized in a final report. Three (3) bound copies of the final report shall be submitted.
2. The report shall include the following Sections:
   a. Description, purpose, basis and scope of the study and a single line diagram of that portion of the power system, which is included within the scope of the study.
   b. Tabulations of circuit breaker, fuse and other protective device ratings versus calculated short circuit duties and commentary regarding it.
   c. Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip settings, fuse selection and commentary regarding it.
   d. Fault current calculations including a definition of terms and guide for interpretation of computer printout.

e. Recommended size for power fuses and recommended settings for ground fault relays and for all adjustable trip relays.

f. Confirmation in writing of compliance with Arc Energy Reduction per CEC Articles 240.67 and 240.87.

g. Tabulations of arc flash and shock risk assessment results and commentary regarding results.

h. Sample arc flash and shock hazard warning label.

3. Contractor shall also provide an electronic copy of the report as part of the Record Document process. Electronic copy of the report shall be in PDF format and its native file format (e.g. XXX.PRJ).

B. The study shall be submitted prior to final review of the distribution equipment Shop Drawings, prior to release of equipment for manufacture. If formal completion of the study may cause delay in equipment manufacture, approval from the Engineer may be obtained for a preliminary submittal of sufficient data to ensure that the selection of device ratings and characteristics will be satisfactory. Then the formal study will be provided to verify the preliminary findings.

1.04 QUALITY ASSURANCE

A. The system analysis studies shall be performed by the Switchboard/Switchgear Manufacturer or by an approved Independent Testing Company. The analysis shall be stamped by a professional engineer licensed in the State of California.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.01 GENERAL

A. The studies shall include all portions of the electrical distribution system from the main normal power services down to and including the 208 volt AC distribution system. Normal system connections and those that result in maximum fault conditions shall be adequately covered in the study.

3.02 SHORT CIRCUIT STUDY AND PROTECTIVE DEVICE EVALUATION STUDY

A. The short circuit study shall be performed with the aid of a computer program and shall be in accordance with the latest applicable IEEE and ANSI standards.

B. The study input data shall include the maximum available short circuit contribution, resistance and reactance components of the branch impedance, the X/R ratios, base quantities selected and other source impedance.

C. Short circuit close and latch duty values and interrupting duty values shall be calculated on the basis of maximum available current at each substation bus, switchgear bus, medium voltage controller, switchboard, low voltage motor control center, distribution panelboard, pertinent branch circuit panel and other significant locations through the system. The short circuit tabulations shall include asymmetrical fault currents, symmetrical fault currents and X/R ratios. For each fault location, the total duty on the bus, as well as the individual contribution from each connected branch, shall be listed with its respective X/R ratio.

D. A protective device evaluation study shall be performed to determine the adequacy of circuit breakers, switches, transfer switches and fuses by tabulating and

comparing the short circuit ratings of these devices with the calculated fault currents. Appropriate multiplying factors based on system X/R ratios and protective device rating standards shall be applied. Any problem areas or inadequacies in the equipment due to short circuit currents shall be promptly brought to the Architect's attention.

3.03 PROTECTIVE DEVICE COORDINATION STUDY

A. A protective device coordination study shall be performed to provide the necessary calculations and logic decisions required to select or to check the selection of power fuse ratings, protective relay characteristics and settings, ratios and characteristics of associated current transformers, ground fault relays and low voltage breaker trip characteristics and settings. The studies shall be in accordance with the latest applicable IEEE and ANSI standards.

B. The coordination study shall include all medium and low-voltage classes of equipment from the building or plant service protective devices down to and including low voltage motor control centers and panelboards. The phase and ground overcurrent protection shall be included as well as settings of all other adjustable protective devices

C. The time-current characteristics of the specified protective devices shall be drawn on log-log paper. The plots shall include complete titles, representative one-line diagram and legends, significant motor starting characteristics, complete parameters of transformers, complete operating bands of low voltage circuit breaker trip curves and fuses, phase cable damage curves, ground cable damage curves, medium-voltage cable shield damage curves, ground resistor damage curves, etc. as appropriate for the project. The coordination plots shall indicate the types of protective devices selected, proposed relay taps, time dial and instantaneous trip settings, transformer magnetizing inrush and ANSI transformer withstand parameters, cable thermal overcurrent withstand limits and significant symmetrical and asymmetrical fault currents. All restrictions of the National Electrical Code shall be adhered to and proper coordination intervals and separation of characteristic curves shall be maintained. The coordination plots for phase and ground protective devices shall be provided on a system basis. A sufficient number of separate curves shall be used to clearly indicate the coordination achieved.

D. The selection and settings of the protective devices shall be provided separately in a tabulated form listing circuit identification, IEEE device number, current transformer ratios and connection, Manufacturer and type, range of adjustment and recommended settings. A tabulation of the recommended power fuse selection shall be provided for the medium voltage fuses where applied in the system. Any discrepancies, problem areas or inadequacies shall be promptly brought to the Architect's attention.

E. In addition to the protective device coordination study settings, arc energy reduction settings shall also be tabulated. Consider all operating scenarios.

F. The company performing the protective device coordination study shall provide completed and filled out circuit breaker settings labels. Label type (size, colors, text size, etc.) shall be approved by the Owner. Labels shall be similar to the following example with industrial grade self-adhesive backing, weatherproof, and UV proof. Labels shall be provided to the commissioning agent for the commissioning agent to install during commissioning.

CIRCUIT BREAKER SETTINGS			
T/U Mfr:		T/U Model:	
LTPU:		LTD:	
STPU:		STD:	
GFPU:		GFTD:	
INST:		Zone Intlk: (Y/N)	
Name:		Date:	
Verified By:		Date:	
Study Version:			

3.04 ARC FLASH AND SHOCK RISK ASSESSMENT

A. An arc flash and shock risk assessment shall be performed in accordance with NFPA 70E (utilizing IEEE 1584 calculation method for incident energy analysis method) at each switchboard, distribution board, panelboard, etc. in accordance with the referenced standards. NFPA 70E hazard/ risk tables for arc flash PPE category method are not acceptable for compliance with this section.

B. The arc flash and shock risk assessment shall include all voltage classes of equipment from the service entrance down to and including the panelboards, etc. in addition to all possible scenario configurations from alternate power sources (e.g. generators, etc.).

C. The company performing the arc flash and shock risk assessment shall provide arc flash and shock hazard warning labels for all equipment evaluated in accordance with NFPA 70E and ANSI Z535.4. Labeling shall be as follows:

1. Label type:

   a. White vinyl or polyester with the following warning symbol color and black text:

      1) Incident energy below 40 cal/cm² = Orange.

      2) Incident energy for 40 cal/cm² and above = Red with DANGER symbol in lieu of WARNING.

   b. Industrial grade self-adhesive backing.

   c. Suitable for indoor or outdoor environments for a minimum of 3-years without fading or degrading.

2. Label information (minimum):

   a. Nominal system voltage.

   b. Arc flash boundary (inches).

   c. Available incident energy and the corresponding working distance (inches).

   d. Limited approach boundary (inches).

   e. Restricted approach boundary (inches).

   f. Equipment identification.

   g. Date.

3. Labels shall be affixed to all equipment covered under the risk assessment by the company performing the arc flash and shock risk assessment.
4. Prior to printing and affixing labels, coordinate with the Owner and Architect, which scenario will be used for the labels.

3.05 PROTECTIVE DEVICE TESTING, CALIBRATION AND ADJUSTMENT

A. The equipment Manufacturer shall provide the services of a qualified field Engineer and necessary tools and equipment to test and calibrate the protective relays, ground fault relays and circuit breaker trip devices as recommended in the Power System Study.

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. Underwriters Laboratories, Inc. (UL):

UL 44;	Thermoset-Insulated Wires and Cables.
UL 83;	Thermoplastic-Insulated Wires and Cables.
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 1581;	Reference Standard for Electrical Wires, Cables and Flexible Cords.

2. National Electrical Manufacturer Association (NEMA):

NEMA WC-70;	Power Cables Rated 2,000 V or Less for the Distribution of Electrical Energy.

3. Institute of Electrical and Electronic Engineers (IEEE):

IEEE 82;	Test Procedure for Impulse Voltage Tests on Insulated Conductors.

IEEE 576; Recommended Practice for Installation, Termination, and Testing of Insulated Power Cable as Used in Industrial and Commercial Applications.

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 (or equal) shall be acceptable if in compliance with all features specified herein and indicated on the Drawings.

1. Building wire:
   a. Cerrowire
   b. General Cable
   c. Southwire Company
   d. Or equal
2. Wiring connectors and terminations:
   a. 3M Company.
   b. Ideal.
   c. Blackburn-Holub.
   d. Burndy.
   e. Thomas & Betts Corp.
   f. Beau Barrier.
   g. Or equal

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

2.02 BUILDING WIRE

A. Conductor material:

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

B. Insulation material:

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

2.03 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-striping 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-crimping tools and dies as stipulated by the lug Manufacturer or as indicated on Drawings. Notch or single point type crimping is NOT acceptable.
2. Two-hole, long barrel lugs shall be provided for size #4/0 and larger wire where terminated to bus bars. Use minimum of three crimps per lug, on sizes where possible.

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.

F. 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.

G. 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 system.

H. 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.

I. 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.

J. 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.

K. 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 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

2. Grounded neutral conductors #6 AWG or smaller must be color coded with a white or gray continuous outer finish (no taping). Grounded conductors #4 AWG or larger are allowed to be taped for identification.

3.03 WIRING METHODS

A. Install wires and cables in accordance with Manufacturer's written instructions, CEC Article 310 Part III, as indicated on Drawings and as specified herein.

B. Install all single conductors in raceway system, unless otherwise noted.

C. Parallel circuit conductors and terminations shall be equal in length and identical in all ways.

D. Provide adequate length of conductors within electrical enclosures and train the conductors to terminal points with no excess. Bundle multiple conductors, with conductors larger than #10 AWG cabled in individual circuits. Make terminations so there is no bare conductor at the terminal.

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

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

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

H. Seal cable or wire, entering a building from underground, between the wire or cable and raceway, where it exits the raceway, with a sealant identified for use with the cable insulation, bare conductor, shield, or other component within the raceway.

I. Provide UL-listed factory-fabricated, solderless metal connectors of size, ampacity rating, material, type, and class for applications and for services indicated. Use connectors with temperature ratings equal to or greater than the wires that are being terminated.

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

3.04 WIRING INSTALLATION IN RACEWAYS

A. Install wire in raceway in accordance with IEEE 576, Manufacturer’s written instructions, as indicated on the Drawings and as specified herein 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 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 #1 AWG.

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.
5. Pulling tensions and sidewall pressures shall not exceed 60% of the manufacturer's recommended maximum values. Pulling tension shall be continuously monitored during the pull by a calibrated dynamometer. If pulling tension is exceeded during the pull, immediately notify the engineer to determine if the cables will be considered damaged and require contractor replacement.

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

3.05 INSTALLATION IN MANHOLES

A. Install and support cables in manhole on the steel racks with porcelain or equal insulators, unless otherwise noted. Train the cables around the manhole walls, but do not bend to a radius less than six times the overall cable diameter.

3.06 WIRE SPLICES, JOINTS AND TERMINATION

A. Join and terminate wire, conductors, and cables in accordance with UL 486A, C, CEC 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, pull boxes 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 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 kCMIL)

1. Join or tap conductors from #6 AWG to 750 kCMIL 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 kCMIL 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 kCMIL 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 recommendations 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.

3.07 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, pull boxes and handholes, provide tags of the embossed brass type and show the cable type and voltage rating. Attach the tags to the cables with slip-free plastic cable lacing units.

3.08 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:

a. Compare cable data with Contract Documents.

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 indention.

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, inspect 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 1000 volt 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.

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.
IEEE No. 81	Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.

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. 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.

D. 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 (or equal) 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 CEC.

C. Bare conductors in direct contact with earth or encased in concrete: #4/0 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 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 BUILDING GROUND BUS REQUIREMENTS

A. Building power system reference ground bus:

1. The reference ground bus is furnished as part of the main electrical switchboard, 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.

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. Concrete encased grounding electrode (UFER ground): Provide a #4/0 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.

2. 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 #2 AWG bare copper conductor. Ground rod shall not be less than 10 feet 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 CEC Article 250, whichever is greater.

C. Power system grounding:

1. 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 CEC Article 250 as a minimum, unless greater requirements are required elsewhere in the Contract Documents.

E. Equipment bonding/grounding:

1. Provide a CEC sized insulated copper ground conductor in all 120 volt AC through 600 volt AC feeder and branch circuit distribution conduits and cables.

2. Provide a separate grounding bus at panelboards, switchboards. 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.

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.

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 (or equal) 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 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 1.5-inch by 1.5-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. Layout support devices to maintain headroom, neat mechanical appearance and to support the equipment loads.

B. Where indicated on the Contract Documents, install freestanding electrical equipment on concrete pads.

3.03 INSTALLATION

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

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

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

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

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

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

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

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

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

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

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

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

3.04 ERECTION OF METAL SUPPORTS

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

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

3.05 ANCHORAGE

A. All floor mounted, free standing electrical equipment such as transformers, switchboards, distribution boards, 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. Rigid non-metallic conduit and fittings.
6. Flexible metallic conduit and fittings.
7. Liquidtight flexible metallic conduit and fittings.
8. Miscellaneous conduit fittings and products.

1.02 REFERENCES

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

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

ANSI C80.1;	Rigid Steel Conduit, Zinc-Coated.
ANSI C80.3;	Electrical Metallic Tubing, Zinc Coated.

2. 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.
UL 651;	Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings.
UL 797;	Electrical Metallic Tubing - Steel.
UL 1242;	Intermediate Metal Conduit - Steel.

3. National Electrical Manufacturer Association (NEMA):

NEMA RN1;	PVC Externally coated Galvanized Rigid Steel Conduit.
NEMA TC 2;	Electrical Plastic Tubing and Conduit.
NEMA TC 3;	PVC Fittings for use with Rigid PVC Conduit.

1.03 SUBMITTALS

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

1. Data/catalog cuts for each product and component specified herein, listing all physical and electrical characteristics and ratings indicating compliance with all listed standards.
2. Clearly mark on each data sheet the specific item(s) being submitted and the proposed application.
3. Submit Manufacturer's installation instruction. Provide written instructions for raceway products requiring glues, special tools, or specific installation techniques.

1.04 QUALITY ASSURANCE

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

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

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. Metal conduit:
    a. Allied Tube and Conduit Co.
    b. Triangle PWC, Inc.
    c. Western Tube and Conduit Corp.
    d. Spring City Electrical Manufacturing Co.
    e. Occidental Coating Co. (OCAL).
    f. Alflex Corp.
    g. American Flexible Metal Conduit Co.
    h. Anaconda.
2. Nonmetallic conduit:
    a. Prime Conduit.
    b. JM Eagle.
    c. Cantex.
3. Fittings:
    a. Appleton Electric Co.
    b. OZ/Gedney.
    c. Thomas & Betts Corp.

d. Spring City Electrical Manufacturing Co.

e. Occidental Coating Co. (OCAL).

f. Carlon.

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

2.02 GALVANIZED RIGID STEEL CONDUIT (GRS)

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

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: Hot dip galvanized, cast malleable iron.

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

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

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

G. All fittings and connectors shall be threaded.

2.03 PVC INSULATED GALVANIZED RIGID STEEL CONDUIT (PVC GRS)

A. Conduit: Full weight, threaded, hot-dip galvanized steel, conforming to ANSI C80.1 and NEMA RN-1 with nominal 20 or 40 mil thermoplastic vinyl coating, heat fused and bonded to the exterior of the conduit.

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

2.04 INTERMEDIATE METAL CONDUIT (IMC)

A. Conduit: Hot dip galvanized steel meeting the requirements of CEC Article 342 and conforming to ANSI C80.6 and UL 1242.

B. Fittings: Conduit couplings, connector and bushing shall be as specified for galvanized rigid steel conduit. Integral retractable type IMC couplings are also acceptable.

2.05 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: Hot dip galvanized, 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: Hot dip galvanized, 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: Hot dip galvanized, steel or cast malleable iron; UL listed raintight and concrete tight, using gland and ring compression type construction.

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

2.06 RIGID NON-METALLIC CONDUIT (PVC)

A. Conduit:

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

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

2.07 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 luminaire connection in suspended ceilings and cut-in outlet boxes within existing furred walls.

2.08 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.

2.09 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 0.75-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) can 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 CEC 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: Refer to 260543.

C. Intermediate metal conduit (IMC): Can be used for the same application as galvanized rigid steel conduit as specified herein.

D. Electrical metallic tubing (EMT): Can 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. Rigid non-metallic conduit (PVC): Refer to 260543.

F. Flexible metallic conduit (FMC): Can 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 luminaires installed in suspended ceilings, minimum sizes shall be 3/8" for luminaires and control wiring and 1/2" for motor and transformer connections. U.O.N.

G. Liquidtight flexible metallic conduit (LFMC): Can 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.

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, except for 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 dents, bruises or deformations. Remove and replace any damaged conduits with new undamaged material.

H. Conduits shall be well protected and tightly covered during construction using metallic bushings and bushing "pennies" to seal open ends.

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

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

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

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

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

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

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

3.05 PENETRATIONS

A. 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.

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

3.06 TERMINATIONS AND JOINTS

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

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

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

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

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

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. Raceway seal: Inject into wire filled raceways, a pre-formulated rigid 2 lbs. density polyurethane foam which expands a minimum 35 times its original bulk. Foam shall have the physical properties of water vapor transmission of 1.2 to 3.0 perms: water absorption less than 2% by volume, fungus and bacterial resistant. Foam shall

permanent seal against water, moisture, insects, and rodents. Install raceway sealing foam at the following points:

1. Where conduits enter switchboard from below grade.

H. Install expansion couplings where any conduit crosses a building separation.

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.

1.02 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, Non-Environmental Considerations.
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 (or equal) 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.

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 or welded, knockout type box of size and configuration best suited to the application indicated on the Drawings.

2. 4-inch square by 1.5-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. Cast metal outlet body:

1. Provide 4-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.

D. Conduit outlet body: Provide Cadmium plated cast iron alloy, oblong conduit outlet bodies with threaded conduit hubs and neoprene gasket, cast iron covers.

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 luminaires.

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

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

E. Welded outlet boxes shall only be used in concealed interior installations.

F. 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.

G. 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 luminaires 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 260543

UNDERGROUND DUCTS AND STRUCTURES

PART 1 - GENERAL

1.01 SUMMARY

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

1. Underground conduits and ducts.
2. Duct banks.
3. Handholes and pullboxes.
4. Manholes and vaults.
5. Other underground utility structures.
6. Excavation, trenching and backfill.

1.02 REFERENCES

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

1. American Concrete Institute (ACI):

ACI 318;	Building Code Requirements for Structural Concrete

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

ANSI C80.1;	Rigid Steel Conduit, Zinc-Coated.

3. American Society for Testing And Materials (ASTM):

ASTM C31;	Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C39;	Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C172;	Standard Practice for Sampling Freshly Mixed Concrete
ASTM C192;	Practice for Making and Curing Concrete Test Specimens in the Laboratory
ASTM C231;	Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C478;	Specification for Precast Reinforced Concrete Manhole Sections
ASTM C805;	Test Method for Rebound Number of Hardened Concrete
ASTM C857;	Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures
ASTM C858;	Specification for Underground Precast Concrete Utility Structures

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

4. Underwriters Laboratories, Inc. (UL):

UL 6;	Rigid Metal Conduit.
UL 651;	Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings.

5. National Electrical Manufacturer Association (NEMA):

NEMA RN1;	PVC Externally-coated Galvanized Rigid Steel Conduit.
NEMA TC 2;	Electrical Plastic Tubing and Conduit.
NEMA TC 3;	PVC Fittings for use with Rigid PVC Conduit.
NEMA TC6;	PVC Plastic Utilities Duct (EB and BD Type).

1.03 DEFINITIONS

A. Duct: Electrical conduit and other raceway, either metallic or nonmetallic, used underground embedded in earth.

B. Duct bank: Two or more conduits or another raceway installed underground in same trench.

C. Handhole: An underground junction box in a duct or duct bank.

D. Manhole: An underground utility structure, large enough for a person to enter, connecting with ducts to afford facilities for installing and maintaining cables.

E. Vault: An underground utility structure, large enough for a person to enter, connecting with ducts to afford facilities for installing, operating and maintaining equipment and wiring.

1.04 SUBMITTALS

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

1. Data/catalog cuts for each product and component specified herein, listing all physical and electrical characteristics and ratings indicating compliance with all listed standards.
2. Clearly mark on each data sheet the specific item(s) being submitted and the proposed application.
3. Shop Drawings showing details and design calculations for precast vaults and handholes, including reinforced steel.
4. Submit Manufacturer's installation instructions.
5. Complete bill of materials listing all components.
6. Certificate for concrete and steel used in underground precast concrete utility structures, according to ASTM C858.

1.05 QUALITY ASSURANCE

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

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

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

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. Underground precast concrete utility structures:
    a. Oldcastle Enclosure Solutions.
    b. Jensen Precast.
2. Conduits, ducts and fittings:
    a. Prime Conduit.
    b. JM Eagle.
    c. Cantex.
    d. Occidental Coating Company (OCAL).

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

2.02 CONDUIT AND DUCT

A. Refer to Section 260531: Conduit.

B. Galvanized rigid steel conduit (GRS) in underground installations:

1. PVC insulated galvanized rigid steel conduit (PVC GRS):

a. Conduit: Full weight, threaded, hot-dip galvanized steel, conforming to ANSI C80.1 and NEMA RN-1 with nominal 20 or 40 mil thermoplastic vinyl coating, heat fused and bonded to the exterior of the conduit.

b. Fittings: Conduit couplings and connectors shall be steel or malleable iron as required with factory PVC coating and insulated jacket equivalent to that of the coated material.

2. Tape insulated galvanized rigid steel conduit (Tape GRS):

a. Conduit: Full weight, threaded, hot-dip galvanized steel, conforming to ANSI C80.1 and NEMA RN-1 with half lapping of PVC 10 mil tape over the exterior of the conduit. Half lap all raceways a minimum of one time and extend to 12-inches above grade.

b. Fittings: Conduit couplings and connectors shall be steel or malleable iron as required with half lapping of PVC 10 mil tape over the exterior of the fittings. Half lap shall extend to 12-inches above grade.

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

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

2.03 PULLBOXES AND HANDHOLES

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

B. Size: As indicated on the Drawings.

C. Cover markings: Covers shall read "ELECTRICAL", “COMMUNICATIONS”, or "SIGNAL" as appropriate.

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

2.04 MANHOLES AND VAULTS

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

B. Construction:

1. Monolithic or modular assembled sections.

2. Assembled sections shall have mating edges with tongue and groove joints. Joints shall firmly interlock adjoining components and provide waterproof junctions. Seal joints watertight using preformed plastic strip.

3. Provide lifting devices cast into units for proper handling of units.
4. Identify all structures with Manufacturer's name embedded in or otherwise permanently attached to an interior wall face.
5. Include concrete knockout panels for conduit entrance and sleeve for ground rod.

C. Size and dimensions: As indicated on Drawings.

D. Accessories:

1. Frames and covers: Cast iron with cast-in legend "ELECTRICAL", “COMMUNICATIONS”, or "SIGNAL" as appropriate. Machine cover-to-frame bearing surfaces.
2. Pulling eyes in walls: Eyebolt with reinforcing bar fastening insert. 2-inch diameter eye, 1-inch by 4-inch bolt. Working load embedded in 6-inch, 4000-PSI concrete: 13,000 pounds minimum tension.
3. Pulling and lifting irons in floor: 7/8-inch diameter, hot-dipped galvanized, bent steel rod, stress relieved after forming and fastened to reinforced rod. Exposed triangular opening. Ultimate yield strength: 40,000 pounds shear and 60,000 pounds tension.
4. Bolting inserts for cable stanchions: Flared, threaded inserts of non-corrosive, chemical resistant, nonconductive thermoplastic material; 1/2-inch internal diameter by 2.75-inch deep, flared to 1.24-inch minimum at base. Tested ultimate pull-out strength at 12,000pounds minimum.
5. Expansion anchors for installation after concrete is cast: Zinc-plated carbon steel wedge type with stainless-steel expander cup 1/2-inch bolt size, 5,300 pound rated pull-out strength and 6800pound rated shear strength minimum.
6. Cable stanchions: Hot-rolled, hot-dipped, galvanized "T" section steel, two 1/4-inches size, punched with 14-holes on 1.5-inch centers for cable arm attachment.
7. Cable arms: 3/16-inch thick hot-rolled, hot-dipped galvanized sheet steel pressed to channel shape, approximately two 12-inches wide by 14-inches long and arranged for secure mounting in horizontal position at any position on cable stanchions.
8. Cable support insulators: High glaze, wet-process porcelain arranged for mounting on cable arms.
9. Ground rods: Solid copper, 3/4-inch diameter by 10-feet length (minimum).
10. Ground wire: Stranded bare copper conductor, #6 AWG (minimum). Size in accordance with CEC Article 250.
11. Steps: Cast iron, suitable for shape and construction.

2.05 CONSTRUCTION MATERIALS

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

PART 3 - EXECUTION

3.01 EXAMINATION

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

3.02 EARTHWORK

A. Excavation for underground electrical structures: Conform to elevations and dimensions indicated within a tolerance of plus or minus 0.10 foot; plus, a sufficient distance to permit placing and removal of concrete formwork, installation or services, other construction and for inspection.

1. Excavate, by hand, areas within dripline of large trees. Protect the root system for damage and dry-out. Maintain moist conditions for root system and over exposed roots with burlap. Paint root cuts of 1 inch in diameter and larger with emulsified asphalt tree paint.

2. Take care not to disturb bottom of excavation. Excavate by hand to final grade just before concrete reinforcement is placed.

B. Trenching: Excavate trenches for electrical installation as follows:

1. Excavate trenches to the uniform width, sufficiently wide to provide ample working room and a minimum of 6 to 9 inches clearances on both sides of raceways and equipment.

2. Excavate trenches to depth indicated or required.

3. Limit the length of open trench to that in which installations can be made and the trench backfilled within the same day.

4. Where rock is encountered, carry excavation below required elevation and backfill with a layer of crushed stone or gravel prior to installation of raceways and equipment. Provide a minimum of 6 inches of stone or gravel cushion between rock bearing surface and electrical installations.

C. Backfilling and filling: Place soil materials in layers to required sub-grade elevations for each area classification, using materials and methods specified in the Caltrans Standard Specifications 2018 and County Special Provisions.

1. Under building slabs, use drainage fill materials.

3.03 CONDUIT AND DUCT INSTALLATION

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

B. Application:

1. Direct burial ducts: Schedule 40, minimum 24-inches below finished grade.

2. Below building slab-on-grade: Schedule 40, minimum 4-inches below bottom of slab except that bends and penetrates through floor slab shall be insulated galvanized rigid steel conduit.

3. Below roads and paved surfaces:

a. Schedule 40, minimum 36-inches below finished grade.

4. Penetrations of building and equipment slabs: Insulated galvanized rigid steel conduit.

C. Slope duct to drain towards vaults and handholes and away from building and equipment entrances. Pitch not less than 4-inches per 100-feet.

D. Curved sections in duct lines shall consist of long sweep bends with a minimum radius of 25-feet in the horizontal and vertical directions. The use of manufactured bends is limited to building entrances and equipment stub-ups.

E. For communications and signal conduits, do not exceed a combined bend radius of greater than 180 degrees between pull points.

F. Underground conduit stub-ups to inside of building and exterior equipment shall be insulated galvanized rigid steel conduit.

G. Make joints in ducts and fittings watertight according to Manufacturer's instructions. Stagger couplings so those of adjacent ducts do not lie in the same plane.

H. Terminate duct lines at vaults and handholes with end bells spaced 10-inches on center for 5-inch ducts and varied proportionately for other duct sizes. Change from regular spacing to end-bell spacing 10-feet from the end bell without reducing duct line slope and without forming trap in the line. Grout end bells into manhole walls from both sides to provide watertight entrance.

I. Separation between direct buried duct lines shall be 3-inches minimum for like systems and 12-inches minimum between power and signal ducts.

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

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

3.04 HANDHOLE AND PULL BOX INSTALLATION

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

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

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

3.05 MANHOLE AND VAULT INSTALLATION

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

B. Install manhole with rooftop at least 15-inches below finished grade. Access shall be via 30-inch diameter precast chimney from roof opening to finished grade.

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

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

E. Install drains in bottom of units where indicated.

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

G. Provide cable rack support as indicated and required. Support intervals shall not exceed 36-inches. Each rack shall include cable support insulators.

H. Drive ground rod into earth, through the floor sleeve, after manhole is set in place. Fill the sleeve with a sealant to make a watertight seal.

I. Install ground wire around the inside perimeter of manhole and anchor to wall. Connect the wire to the ground rod by exothermic welding process to form solid metal joint. Bond the ground wire to the exposed non-current carrying metal parts of racks and like items in the manhole.

J. Do not drill deeper than 3-7/8” for anchor bolts installed in the field. Use a minimum of 2 anchors for each cable stanchion.

3.06 FIELD QUALITY CONTROL

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

1. Grounding: Test vault grounding to ensure electrical continuity of bonding and grounding connections. Measure ground resistance at each ground rod and report results.

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

3.07 CLEANING

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

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

END OF SECTION

SECTION 260553

ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.01 SUMMARY

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

1. Electrical equipment nameplates.
2. Panelboard directories.
3. Wire and cable identification.
4. Buried electrical line warnings.
5. Junction box identification.
6. Warning and caution signs.
7. Inscribed device coverplates.

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 (or equal) 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) for all 42-pole panelboards. For 84-pole panelboards the numbering is Section 1 (circuit numbers 1-84), Section 2 (circuit numbers (85-168), etc.

2.06 WIRE AND TERMINAL MARKERS

A. Provide self-adhering, pre-printed, machine printable or write-on, self-laminating vinyl wrap around strips.

B. 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".

PART 3 - EXECUTION

3.01 EXAMINATION

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

3.02 NAMEPLATES

A. Installation:

1. Degrease and clean surfaces to receive nameplates.

2. Install nameplates parallel to equipment lines.

3. Secure nameplates to equipment fronts using machine screws.

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

1. Equipment or device designation:
2. Amperage, KVA or horsepower rating, where applicable.
3. Voltage or signal system name.
4. Source of power or control.

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

D. Minimum letter height shall be as follows:

1. For panelboards, switchboards, 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, distribution boards, and switchboards use 3/8-inch letters to identify equipment designation. Use 1/8-inch letters to identify all other.
3. For individual mounted circuit breakers and disconnect switches use 3/8-inch letters to identify equipment designation. Use 1/8" letters to identify all other.

3.03 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.

3.04 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.

3.05 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.

3.06 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.

END OF SECTION

SECTION 262413

SWITCHBOARDS

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. Main service switchboard.
2. Outdoor enclosure and accessories.

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):

ANSI C12;	Code for Electricity Metering.
ANSI C37.5;	Current and Potential Transformers.
ANSI C39.1;	Electrical Analog Indicating Instruments.
ANSI C57.13;	Requirements for Instrument Transformers.

2. Underwriters Laboratories, Inc. (UL):

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 869A;	Service Equipment.
UL 891;	Dead-Front Switchboards.
UL 943;	Ground-Fault Circuit Interrupters.
UL 1053;	Ground-Fault Sensing and Relaying Equipment.

3. National Electrical Manufacturer Association (NEMA):

NEMA AB1;	Molded Case Circuit Breakers.
NEMA PB 2;	Deadfront Distribution Switchboards.
NEMA PB 2.1;	General Instruction for Proper Handling, Installation, Operation and Maintenance of Deadfront Distribution Switchboards Rated 600 Volts or less.
NEMA PB 2.2;	Application Guide Ground Fault Protective Devices for Equipment.
NEMA SG5;	Power Switchgear Assemblies.

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. Shop Drawings to include:
    a. Front, plan, and side view elevations with overall dimensions.
    b. Conduit entrance locations and requirements.
    c. Nameplate legends; size and number of bus bars per phase, neutral and ground.
    d. Switchboard instrument details and accessories.
    e. Electrical characteristics including voltage, frame size and trip rating and withstand ratings.
3. Outdoor weatherproof equipment enclosure and accessories.
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 Materials listing all components.
7. Final test results.
8. Warranty.

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

C. Service entrance switchboard utility metering sections shall be submitted to the local electrical utility company for approval prior to submission to the Engineer. A letter of acceptance from utility company shall be included in submittal package.

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 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.

1.05 QUALITY ASSURANCE

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

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

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

1.06 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Delivery: Switchboard 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. Components shall be properly packaged in factory-fabricated containers and mounted on shipping skids.

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

C. Handling: Handle in accordance with NEMA PB2.1 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. 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 (or equal) shall be acceptable if in compliance with all features specified herein and indicated on the Drawings.

1. ABB/ General Electric.
2. Eaton.
3. Industrial Electric Mfg.
4. Siemens.
5. Square D.

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

2.02 SWITCHBOARDS - GENERAL

A. Enclosure:

1. Each switchboard shall consist of a dead front, completely metal enclosed self-supporting structure. Construction shall consist of vertical sections of the universal frame type bolted together and braced with self-tapping bolts. Sides, top and rear shall be covered with captive-bolt fastened steel plates having formed edges all around. Front plates shall be sectionalized and removable. All plates shall be fabricated from 12-gage steel and shall have die-formed edges all around. The switchboard frame shall be suitable for use as floor sills in indoor installations. Corners shall be reinforced with rigged gussets internal and external to the structural members.
2. Switchboards shall have depth as required to house all equipment contained within it. Switchboard shall be constructed so that the back and front of all sections align. Construction of the board shall allow maintenance of incoming line terminations, device connections and all bus bolted connections.
3. All devices shall be accessible and removable from the front unless rear access is indicated on the Drawings.
4. Provide necessary hardware to permit locking every overcurrent protective device handle in the "OFF" position.
5. Provide hinged access doors to all termination, meter, and relay compartments with knurled and slotted large head captive-bolts. The design shall allow access to compartments without tools and without removing any panels.
6. Furnish cable pull sections or top cable pull boxes where indicated on the Drawings complete with cable tie down supports. Where cable pull section or pull boxes contain utility service cables, provide utility acceptable sealing means.
7. Switchboard shall be suitable for use as service entrance equipment and be labeled in accordance with UL requirements.
8. Utility metering compartment section shall be fabricated to meet all utility company requirements. Where separate vertical section is required for utility metering, match and align with switchboard enclosure.
9. Clearances: Comply with CEC Article 408.18 for clearances and connections. Equipment requiring rear or side access to make field connections shall be so marked by the manufacturer on the front of the equipment in accordance with CEC Article 408.18 (C).

B. Bus assembly and terminations:

1. The switchboard bussing shall be highly conductive tin-plated aluminum with sufficient cross-sectional area to meet UL Standard 891 temperature rise requirements.
2. Switchboard bus bars and connections shall consist of high conductivity tin-plated aluminum (750 amps per square inch maximum) mounted on heavy duty glass polyester supports. Bolted connections using Belleville washers are required for all internal connections, including those between protective devices and bus.
3. Bus arrangement shall be Phase A-B-C-N left-to-right, top-to-bottom and front-to-rear as viewed from the front. Horizontal and vertical bus ampere rating shall be uniform from end-to-end.

4. All bussing to and from an overcurrent protective device shall be rated to the frame sizing, not the trip rating.
5. Where "SPACE" is indicated in the switchboards, cross connectors and mounting hardware shall be installed to match the frame size ampere rating noted on the Electrical Drawings. All "SPACES" shall be ready for installation of overcurrent protective devices at a future time.
6. Shipping splits and provisions for future bus extension shall be provided with necessary bus splices.
7. Each switchboard shall contain a full length, bottom/front located copper ground bus that is securely connected to each vertical section. Ground bus shall be sized in accordance with UL 891, Table 25.1.
8. Termination lugs: High compression circumference crimped type rated for use with aluminum/copper conductors.
9. Switchboards shall be fully rated for a minimum of AIC Rating as indicated on the Drawings.
10. Neutral bus shall be 100 percent rated unless otherwise indicated on the Drawings.
11. Main service switchboards:
    a. Removable neutral link: Provide removable bolted bus section for the purpose of disconnecting the ground circuit conductor from the premises wiring at the supply side of the service in accordance with CEC Article 230-75.
    b. Main bonding jumper: Connection between the grounded circuit conductor and the equipment ground conductor at the supply side of the service. Size in accordance with CEC Table 250-102(C)(1).

C. Switching and overcurrent protective devices:
1. Refer to Section 262816: Overcurrent Protective Devices.
2. Main and overcurrent protective devices(s) shall be fixed mounted molded case circuit breaker with interrupting rating and frame and trip ratings as indicated on Drawings.
3. Feeder overcurrent protective device(s) shall be fixed mounted molded case circuit breaker with frame and trip rating as indicated on Drawings.
4. Devices interrupting rating shall match that of switchboard for which the device is installed.
5. Devices shall be manually operated unless shunt trip and/or electrically operated devices are indicated on Drawings.

D. Ground fault protection:
1. General: A solid-state, zone-interlocked, ground fault protection system shall be provided integral on the main, and the feeder device(s) as indicated on Drawings. It shall consist of integral phase current sensors, appropriate solid-state relaying equipment to provide the desired ground fault current sensitivity and time-current response characteristics. Provide neutral ground fault current transformer for

four wire systems. Provisions shall be made for wiring devices for coordination between the main and the feeder devices.

2. Device settings: Adjustable pickup current sensitivity for ground fault currents from 200 amperes to 1200 amperes shall be provided. A calibrated dial shall be provided for setting the current pickup point in the field. Time delay shall be adjustable from 0 to 60 cycles. Settings for individual relays shall be as directed by the short circuit/coordination study specified in Section 260060: Power System Study. A locking screw shall be provided to retain both adjustments at desired setting.
3. All overcurrent devices shall be independently time coordinated irrespective of zone interlocking to allow the last downstream level of ground fault devices to be time coordinated, i.e. it shall NOT revert to the lowest time setting.

E. Instrumentation and controls:

1. Switchboards shall have a digital meter unit (DMU) as indicated on the Drawings. DMU shall be Electro Industries Shark 200 (CAT# SHARK200-60-10-V6-D2-RO1S-1NP100S) with communications software or equal. Control power shall be derived internally.
2. Meter potential circuits shall be fused. Potential transformers if required for the monitoring devices shall be provided with fuses in the primary.
3. Meter current circuits shall have shorting terminal blocks between the meter and the current transformers. Current transformers shall be ring type (one per phase) with ratio, thermal, and mechanical ratings coordinated with the application and protection.
4. Instrument transformer accuracy per IEEE C57.13.6:
    a. Current transformers must maintain 0.3% accuracy from 5% rated current through rating factor at rated burden.
    b. Voltage transformers must maintain 0.15% accuracy from 90% to 110% of rated voltage.
5. All internal devices (relays, transformers, etc.) shall be tagged as to rating and function with permanently fastened engraved nameplates.
6. Control and signal circuits: Control devices, i.e.: contactors, relays, time clocks, etc. shall be mounted in a separate compartment that is fully barrier from the overcurrent protective device compartments. Control devices shall be accessible through a separate hinged cover panel.
7. Relays: All relays shall be industrial control grade with an "ON" indicating neon light, hold down springs, minimum of 10 amp rated contacts and a minimum of four form C contacts. Relays used for control power transfer shall have 20 amp rated contacts. Do NOT use paralleled relays for relays with greater than 4-poles, use relays with the required number of poles. This is to prevent the situation where one relay fails, and half of the intended function is lost, which could be dangerous.

F. Refer to Electrical Drawings for the following:

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

and rating of overcurrent protective devices. Note that the AIC value noted on the Drawings for distribution equipment is the minimum rating of all components; values are in RMS symmetrical amps.

2. If indicated on the Electrical Drawings, provide contactors, relays, time clocks, etc. mounted within switchboard.

G. Miscellaneous requirements:

1. 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.
2. Nameplates: Engraved nameplates shall be provided for each device and all "SPACES" located in the switchboard. An engraved nameplate shall also be provided indicating the switchboard designation. See Section 260553: Electrical Identification for requirements.
3. All control wires shall be labeled with wire markers and referenced to the control wiring diagrams. Provide colored wires with colored stripes to facilitate troubleshooting and locating both ends of wires. Do not use wires with all the same wire color. Use fork, crimp type terminations on all control wires.
4. Provide a test block and plugs for voltage and current monitoring at each main switch. Provide engraved legend plates to indicate function of each test point.
5. Vertically mounted mains shall have the operating handle in the up position when energized.

H. Weatherproof outdoor enclosure and accessories:

1. Provide a NEMA 3R non-walk-in type weatherproof housing with hinged lockable access doors. Each section shall have a minimum of 13-inch deep vestibule. Provide a latch for each door to ensure adequate closing pressure to seal against harmful weather.
2. Provide each section of the switchboard with the following items with power obtained from a control power transformer and circuit breaker within the switchboard.
   a. Thermostatically controlled space heater.
   b. 120 volt AC industrial grade fluorescent lights inside each section vestibule.
   c. One 120 volt AC GFCI type duplex outlet with weatherproof cover. Connect to 120 volt AC light circuit.
3. The weatherproof housings shall be provided with lifting eyes.

I. Finish:

1. 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. A seven-step spray wash electroplate primer with final baked-on enamel finish; ANSI 61 (light gray) is an acceptable finish alternative.

2.03 SOURCE QUALITY CONTROL

A. Factory testing:

1. The switchboard shall be completely assembled, wired, adjusted, and tested at the factory. After assembly, the complete switchboard shall be tested for operation under simulated conditions to assure the accuracy of the wiring and the functioning of all equipment.
2. The main circuits shall be given a dielectric test of 2200 volts for one minute between current carrying components and ground and between opposite polarities. The wiring and control circuits shall be given a dielectric test of 1500 volts for one minute between current carrying components and ground.

PART 3 - EXECUTION

3.01 EXAMINATION

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

3.02 PREPARATION

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

B. As shown on the Drawings, provide a concrete pad beneath equipment.

3.03 INSTALLATION

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

B. Handling, storage, installation and energize of switchboards shall be carried out in accordance with latest edition of NEMA Publications PB 2.1.

C. Freestanding switchboards shall be accurately aligned, leveled, and bolted in place on full-length channels securely fastened to concrete floor.

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

E. Provide mounting hardware brackets, bus bar drilling 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 any panel pieces, doors or trims having dents, bends, warps, or poor fit that may impede ready access, security, or integrity.

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

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

J. Visually inspect switchboards for rust and corrosion if signs of rust and corrosion are present, board shall be restored to new condition or replaced.

3.04 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, testing, and adjustment of the switchboard.

B. 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. Independent Testing Agency shall meet the requirements as outlined in Section 260010: Basic Electrical Requirements. Testing Agencies objectives shall be to:

   1. Assure switchboard 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 switchboard upon satisfactory completion of tests and results.
   5. Verify ratings and settings and make final adjustments.

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

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

E. Prefunctional testing:

   1. Provide Testing Agency with Contract Documents and Manufacturer instructions for installation and testing.
   2. Visual and mechanical inspection:
      a. Compare nameplate information and connections to Contract Documents.
      b. Inspect for physical damage, defects alignment and fit.
      c. Verify appropriate anchorage, required clearances and correct alignment.
      d. Inspect doors, panels and sections for paint, dents, scratches, fit and missing hardware
      e. Check tightness of all control and power connections.
      f. Check that all covers, barriers, and doors are secure.
      g. Verify correct barrier installation.
      h. Verify that relays and overcurrent protective devices meet Drawing, power system study and specified requirements.
      i. Perform mechanical operational tests in accordance with Manufacturer's instructions.
      j. Exercise active components.
      k. Inspect control power and instrument transformers.
      l. Inspect insulators for evidence of physical damage or contaminated surfaces.

m. Ground-fault protection:

1) Verify ground connection is made ahead of neutral disconnect link and on line side of any ground fault sensor.

2) Verify neutral sensors are connected with correct polarity on both primary and secondary.

3) Verify all phase conductors and neutral pass through sensor in same direction for zero sequence systems.

4) Verify grounding conductors do not pass through zero sequence sensors.

5) Verify grounded conductor is solidly grounded.

6) Verify correct operation of self-test panel.

7) Set pickup and time-delay settings in accordance with Specifications. Record operation and test sequences as required by code.

3. Electrical tests:

a. Perform resistance tests through bus joints with low-resistance ohmmeter. Joints that cannot be directly measured due to permanently installed insulation wrap shall be indirectly measured from closest accessible connection.

b. Perform insulation-resistance tests on each bus section, phase-to-phase, and phase-to-ground, at 1000 volt DC for 60-seconds. Investigate resistance values less than 50-megohms.

c. Perform over-potential test on each bus section, each phase-to-ground with phases not under test grounded, in accordance with Manufacturer's published data. Test voltage shall be applied for 60-seconds.

d. Perform insulation-resistance tests at 1000 volt DC for 60-seconds on control wiring. Do not perform this test on wiring connected to solid-state components.

e. Perform current injection tests on the entire current circuit in each section of switchgear.

1) Perform current tests by primary injection, where possible, with magnitudes such that minimum of 1 amp flows in secondary circuit.

2) Where primary injection is impractical, utilize secondary injection with minimum current of 1 amp.

3) Test current at each device.

f. Perform tests on all instrument transformers in accordance with Manufacturer's written instructions.

g. Determine accuracy of meters and instruments per Manufacturer's instructions.

h. Perform the following tests on control power transformers:

1) Perform insulation-resistance test. Perform measurements from winding-to-winding and each winding-to-ground. Test voltages shall be determined in accordance with Manufacturer's instructions.

2) Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to correct secondary voltage. Confirm potential at all devices.

3) Verify correct secondary voltage by energizing primary winding with system voltage. Measure secondary voltage with secondary wiring disconnected.

i. Potential transformer circuits:

1) Perform insulation-resistance tests. Perform measurements from winding-to-winding and each winding-to-ground. Test voltages shall be determined in accordance with Manufacturer's instructions.

2) Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to correct secondary voltage.

3) Verify secondary voltage by energizing primary winding with system voltage. Measure secondary voltage with secondary wiring disconnected.

j. Ground resistance:

1) Measure system neutral-to-ground insulation-resistance with neutral disconnect link temporarily removed. Replace neutral disconnect link after test.

2) Measure insulation-resistance of control wiring at 1000 volt DC for 60-seconds. Refer to Manufacturer's instruction for devices with solid-state components

k. Ground fault protection system:

1) Perform the following pickup tests using primary injection:

a) Verify relay does not operate at 90% of pickup setting.

b) Verify pickup is less than 125% of setting or 1200amps, whichever is smaller.

2) For summation type systems using phase-neutral current transformers, verify correct polarities by applying current to each phase-neutral current transformer pair. This test also applies to molded-case breakers using external neutral current transformer.

a) Relay should operate when current direction is the same relative to polarity marks in the two current transformers.

b) Relay should not operate when current direction is opposite relative to polarity marks in the two current transformers.

3) Measure time delay of the relay at 150% or greater of pickup.

4) Verify reduced control voltage tripping capacity at 55% for AC systems and 80% for DC systems.

l. Calibrate digital meters to 0.5-percent and verify meter multipliers.

m. Check phasing of alternate supply sources.

n. Verify operation of switchboard heaters.

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

4. Test values:

a. Bolt torque levels shall be in accordance with Manufacturer's requirements.

b. Compare bus connection resistances to values of similar connections.

c. Insulation-resistance values for bus, control wiring and control power transformers shall be in accordance with Manufacturer's published data. Values of insulation resistance less than Manufacturer's minimum levels should be investigated. Over-potential tests should not proceed until insulation-resistance levels are raised above minimum values.

d. Insulation shall withstand the over-potential test voltage applied.

e. Determine contact resistance in microhms. Resistance values shall not exceed high limit of normal range as indicated in Manufacturer's published data.

f. System neutral-to-ground insulation shall be a minimum of one megohm.

g. Ground fault protection systems relay timing shall be in accordance with Manufacturer's Specifications but must also be no longer than one second at 3000 amps.

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.

3.05 CLEANING

A. Prior to energizing of switchboard, 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 switchboard 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 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 262816

OVERCURRENT PROTECTIVE DEVICES

PART 1 - GENERAL

1.01 SUMMARY

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

1. Molded case circuit breakers.

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

1.02 REFERENCES

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

1. Underwriters Laboratories, Inc. (UL):

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

2. National Electrical Manufacturer Association (NEMA):

NEMA AB 1;	Molded Case Circuit Breakers.

1.03 SUBMITTALS

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

1. Data/catalog cuts for each product and component specified herein, listing all physical and electrical characteristics and ratings indicating compliance with all listed standards.
2. Describe product operation, equipment and dimensions and indicate features of each component.
3. Clearly mark on each data sheet the specific item(s) being submitted and the proposed application.
4. Provide factory certification of trip characteristics for each type and rating of circuit breaker.
5. Provide current let-through and melting time information for each type and rating of fuses.
6. Confirmation in writing of compliance with Arc Energy Reduction per CEC Articles 240.67 and 240.87.
7. Submit Manufacturer's installation instructions.
8. Complete bill of materials listing all components.
9. 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 (or equal) shall be acceptable if in compliance with all features specified herein and indicated on the Drawings.

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

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

2.02 GENERAL

A. Overcurrent protective devices shall satisfy all CEC mandated selective coordination requirements.

B. Circuit breakers rated (or can be adjusted) 1200 amps or higher shall satisfy CEC Article 240.87 requirements.

2.03 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.

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

G. 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.

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

I. Circuit breakers with frame ratings 100 amps 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.

J. Circuit breakers with frame ratings above 100 amps through 400amps 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.

K. Circuit breakers with frame ratings above 401 amps through 2500 amps shall have microprocessor-based RMS sensing trip units with the following characteristics:

1. Interchangeable current rating plug or an adjustable trip setting to match the trip rating as indicated on Drawings.

2. Adjustable long-time pick-up setting. Minimum of five settings from 50% to 100%.
3. Adjustable long-time delay setting. Minimum of three delay bands.
4. Adjustable short time pick-up setting. Minimum of five settings from 200% to 800%.
5. Adjustable short-time delay setting. Minimum of three delay bands with I2t IN and OUT curves.
6. Adjustable instantaneous pick-up setting. Minimum of five settings from 200% to 1000%. Where the instantaneous feature is omitted on the Drawings, the trip unit shall have an instantaneous override feature.
7. Zone selective interlocking (ZSI) for short-time delay and ground-fault delay trip functions, if indicated on the drawings.
8. LED status indication to show “health” of trip unit.
9. Three-phase ammeter, if indicated on the drawings.
10. Trip indication targets on overload, ground fault and short circuit, if indicated on the drawings.

L. Accessories: Provide accessories as noted on the Drawings, i.e. shunt-trip, auxiliary contacts, undervoltage trip, alarm switch, etc.

M. 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.

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

O. Breaker shall be rated to operate in an ambient temperature of 40-degrees C and at 100% of their frame ampere rating on a continuous basis.

P. For circuit breakers rated or can be adjusted to 1200 amps (or higher), provide zone selective interlocking (ZSI) with downstream protective devices, if indicated on the drawings. If ZSI is not indicated on the drawings, provide a key interlock maintenance mode switch and blue LED indicating lamp in the same section, which shall allow an operator to manually enable arc energy reduction protective device maintenance settings to reduce the arc flash energy level in accordance with CEC Article 240.87 requirements. Key shall be held captive when maintenance mode signal is disabled and removable when maintenance mode signal is enabled. Maintenance mode switch positions shall be labeled “Enabled” and “Disabled”. Blue indicating lamp shall be push-to-test type.

Q. Refer to the Drawings for breakers requiring ground fault protection. See Section 262413: Switchboards for requirements of ground fault protection system.

PART 3 - EXECUTION

3.01 EXAMINATION

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

3.02 INSTALLATION

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

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

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

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 prior to system being energized.

E. Prefunctional testing:

1. Provide Testing Agency with Contract Documents and Manufacturer instructions for installation and testing.

2. Visual and mechanical inspection:

a. Inspect for physical damage, defects alignment and fit.

b. Perform mechanical operational tests in accordance with Manufacturer's instructions.

c. Compare nameplate information and connections to Contract Documents.

d. Check tightness of all control and power connections.

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

3. Electrical tests:

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

   b. Test all circuit breakers with frame size 225 amps and larger in each panelboard, distribution board, switchboard, etc. unless otherwise noted via primary current injection testing. Testing shall verify the following:

      1) Determine that circuit breaker will trip under overcurrent conditions, with tripping time in conformance with NEMA AB 1 requirements.

      2) Circuit breaker pickup and delay measurements are within the manufacturers published tolerances for long time, short time, instantaneous, and ground fault.

      3) For circuit breakers rated or can be adjusted to 1200 amps (or higher), confirm ZSI protection is acceptable or the maintenance mode switch is operational (enabled and disabled) with reduced pickup and delay measurements when enabled.

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

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

3.04 ADJUSTING

A. Adjust circuit breaker trip settings based on recommendations of Section 260060: Power System Study.

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

C. 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 270010

BASIC COMMUNICATION REQUIREMENTS

PART 1 - GENERAL

1.01 SUMMARY

A. Table of Contents, Division 27 - Communications:

SECTION NO.	SECTION TITLE
270010	BASIC COMMUNICATION REQUIREMENTS
270528	COMMUNICATION PATHWAYS
271500	COMMUNICATION HORIZONTAL CABLING

B. Work included: This Section includes general administrative and procedural requirements for Division 27. 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.
3. Submittals.
4. Coordination.
5. Record documents.
6. Operation and maintenance manuals.
7. Excavation
8. Rough-in.
9. Communication installation.
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 27 Sections.
2. Earthwork: Include trenching, backfilling, boring and soil compaction as required for the installation of underground conduit, in-grade pull boxes, vaults, etc. Refer to Division 31, Earthwork.
3. Concrete Work: Include forming, steel bar reinforcing, cast-in- place concrete, finishing and grouting as required for underground conduit encasement, pull box slabs, vaults, etc. Refer to Division 03, Concrete.
4. Conduit: Include conduit and boxes for Interbuilding and Intrabuilding distribution of cabling. Refer to Division 26: Sections 260531, 260533, and 260543.

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:

1. California Electrical Code (CEC).
2. California Building Code (CBC).
3. California Fire Code (CFC).
4. California Mechanical Code (CMC).

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
BICSI	Building Industry Consulting Service International, Inc
EIA	Electronics Industries Alliance
FCC	Federal Communications Commission
ICEA	Insulated Cable Engineers Association
IEEE	Institute of Electrical and Electronics Engineers, Inc
NEMA	National Electrical Manufacturer's Association
NFPA	National Fire Protection Association
TIA	Telecommunication Industry Association
UL	Underwriters' Laboratories

1.03 DEFINITIONS

A. The following list of terms as used in the Division 27 documents shall be defined as follows:

1. Adapter: Shall mean a connecting device joining two fiber connectors, either like or unlike.
2. Administration: The methodology defining the documentation requirements of a cabling system and its containment, the labeling of functional elements and the process by which moves, additions, and changes are recorded.
3. Attenuation: The decrease in magnitude of transmission signal strength between points, expressed in dB as the ratio of output to input signal level.

4. Attenuation-to-crosstalk ratio (ACR): The ratio obtained by subtracting insertion loss (attenuation dB) from near-end crosstalk (dB). ACR is normally stated at a given frequency.
5. Auditory assistance device: An intentional radiator used to provide auditory assistance to a handicapped person or persons. Such a device may be used for auricular training in an educational institution, for auditory assistance at places of public gatherings, such as a church, theater, or auditorium, and for auditory assistance to handicapped individuals, only, in other locations.
6. Backboard: Backboard generally refers to the 3/4" A-C grade plywood sheeting, lining the walls of the telecommunications room. Plywood shall be void-free, with two coats of fire-retardant paint matching the painted interior walls covering both sides.
7. Backbone: A facility (e.g., pathway, cable, or conductors) between any of the following spaces: telecommunications rooms, common telecommunications rooms, floor-serving terminals, entrance facilities, equipment rooms, and common equipment rooms.
8. Basic link test configuration: Horizontal cable of up to 295 feet plus up to 6.5 feet of test equipment cord from the main unit of the tester to the local connection, and up to 6.5 feet of test equipment cord from the remote connection to the remote unit of the tester. Maximum length is 308 feet.
9. Bonding Conductor (BC): A conductor used specifically for the purpose of bonding.
10. Cable Labeling System:
    a. The scheme employed when identifying cable or its associated hardware.
    b. Scheme adapted for labeling cables to identify them based on ANSI/TIA/ EIA-606-A, Administration Standard for Commercial Telecommunications Infrastructure.
11. Cable Runway: Hardware designed and manufactured for horizontal pathway distribution of cable and inside wiring inside the MC, IC, or TR rooms.
12. Cabling: A system comprised of cables, wires, cords, and connecting hardware.
13. Ceiling Distribution System: A distribution system that utilizes the space between a suspended or false ceiling and the structural surface above.
14. Channel: End-to-end transmission path, i.e. the entire portion of the horizontal cabling to each outlet consisting of the Permanent Link, line cord (at the workstation), patch cord, and, if a full cross-connection is implemented, the cross-connect termination/connecting apparatus and equipment cord.
15. Connect: To install required patch cords, equipment cords, cross-connect wires, etc. to complete an electrical or optical circuit.
16. Cord: Shall mean length of cordage having connectors at each end. The term “cord” is synonymous with the term “jumper” and “lead.”
17. Entrance Conduit: Conduit that connects the campus underground infrastructure with the building's Telecommunications Room.
18. Fire Retardant: Any substance added to delay the start or ignition of fire or slow the spread of the flame of any material.

19. Firestopping: The process of installing (specialty) listed fire-rated materials into penetrations of fire-rated barriers to reestablish the fire-resistance rating of the barrier.
20. Firestopping Location: A penetration through a fire-rated wall with a sleeve.
21. Firestop System: A specific installation consisting of the material(s) (firestop penetration seals) that fill the opening in the wall or floor assembly, and around and between any items that penetrate the wall or floor (e.g., cables, cable trays, conduit, ducts, pipes), and any termination devices (e.g., electrical outlet boxes) along with their means of support.
22. Horizontal Cabling: The part of the cabling system that extends from the work area telecommunications outlet to the horizontal cross-connect in the telecommunications room.
23. Hybrid Cable: An assembly of two or more cables, of the same or different types or categories, covered by one overall sheath.
24. Identifier: A unique code assigned to an element of the communication infrastructure that links it to its corresponding record.
25. Infrastructure (Telecommunications): A collection of those telecommunications components, excluding equipment, that together provide the basic support for the distribution of all information within a building or campus.
26. Loose Tube: A type of optical fiber cable construction where one or more fibers are laid loosely in a tube. Also called loose tube fiber.
27. Passive link segment: Shall mean the cable, connectors, couplings, and splices between two fiber optic termination units.
28. Permanent link: Test configuration for a horizontal cabling link excluding test cords, connections at the ends of the test cords, patch cords, equipment cords, line cords, etc. The “permanent” portion of the horizontal cabling to each outlet consisting of cable, consolidation point (if used), termination/connecting apparatus in equipment rooms, and the connectors at outlets.
29. Telecommunications Entrance Facility: Utility Partnerships/Alternate Carrier Minimum Point of Entry that is usually located within the Main Cross-connect Room (MC).

B. Abbreviations:

1. AFF: Above Finish Floor. Standard mounting height (e.g. 18” AFF) for a device using the center line of the device as the measurement point.
2. BEP: Building Entrance Protection. For termination of OSP twisted pair cabling.
3. CAT: Category. Used when identifying the performance characteristics of twisted pair cabling.
4. CMP: Communication Media Plenum. Rating applied to ISP twisted pair cable. Cable shall be listed as being suitable for use in ducts, plenums, and other spaces used for environmental air and shall also be listed as having adequate fire-resistant and low smoke-producing characteristics. Cables must pass required test for fire and smoke characteristics of wires and cables, NFPA 262 or UL 910.

5. CMR: Communication Media Riser. Rating applied to ISP twisted pair cable. Cable shall be listed as being suitable for use in a vertical run in a shaft or from floor-to-floor and shall also be listed as having fire-resistant characteristics capable of preventing the carrying of fire from floor to floor. Cables must pass requirements for flame propagation.
6. CCTV: Closed-Circuit Television. A private television system, typically used for security purposes, in which the signal is transmitted to a limited number of receivers.
7. EMI: Electromagnetic Interference. Radiated or conducted electromagnetic energy that has an undesirable effect on electronic equipment or signal transmissions.
8. IC: Intermediate Cross-Connect. The cross-connect points between a backbone cable that extends from the main cross-connect and the backbone cable from the horizontal cross-connect.
9. IDF: Intermediate Distribution Facilities. Telecommunication equipment rooms housing network equipment and containing termination fields for backbone cabling from MDF and horizontal cabling from outlet devices.
10. IR: Intermediate Cross-Connect Room. Telecommunication equipment rooms housing network equipment and containing termination fields for backbone cabling from MDF and horizontal cabling from outlet devices.
11. ISP: Inside Plant. Cable installation within building.
12. NAM: Metropolitan Area Network. A data communications network that covers an area larger than a campus area and smaller than a wide area network. Typically interconnects two or more LANs and usually covers an entire metropolitan area.
13. MC: Main Cross-Connect. The cross-connect normally located in the MDF room for cross-connection and interconnection of entrance cables, first-level backbone cables, and equipment cables.
14. MDF: Main Distribution Facilities. Telecommunication equipment room housing possible service entrance facilities for interbuilding backbone cabling, network equipment, house voice system equipment headend, backbone cabling distribution headend, termination fields for backbone and horizontal cabling.
15. MMF: Multimode Fiber Cable. An optical fiber that carries many paths of light or an optical waveguide that allows many bound modes to propagate.
16. MPOE: Minimum Point of Entry. For serving communications utility terminations. House's service provider's termination field(s) and interfaces between utility's facilities and premises facilities.
17. NAM: Network Access Module. Workstations.
18. OFN: Optical Fiber Non-Conductive. General purpose indoor non-plenum rated.
19. OFNP: Optical Fiber Non-Conductive Plenum. Plenum rated cable.
20. OFNR: Optical Fiber Non-Conductive Riser. Non-plenum rated riser cable.
21. OSP: Outside Plant. Cable installation outside of building.
22. PIC: Plastic Insulated Conductors.

23. PVC: Polyvinyl Chloride.
24. SMF: Singlemode Fiber Cable. An optical fiber, usually step-index grade, which supports only one mode of light propagation. This does not necessarily imply single wavelength operation. The light source is normally a laser.
25. STR: Strand. A single unit of optical fiber within a cable (e.g., a 12-strand fiber cable has 12 individual optical fibers within the cable sheath).
26. TMGB: Telecommunications Main Grounding Busbar. A grounding busbar, located in the MDF room, connected to the power system main building ground bus by a continuous #1/0 THHN wire.
27. TGB: Telecommunication Grounding Busbar. A grounding busbar, located in the IDF and MPOE rooms, connected to the telecommunication main ground bus at ground or second floor, and as a riser to all stacked IDF rooms by a continuous #1/0 THHN wire.
28. TER: Telecommunications Equipment Room. A centralized space that provides space and maintains a suitable operating environment for the termination of backbone and campus cabling and house centralized communications and/ or computer equipment (such as Core Switches and Servers). Note: An equipment room is considered distinct from a telecommunications closet because of the nature or complexity of the equipment housed by the equipment room.
29. TR: Telecommunications Room. A room dedicated to housing a group of telecommunications connectors (e.g., patch panel or punch-down block) that allows equipment and backbone cabling to be cross connected with patch cords or jumpers.
30. UTP: Unshielded Twisted Pair. Copper cable type.

1.04 SUBMITTALS

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

B. Submittals shall consist of detailed Shop Drawings, Specifications, block wiring diagrams, "catalog cuts" and data sheets containing physical and dimensional information, performance data, electrical characteristics, materials used in fabrication and material finish. Clearly indicate by arrows or brackets precisely what is being submitted on and those optional accessories which are included and those which are excluded. Furnish quantities of each submittal as noted in Division 01.

C. Each submittal shall be labeled with the Specification Section Number and shall be accompanied by a cover letter or shall bear a stamp stating that the submittal has been thoroughly reviewed by the Contractor and is in full compliance with the requirements of the Contract Documents or provide a Specification Section line-by-line compliance response statement with detailed exception/ deviation response statements for all applicable provisions for the applicable Specification Section. Any Specification Section lines without a detailed exception/ deviation response statement shall be treated as the Contractor or Vendor is submitting in full compliance with the applicable Specification Section requirements. 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 communications equipment rooms and closets if the proposed installation layout differs from the construction

documents. Physical size of communications equipment indicated on the Drawings shall match those of the communications equipment that is being submitted for review, i.e.: equipment racks, cable ladder, fuse protectors, ground bars, etc. Minimum scale: 1/4" = 1'- 0". Revised communications equipment layouts must be approved prior to release of order for equipment and prior to installation.

E. As part of the equipment submittals, the Contractor shall provide anchorage calculations for floor and wall mounted communication equipment, conduits, and raceways, in conformance with the latest edition of the California Building Code (CBC) and ASCE 7. Use the Occupancy Category, Ground Accelerations, Site Class, Seismic Design Category, and Seismic Importance Factor as noted in the structural drawings. For components required for Life Safety or containing hazardous materials use Ip=1.5. Structural Calculations shall be prepared, stamped, 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. Review of submittals is for general conformance to design concept and general compliance with the Specification Sections. Submittal Review Comments do not imply waiver of Specifications Section requirements unless specifically noted.

H. All re-submittals 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. Re-submittal packages will not be reviewed unless accompanied by this cover letter. Failure to include this cover letter will constitute rejection of the re-submittal package.

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 and Owner shall be notified as delineated in the Special Provisions and the articles of the Contract.
2. In the event that time does not permit notification or clarification of discrepancies prior to the Bid Opening, the governing ranking of documents established in Article X of the Contract Documents shall be applied. Such discrepancies shall be noted and clarified in the Contractor's Bid.
3. No additional allowances will be made due to conflicts, errors, ambiguities or omissions that reasonably should have been discovered during preparation of the Contractor's Bid.

1.

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 communications 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 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 telecom outlets, patch panels, termination blocks, security panels, security devices, fiber panels, fire alarm panels, intercom systems, clock system, video system, labeling of all components and systems, correct conduit and cabling as well as routing, revised fire alarm schedule listing Manufacturers and products actually installed. Contractor shall record all changes in the Work during the course of construction on 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) or building information modeling (Revit) process. A set of CAD or Revit files of the communication construction documents will be provided to the Contractor by the Engineer.

3. Record drawing submissions shall be provided to the Engineer to review upon the completion of the following phases of Work:

a. All underground installation.

b. Building communications rough-in.

c. Final communications installation.

4. A single set of half size prints of the Record Drawings shall be submitted for review. Upon receipt of the Engineer's review comments, corrections shall be made, and the Contractor shall provide the following:

a. One sets of full-size prints.

b. Two sets of half size prints.

c. One electronic file of Cad or Revit

d. One electronic set in pdf.

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 27. Binders shall be indexed into Division Sections and labeled for easy reference. Bulletins containing more information than the equipment concerned shall be properly stripped and assembled.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.01 EXCAVATION

A. General: Cutting and digging shall be under the direct supervision of the General Contractor and included as necessary for the Work of this Section.

B. Excavation for underground vaults and electrical structures: Conform to elevations and dimensions indicated within a tolerance of plus or minus 0.10-feet; plus, a sufficient distance to permit placing and removal of concrete formwork, installation or services, other construction and for inspection.

1. Excavate, by hand, areas within dripline of large trees. Protect the root system for damage and dry-out. Maintain moist conditions for root system and over exposed roots with burlap. Paint root cuts of 1 inch in diameter and larger with emulsified asphalt tree paint.

2. Take care not to disturb bottom of excavation. Excavate by hand to final grade just before concrete reinforcement is placed.

C. Trenching: Excavate trenches for electrical installation as follows:

1. Excavate trenches to the uniform width, sufficiently wide to provide ample working room and a minimum of 6 to 9 inches clearances on both side of raceways and equipment.

2. Excavate trenches to depth indicated or required.

3. Limit the length of open trench to that in which installations can be made and the trench backfilled within the same day.

4. Where rock is encountered, carry excavation below required elevation and backfill with a layer of crushed stone or gravel prior to installation of raceways and equipment. Provide a minimum of 6 inches of stone or gravel cushion between rock bearing surface and electrical installations.

D. Backfilling: Place soil materials in layers to required subgrade elevations for each area classification, using materials and methods specified in Division 31, Earthwork.

1. Under building slabs, use drainage fill materials.

3.02 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-in with field measurements and with the requirements for the actual equipment to be connected.

3.03 COMMUNICATIONS 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 communications 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 communications materials and equipment for efficient flow of the Work. Give 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. 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.
8. Install systems, materials, and equipment level and plumb, parallel, and perpendicular to other building systems and components, where installed exposed in finished spaces.
9. Install communications 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.
10. Coordinate communications systems, equipment, and materials installations with other building components.
11. 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.
12. Install systems, materials and equipment giving right-of-way priority to other systems that are required to maintain a specified slope.
13. Conform to the National communications Contractor's Association "Standard of Installation" for general installation practice.

3.04 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 communications systems equipment, components, and materials as indicated, including but not limited to removal of communications 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 communications 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.

3.05 FIELD QUALITY CONTROL

A. General testing requirements:

1. The purpose of testing is to ensure that all tested communications 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 All systems for proper operation

2. Circuit numbering verification: Select on a random basis various patch panel ports and wire test to verify compliance of the port labeling with actual field wiring.

C. Contractor shall perform testing on fiber strands with an OTDR and Power Meter.

D. Contractor shall perform testing on each cable of the Structured Cabling system with test equipment that will provide a full test of the EIA/TIA requirements for the installed category cable and provide test results of each cable under test.

E. 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.

F. 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.

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

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

I. 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.

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

K. Include all test results in the maintenance manuals.

3.06 CLEANING

A. Prior to acceptance of communications systems, the Contractor shall thoroughly clean communications rooms 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 communications 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.

3.07 PROJECT CLOSEOUT

A. Training: At the time of completion, a period of not less than 2-hours shall be allotted by the Contractor for instruction of building operating and maintenance personnel in the use of all systems. This 2-hours training is in addition to any instruction time called out in the Specifications for specific systems. 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 270528

COMMUNICATION PATHWAYS

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 and fittings.
2. Fire-rated wall and floor through-penetration.
3. Boxes
4. Vaults
5. J-Hooks.

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 03: Cast-in-place concrete. Protective envelope for underground conduit installations.

1.02 REFERENCES

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

1. American National Standards Institute (ANSI)/National Electrical Manufacturer Association (NEMA):

ANSI C80.3;	Electrical Metallic Tubing, Zinc Coated.
ANSI/NEMA OS-1;	Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports.
NEMA 250;	Enclosures for Electrical Equipment (1000 volts maximum).

2. American Society for Testing and Materials (ASTM):

ASTM E84;	Surface Burning Characteristics of Building Materials
ASTM E119;	Fire Tests of Building Construction and Materials
ASTM E814;	Fire Tests of Penetration Fire Stops
ASTM E1725;	Standard Test Methods for Fire Tests of Fire Resistive Barrier Systems for Electrical System Components

3. Underwriters Laboratories, Inc. (UL):

UL 50;	Enclosures for Electrical Equipment, Non-Environmental Considerations.
UL 263;	Fire Tests of Building Construction and Materials

UL 514A;	Metallic Outlet Boxes.
UL 514B;	Conduit, Tubing and Cable Fittings.
UL 635;	Insulating Bushings.
UL 651;	Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings.
UL 651A;	Schedule 40 and 80 High Density Polyethylene (HDPE) Conduit.
UL 723;	Surface Burning Characteristics of Building Materials
UL 797;	Electrical Metallic Tubing - Steel.
UL 1479;	Fire Tests of Through Penetration Firestops
UL 1773;	Termination Boxes.
UL 2239;	Hardware for the Support of Conduit, Tubing, and Cable

4. National Electrical Manufacturer Association (NEMA):

NEMA TC 2;	Electrical Plastic Tubing and Conduit.
NEMA TC 3;	PVC Fittings for use with Rigid PVC Conduit.
NEMA TC 6;	PVC Plastic Utilities Duct (EB and DB Type)
NEMA TC 9;	Fittings for PVC Plastic Utilities Duct (EB and DB Type)

1.03 SYSTEM DESCRIPTION

A. Conduits supported from structure and within stud walls for the continuous routing of communication cables, where non-accessible concealed Work is indicated and where required by Code and/or shown on the Drawings. Conduits shall be sized for a 40-percent maximum cable fill ratio.

B. Assemblies supported from structure for the continuous routing of communication cables, where exposed Work is indicated on the Drawings.

C. J-Hooks supported from structure, above suspended ceiling, for the routing of communication cables, where accessible through ceiling and where shown on the Drawings. J-hooks shall be sized for a 40-percent maximum cable fill ratio.

D. Where exposed cable routing is indicated, provide conduit sleeves through walls, above suspended ceilings or at cable routing elevation, with insulated bushings on both ends, for access into enclosed spaces, i.e., offices, workrooms, conference rooms, etc. Sleeves shall be 2” minimum and 4” maximum conduits and shall be sized for a 40-percent maximum cable fill ratio.

E. Provide UL listed fire-rated sleeves for passing through 1 and 2-hour rated walls and/or floors assemblies.

1.04 SUBMITTALS

A. Submit in accordance with the requirements of Section 270010: Basic Communications 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. Furnish structural calculations for equipment anchorage as described in Section 270010: Basic Communications Requirements.
4. Submit Manufacturer's installation instructions.
5. Complete Bill of Material listing all components.

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

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 or equal shall be acceptable if in compliance with all features specified herein and indicated on the Drawings.

1. Conduit:
   a. Metal conduit:
      1) Allied Tube and Conduit Co.
      2) Triangle PWC, Inc.
      3) Western Tube and Conduit Corp.
   b. Nonmetallic conduit:
      1) Prime Conduit.
      2) JM Eagle.
      3) Cantex.
   c. Fittings:
      1) Appleton Electric Co.
      2) OZ/Gedney.
      3) Thomas & Betts Corp.
      4) Carlon.
2. Fire-rated penetration assemblies:
   a. EZ-Path, STI Firestop.
   b. Hilti
   c. 3M
   d. Lowry’s, Inc.

3. Boxes:
    a. Outlet and junction boxes:
        1) Spring City Electrical Manufacturing Co.
        2) Thomas & Betts Corp.
        3) Raco, Inc.
    b. Cast boxes:
        1) Appleton Electric Co.
        2) Crouse-Hinds.
    c. Floor boxes:
        1) Hubbell Inc.
        2) Walker.
        3) Wiremold/Legrand.
    d. Pullboxes:
        1) Circle AW Products.
        2) Hoffman Engineering Co.
4. Precast concrete vaults:
    a. Oldcastle Enclosure Solutions.
    b. Jensen Precast.
5. J-Hook Systems:
    a. nVent CADDY Cat HP
    b. Or approved equal

B. Substitutions: Under provisions of Section 270010: Basic Communications Requirements.

2.02 CONDUIT

A. Electrical metallic tubing (EMT):

1. 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.
2. Set screw type couplings: Hot dip galvanized, 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.
3. Set screw type connectors: Hot dip galvanized, 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.
4. Raintight couplings: Hot dip galvanized, steel or cast malleable iron; UL listed raintight and concrete tight, using gland and ring compression type construction.

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

B. Rigid non-metallic conduit (PVC)

1. Conduit:

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

b. Rigid polyvinyl chloride, Type EB or DB conforming to NEMA TC 6 and UL 651, latest edition. UL listed for concrete encased burial and direct burial applications and for 90 degrees C conductor insulation. Conduit shall include an integral bell fitting at one end.

2. Fittings: Couplings, adaptors, transition fittings, etc., shall be molded PVC, slip on, solvent weld type conforming to NEMA TC3 for Schedule 40 or 80 and NEMA TC 9 for type EB or DB.

C. Miscellaneous conduit fittings and products:

1. 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.

2. 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.

3. 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.

4. 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 0.75-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.

5. Standard products not herein specified:

a. Provide listing of standard electrical conduit hardware and fittings not herein specified for approval prior to use or installation, i.e. locknuts, bushings, etc.

b. Listing shall include Manufacturers name, part numbers and a written description of the item indicating type of material and construction.

c. Miscellaneous components shall be equal in quality, material and construction to similar items herein specified.

2.03 FIRE-RATED WALL AND FLOOR THROUGH-PENETRATION

A. General:

1. Through-penetration firestop system shall have been tested for specific fire resistance rated construction conditions or acoustical and smoke related requirements conforming to construction assembly type, penetrating item type, annular space requirements, and rating involved for each separate instance.
2. Firestop rating shall match that of the wall or floor construction being penetrated.
3. Firestop systems shall be as outlined below:
    a. Firestop putty.
    b. Firestop putty pads.
    c. Fire-rated cable pathways.

B. Firestop putty:

1. Intumescent, non-hardening, water resistant putties containing no solvents, inorganic fibers, or silicone compounds.
2. Putty shall be used to seal openings around conduit penetrations through rated walls or floors, to maintain the construction rating.

C. Firestop putty pads:

1. Intumescent, non-hardening, pliable putty pads designed to seal both through and membrane penetrations against the spread of fire and smoke around outlet boxes in rated construction.
2. The pads are 6” x 8” x 0.125” thick.
3. Pads are rated for up to 4-hour rated wall assemblies.

D. Fire-rated cable pathway penetrations:

1. Cable pathway penetrations shall be used in fire-rated construction for low-voltage cabling, where cables pass through fire-rated wall or floor construction.
2. Cable pathways shall consist of an enclosed heavy-gauge galvanized steel housing lined with intumescent material engineered for rapid expansion when exposed to fire or high temperatures, quickly sealing the pathway, and preventing the passage of flames and smoke. The pathway shall be approximately 4” square x 14” long.
3. Cable pathways shall meet the hourly fire-rating of fire rated wall and/or floor penetrated.
4. Cable pathways shall be tested for the surrounding construction and cable types involved.
5. Pathways shall be UL Systems permitting cable loads from 0 to 100-percent fill. This requirement eliminates need for fill-ratio calculations to be made by cable technicians to ensure cable load is within maximum allowed by UL System.
6. Pathway shall be maintenance-free, having a corresponding Evaluation Services Report from a Nationally Recognized Third-Party Laboratory. Maintenance-free

is defined as no action required by cabling technician to open and/or close pathway for cable moves, adds or changes, such as, but not limited to:

a. Opening or closing of doors.

b. Spinning rings to open or close fabric liner.

c. Removal and or replacement of any material such as, but not limited to, firestop caulk, putty, pillows, bags, foam muffins, foam, foam plugs, foam blocks, or foam closures of any sort.

d. Evaluation Services Report (ESR) from an accredited Nationally Recognized Third-party Laboratory certifying compliance with this definition of “Maintenance-Free” and all relevant codes and standards.

7. Pathways shall be engineered such that two or more devices may be ganged together for larger cable capacities.

8. Pathways shall be engineered to be re-enterable so they can be retrofitted and removed from around existing cables without cutting and re-splicing them.

9. Affix adhesive wall label immediately adjacent to devices to communicate to future cable technicians, authorities having jurisdiction and others the manufacturer of the device and the corresponding UL System number installed.

2.04 OUTLET BOXES

A. Standard outlet box:

1. Provide galvanized, one-piece die formed or drawn steel or welded, knockout type box of size and configuration best suited to the application indicated on the Drawings.

2. 4-inch square by 2.125-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. Pull and junction boxes:

1. Sheet metal pull and junction box:

a. 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.

b. ANSI/NEMA OS 1.

2. 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.

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

2.05 VAULTS

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

B. Construction:

1. Monolithic or modular assembled sections.

2. Assembled sections shall have mating edges with tongue and groove joints. Joints shall firmly interlock adjoining components and provide waterproof junctions. Seal joints watertight using preformed plastic strip.

3. Provide lifting devices cast into units for proper handling of units.

4. Identify all structures with Manufacturer's name embedded in or otherwise permanently attached to an interior wall face.

5. Include concrete knockout panels for conduit entrance and sleeve for ground rod.

C. Size and dimensions: As indicated on Drawings.

D. Accessories:

1. Frames and covers: Cast iron with cast-in legend “COMMUNICATIONS” or "LOW-VOLTAGE" as appropriate. Machine cover-to-frame bearing surfaces.

2. Pulling eyes in walls: Eyebolt with reinforcing bar fastening insert. 2-inch diameter eye, 1-inch by 4-inch bolt. Working load embedded in 6-inch, 4000-PSI concrete: 13,000 pounds minimum tension.

3. Pulling and lifting irons in floor: 7/8-inch diameter, hot-dipped galvanized, bent steel rod, stress relieved after forming and fastened to reinforced rod. Exposed triangular opening. Ultimate yield strength: 40,000 pounds shear and 60,000 pounds tension.

4. Bolting inserts for cable stanchions: Flared, threaded inserts of non-corrosive, chemical resistant, nonconductive thermoplastic material; 1/2-inch internal diameter by 2.75-inch deep, flared to 1.25-inch minimum at base. Tested ultimate pull-out strength at 12,000pounds minimum.

5. Expansion anchors for installation after concrete is cast: Zinc-plated carbon steel wedge type with stainless-steel expander cup 1/2-inch bolt size, 5,300 pound rated pull-out strength and 6800pound rated shear strength minimum.

6. Cable stanchions: Hot-rolled, hot-dipped, galvanized "T" section steel, two 1/4-inches size, punched with 14-holes on 1.5-inch centers for cable arm attachment.

7. Cable arms: 3/16-inch thick hot-rolled, hot-dipped galvanized sheet steel pressed to channel shape, approximately two 12-inches wide by 14-inches long

and arranged for secure mounting in horizontal position at any position on cable stanchions.

8. Cable support insulators: High glaze, wet-process porcelain arranged for mounting on cable arms.
9. Ground rods: Solid copper, 3/4-inch diameter by 10-feet length (minimum).
10. Ground wire: Stranded bare copper conductor, #6 AWG (minimum). Size in accordance with CEC Article 250.
11. Steps: Cast iron, suitable for shape and construction.

2.06 J-HOOK “NON-CONTINUOUS” CABLE SUPPORT SYSTEM

A. General:

1. J-hooks shall provide a bearing surface of sufficient width to comply with required bend radii of high-performance cables per ANSI/TIA 568.0-D.
2. J-hooks shall have flared edges to prevent damage while installing cables.
3. J-hook shall have a cable retainer wire form to provide containment of cables within the hanger. The cable retainer shall be removable and reusable.
4. J-hook shall have a hot-dipped galvanized or G60 finish and shall be rated for indoor use in non-corrosive environments.
5. J-hook shall be made using a metal thickness of 0.052” and in a finish and hardness.
6. Attaching J-hooks and assemblies to ceiling support wires is not allowed per the CEC.

B. Multi-tiered field assemblies:

1. Multi-tiered J-hook assemblies shall be used where separate cabling compartments are required. Assemblies may be created by joining the J-hook with snap-on tree-mounting brackets. Assemblies can be made single-sided for wall-mount applications or single/double sided for ceiling/beam/threaded rod suspended applications. The assembly is rated for indoor use in non-corrosive environments.
2. For installation on threaded rod, a snap-on angle bracket must be added on top of the assembly.
3. If required, the multi-tier J-hook assembly can be attached to snap-on angle or straight brackets riveted to beam clamps, flange clips, angle brackets, etc.

C. Factory assembled multi-tier J-hook assemblies: The assemblies shall be used where separate cabling compartments are required. These assemblies are assembled by the factory. Multi-tier assemblies are available for specific applications including wall mount, ceiling mount, threaded rod mount, and beam/flange mount. The beam/flange mount assembly shall include a beam clamp rated to hold the weight of any of the multi-tier configurations. Assemblies shall be available in 1, 2, 3, & 4 tier double-sided and 2, 3, & 4 tier in single-sided configurations. The assembly shall be rated for indoor use in non-corrosive environments.

D. J-hook assemblies shall be furnished with appropriate fittings and add-on devices to allow for supports in multiple applications. Support fittings and add-on devices

include beam or flange fasteners, threaded rod fasteners, support wire fasteners, construction channel support fasteners, wall or concrete or joist fasteners, raised access floor pedestal supports, etc.

E. Finishes: ASTM B633 Standard Specification for Electro-Deposited Coatings of Zinc on Iron and Steel, or ASTM A924/A924M Standard Specification for General Requirements for Steel Sheet, Metallic Coated by the Hot Dip Process

F. Material: Base material of the J-hooks shall be metal (at least a 0.052” thickness). Any fasteners used to affix the J-hooks shall also be metal and shall be fastened to the metal of the J-hook support.

PART 3 - EXECUTION

3.01 EXAMINATION

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

3.02 CONDUIT APPLICATION

A. Electrical metallic tubing (EMT): Shall be used exposed or concealed for interior communication conduits 4" and smaller, 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 communication rooms or closets.

B. Rigid non-metallic conduit (PVC): Shall be used in the following applications:

1. Direct burial ducts: Schedule 80, minimum 24-inches below finished grade.
2. Below roads and paved surfaces:
    a. Schedule 80, minimum 36-inches below finished grade.
3. Penetrations of building and equipment slabs: Schedule 80 conduit.
4. Slope duct to drain towards vaults and away from building and equipment entrances. Pitch not less than 4-inches per 100-feet.
5. Curved sections in duct lines shall consist of long sweep bends with a minimum radius of 25-feet in the horizontal and vertical directions. The use of manufactured bends is limited to building entrances and equipment stub-ups.
6. For communications conduits, do not exceed a combined bend radius of greater than 180-degrees between pull points.
7. Underground conduit stub-ups to inside of building and exterior equipment shall be Schedule 80 conduit.
8. Make joints in ducts and fittings watertight according to Manufacturer's instructions. Stagger couplings so those of adjacent ducts do not lie in the same plane.
9. Terminate duct lines at vaults with end bells spaced 10-inches on center for 5-inch ducts and varied proportionately for other duct sizes. Change from regular spacing to end-bell spacing 10-feet from the end bell without reducing duct line

slope and without forming trap in the line. Grout end bells into manhole walls from both sides to provide watertight entrance.

10. Separation between direct buried duct lines shall be 3-inches minimum for like systems and 12-inches minimum between power and communication ducts.
11. For direct burial installations install continuous warning strip of heavy gage plastic imprinted "communication ducts below", approximately 12-inch wide at 12-inches above ducts.
12. Mandrel all ducts upon completion of installation and prior to pulling cables.

3.03 PREPARATION

A. Conduit:

1. 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.
2. Where practical, install conduits in groups in parallel vertical or horizontal runs and at elevations that avoid unnecessary offsets.
3. 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.
4. Communications conduits shall not be placed closer than 12-inches to power, a flue, parallel hot water, steam line or other heat producing source or three inches from such lines when crossing perpendicular to the runs.
5. 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.
6. 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.
7. 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.
8. Communication conduit bends shall not exceed 180-degrees within any single run of conduit.
9. 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.

B. Boxes:

1. Install all outlet boxes flush with building walls, ceilings, and floors.

2. Locate pullboxes and junction boxes in concealed locations above removable ceilings or exposed in electrical rooms, utility rooms or storage areas.
3. Install outlet boxes at the locations and elevations indicated on the Drawings or specified herein. Adjust locations as required by structural conditions and to suit coordination requirements of other trades.
4. 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.
5. 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.

C. J-hooks:

1. Location of J-hooks 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.
2. J-hooks 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.
3. J-hooks shall not be placed closer than 3-inches to any branch circuit power raceway.

3.04 INSTALLATION

A. Conduit:

1. Install conduit in accordance with Manufacturer's written instructions, as indicated on Drawings and as specified herein.
2. Minimum communication conduit size: Unless otherwise noted herein or on Drawings, minimum conduit size shall be 1-1/4" for interior applications and 2" for exterior and underground applications.
3. All communication conduit sizes indicated on the Drawings are sized for 40-percent fill or less for category 6 or 6A cable. If cable type or size is changed the Contractor shall be responsible for resizing conduits upward to meet a maximum 40-percent fill.
4. In general, all conduit work shall be concealed where possible. Exceptions shall be communication rooms, exposed ceiling areas, and parking garages.
5. Install conduits in complete runs before pulling in cables or wires.
6. Install conduit free from dented, bruises or deformations. Remove and replace any damaged conduits with new undamaged material.
7. Conduits shall be well protected and tightly covered during construction using metallic bushings and bushing "pennies" to seal open ends.
8. Clean any conduit in which moisture or any foreign matter has collected before pulling in conductors. Paint all field-threaded joints to prevent corrosion.

9. 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.
10. Metallic conduit shall not be in contact with other dissimilar metal pipes (i.e. plumbing).
11. 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.
12. A run of communications conduit between terminations at wire pulling points shall not contain more than the equivalent of two-quarter bends (180-degrees, total).

B. Fire-rated cable pathways:

1. Install cable pathways in accordance with Manufacturer's written instructions, as indicated on Drawings and as specified herein.
2. Install pathways using mounting plates and gasketing that comes with equipment for the application of each installation.
3. Where multi-gang pathway penetrations occur, use framing hardware brackets recommended by manufacturer for specific applications. Pathways shall be furnished with insert hooks and eye windows to connect units together and align them for multi-gang installations.

C. Boxes:

1. Install boxes in accordance with Manufacturer's written instructions, as indicated on Drawings and as specified herein.
2. Locate electrical boxes as indicated on Drawings.
3. Install junction or pullboxes where required to limit bends in conduit runs to not more than 180-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.
4. 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.
5. Leave no unused openings in any box. Install close-up plugs as required to seal openings.
6. Provide cast metal boxes with gasketed cast metal cover plates where boxes are exposed in damp or wet locations.
7. Welded outlet boxes shall only be used in concealed interior installations.
8. Provide an access panel in permanent ceiling or wall where boxes are installed and will be inaccessible.
9. For boxes mounted in exterior walls, make sure that there is insulation behind outlet boxes to prevent condensation in boxes.
10. 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.

D. Vaults:

1. Install precast assembly in accordance with Manufacturer's written instructions, as indicated on Drawings and as specified herein.
2. Install cast iron frame and cover. Set frames in paved areas and traffic ways flush with finished grade. Set other frames 1-inch above finished grade.
3. Units shall be installed on a level 12-inch bed of well-tamped gravel or crushed stone.
4. Install drains in bottom of units where indicated.
5. Install removable hardware, including pulling eyes, cable stanchions, cable arms and insulators, as required for installation and support of cable and conductors and as indicated.
6. Do not drill deeper than 3-7/8” for anchor bolts installed in the field. Use a minimum of 2 anchors for each cable stanchion.

E. J-hooks:

1. Install J-hooks in accordance with Manufacturer's written instructions, as indicated on Drawings and as specified herein.
2. Support J-hooks every 48-inches or less throughout the cable pathway.
3. J-hook support shall consist of 1/4" to 3/8" threaded rods supported from structure above, to structural wall studs with #10 wood or Tek screws or to #12 ceiling wire (independent of ceiling support) to structure.

3.05 PENETRATIONS

A. Conduit:

1. 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:
   a. Where indicated on the Structural Drawings.
   b. As approved by the Structural Engineer prior to construction and after submittal of Drawing showing location, size, and position of each penetration.
2. Cutting or holes:
   a. 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.
   b. 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.

c. 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.

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

3. Sealing:

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

b. Firestop: Where conduits and other communication 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.

4. 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.

a. 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 Schedule 80 PVC conduit.

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

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

d. 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 CONDUIT CONCEALED IN CONCRETE

A. Install conduits approximately in the center of the slab so that there will be a minimum of 1-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 EMT 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 UNDERGROUND CONDUIT INSTALLATION

A. Perform trenching, backfilling and compaction operations as specified in Division 31: Trenching.

B. Install service utility company underground conduits in strict conformance to each utility company's requirements. Obtain a copy of each utility company's installation guidelines prior to commencing Work.

C. Tops of conduits shall be as follows unless otherwise noted:

D. Not less than 18-inches below finished grade.

E. Not less than 30-inches below roadways, paved parking lots, driveways or any surface subject to vehicular traffic.

F. Not less than 4-inches below building floor slab for branch circuits. Major feeders and large signal conduits (2" and greater) at not less than 18-inches.

G. Depth of service utility conduits shall conform to utility company requirements.

H. Furnish and install specified underground conduit marker 12" above conduits in trenches with all buried conduits.

3.08 CONDUIT TERMINATIONS AND JOINTS

A. Use raceway fittings that are of types compatible with the associated raceway and suitable for the use and location.

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

C. Stub-up connections: Extend conduits through concrete minimum of 3" and terminate with insulated bushing.

D. Install specified cable sealing bushings on all conduits originating outside the building walls and terminating 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.

E. 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 green copper ground-bonding jumper installed. For concrete embedded conduit, use expansion and deflection couplings as specified above for three inches and larger conduits.

3.09 SUPPORTS

A. Conduit:

1. Provide supports for raceways as specified in Section 270529: Communication Hangers and Supports.

2. All raceways systems shall be secured to building structures using specified fasteners, clamps and hangers spaced according to the CEC.
3. 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.
4. 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.
5. Fasteners and supports in solid masonry and concrete:
    a. Use steel or malleable iron concrete inserts set in place prior to placing the concrete.
    b. After concrete installation:
        1) Steel expansion anchors not less than ¼ inch bolt size and not less than 1-1/8” embedment.
        2) Power set fasteners not less than ¼-inch diameter with depth of penetration not less than 3-inches.
        3) Use vibration and shock resistant anchors and fasteners for attaching to concrete ceilings.
6. Hollow masonry: Toggle bolts are permitted. Bolts supported only by masonry block are not acceptable.
7. Metal structures: Use machine screw fasteners or other devices specifically designed and approved for the application.

B. Boxes:
1. Provide boxes installed in metal stud walls with brackets designed for attaching directly to the studs or mount boxes on specified box supports.
2. 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.
3. Support boxes independently of conduit system.
4. Support boxes, installed in suspended ceilings supporting acoustical tiles or panels, directly from the structure above wherever pendant mounted luminaires are to be installed from the box.
5. Support boxes mounted above suspended acoustical tile ceilings, directly from the structure above.

3.10 CLEANING

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

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

END OF SECTION

SECTION 271500

COMMUNICATIONS HORIZONTAL CABLING

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. Horizontal twisted pair cabling.
2. Horizontal cable terminations.
3. Cable testing equipment.

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 Communications Commission (FCC) Regulations:

FCC Part 15;	Radio Frequency Devices & Radiation Limits.
FCC Part 68;	Connection of Terminal Equipment to the Telephone Network.

2. Electronics Industries Alliance (EIA):

EIA 230;	Color Marking of Thermoplastic Wire.

3. American National Standards Institute, Inc. (ANSI) / Telecommunications Industry Association (TIA) / Electronics Industries Alliance (EIA):

ANSI/TIA/EIA-568-C; Commercial Building Telecommunications Cabling Standards, including the following:

Part 1: General Requirements.

Part 2: Balanced Twisted-Pair Cabling Components.

Part 2, Addendum 1: Transmission Performance Specifications for 4-Pair 100 Ohm Category 6A Cable.

TIA SP 3-4426 (12/28/06 or latest version): Transmission Performance Specifications for 4-Pair 100 Ohm Augmented Category 6A Cable (to be published as TIA-568-C.2-10).

ANSI/TIA/EIA-569-A; Commercial Building Standard for Telecommunications Pathways and Spaces, including the following:

TIA/EIA-569-A-1: Perimeter Pathway Addendum.

TIA/EIA-569-A-2: Furniture Pathway Fill Addendum.

TIA/EIA-569-A-3: Access Floors.

TIA/EIA-569-A-4: Poke-Thru Devices.

TIA/EIA-569-A-6: Multi-Tenant Pathway and Spaces.

TIA/EIA-569-A-7: Cable Trays and Wireways.

ANSI/TIA/EIA-606-C; Administration Standard for Commercial Telecommunications Infrastructure.

TIA TSB-155; Guidelines for the Assessment and Mitigation of Installed Category 6A Cabling to Support 10GBase-T.

4. Building Industry Consulting Service International, Inc. (BICSI):

BICSI (TDMM); Telecommunication Distribution Methods Manual.

BICSI (WDRM); Wireless Design Reference Manual.

BICSI (NDRM); Network Design Reference Manual.

5. Underwriters Laboratories, Inc. (UL):

UL 444; Communication Cables.

UL 1690; Data-Processing Cable.

UL 1963; Communications-Circuit Accessories.

1.03 SYSTEM DESCRIPTION

A. Provide a complete telecommunication cabling system installation as specified herein and as shown on the Drawings. In general, system shall include, but not be limited to, the following:

1. Workstation horizontal twisted pair cabling:

a. Horizontal twisted pair cables shall route between the IDF/TR and workstation outlets, and shall consist of Category 6, 4-pair, UTP, riser, plenum, and OSP rated copper cables.

b. Category 6 horizontal twisted pair cable will support communication devices such as, but not limited to, the following:

1) Data workstations

2) Electrical utility meters

3) Vehicle Charging Stations

c. All twisted pair cable shall be terminated onto patch panels in wiring rack in communications closet.

d. Copper jack standard is Category 6, RJ-45 connectors at patch panels and workstation outlets.

2. Patch cords:

a. UTP patch cords shall match the physical and performance criteria of the specified horizontal twisted pair cable from the same manufacturer. The cords shall be terminated with the following:

1) 568B to 568B for data between network switch patch panel. Cord shall be blue in color.

b. Patch cords shall be furnished in varying lengths as required.

c. Patch cord quantities shall be two patch cords for each Category 6 cable installed. This includes one standard line cord at the workstation and one patch cord at the IDF/TR rooms.

B. Refer to Drawings for complete documentation of above requirements and all additional requirements.

1.04 SUBMITTALS

A. Submit in accordance with the requirements of Section 270010: Basic Communications 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, 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 prepare in Revit or AutoCAD, to include the following:

a. Building floor plans showing location of all outlets, raceways, cable trays, conduits, and cable routing to each device at same scale as construction documents.

b. Provide 1/4" scale plans of equipment layout in MPOE, ER, MDF, BDF, and IDF/TR rooms.

c. Provide wall elevations of MPOE, ER, MDF, BDF, and IDF/TR rooms at 1/4” scale.

d. Provide equipment rack elevations at 1/4" scale.

e. Use identical symbols as those used in construction documents.

f. Text shall be a minimum of 3/32” high when plotted at full scale.

g. Screen all background information.

5. Furnish structural calculations for equipment anchorage as described in Section 270010: Basic Communications Requirements.

6. Submit Manufacturer’s installation instructions.

7. Complete bill of materials listing all components.

8. Final test results.

9. Warranty.

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

1.05 OPERATION AND MAINTENANCE MANUAL

A. Supply operation and maintenance manuals in accordance with the requirements of Section 270010: Basic Communications 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. Schematic wiring diagrams.
5. Telephone numbers for the authorized parts and service distributor.
6. Include all service bulletins and torque Specifications for all terminations.
7. Final testing reports.

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.

C. Manufacturer qualifications: Manufacturer must have a minimum 5 continuous years of experience in design and manufacturing of the materials and equipment specified herein.

D. Installer's qualifications:

1. Installer must have a minimum 5 continuous years of experience in satisfactory completion for Projects similar in scope and cost. Provide backup information on 5 such Projects.
2. Installer shall possess a current, active, and valid C7 California State Contractors License.
3. Conduit contractor shall possess a current, active, and valid C10 California State Contractors License.
4. The installer shall be the Manufacturer's certified reseller/installer of the telecommunication equipment/cable system provided. The certification shall have been completed 60 days prior to project bid date. Provide evidence of this certification.

1.07 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Delivery: Telecommunication system 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.

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.

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 minimum 25-year product and application warranty for malfunctions resulting from defects in materials and workmanship. Warranty shall be provided from the component manufacturer and shall name the owner on the warranty certificate. Warranty shall begin upon acceptance by the Owner.

B. Contractor shall provide required drawings, test results, application and any other items required by the manufacturer to produce the required warranty.

1.09 MAINTENANCE

A. Maintenance services:

1. Distributor of the major system components shall maintain a replacement parts department and provide testing equipment when needed. A complete parts department shall be located close enough to supply replacement parts within a 4-hour period.

2. Service must be rendered within 4-hours of system failure notification.

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. Category 6 horizontal structured cable systems:

a. Panduit #WMP1E PatchLink Cable Manager for horizontal cables.

b. Or approved equal

2. Category 6 twisted pair patch cord cable:

a. TIA/EIA Berk-Tek LANmark 2000 #10033822 (Type CM or CMG for general use and CMP for plenum space per NEC specification)

b. Or approved equal

3. Cable test equipment:

a. Fluke Networks.

b. Agilent Technologies WireScope 350 Test Set.

c. Tektronix.

B. Substitutions: Under provisions of Section 270010: Basic Communication Requirements.

2.02 HORIZONTAL TWISTED PAIR CABLING

A. Horizontal cables:

1. Application:

a. Suitable for indoor installations, exposed within equipment rooms, above suspended ceilings and below raised floors in cable trays, hangers or on deck, or within walls. If space is used as an air plenum, cable shall either be plenum rated or installed in EMT conduit.

b. Each cable run shall be continuous single cable, homogenous in nature, without splices.

c. Cables shall meet Category 6 performance criteria.

d. Cables shall be CMR or CMP rated as required for rating of space.

2. Conductors:

a. Eight #23 AWG, solid copper wire insulated with FEP for plenum applications or thermoplastic polyethylene or high-density polyolefin for non-plenum rated applications.

b. Two insulated conductors twisted together to form a pair and four such paired cables to form a unit with individually color-coded pairs to conform to industry standards (ANSI/ICEA Publication S-80-576-1994 and EIA-230).

3. Cable sheath:

a. Seamless outer jacket, flame-retardant PVC, applied to and completely covering the internal components (twisted pairs).

b. CMP flame rating according to CEC Chapter 8, tested to NFPA 262 and UL Listed as such.

4. Electrical performance: Meet or exceed TIA/EIA-568-C.2 for Category 6, UTP cabling.

5. Color: Cable shall be blue in color.

B. Patch Cords:

1. Application: Suitable for indoor installations within equipment rooms or workstation environments.

2. Cords assembled from a single, continuous length of cordage, homogenous in nature and terminated at both ends via 8-position modular plugs. Splices are not permitted anywhere.

3. Cordage:

a. Eight #23 AWG, solid copper wire insulated with thermoplastic polyethylene or high-density polyolefin for non-plenum rated applications.

b. Two insulated conductors twisted together to form a pair and four such paired cables to form a unit with individually color-coded pairs to conform to industry standards (ANSI/ICEA Publication S-80-576-1994 and EIA-230).

4. Cable sheath:

a. Seamless outer jacket, flame-retardant PVC, applied to and completely covering the internal components (twisted pairs).

b. CM flame rated according to CEC Chapter 8, tested to UL listed as such.

5. Electrical performance: Meet or exceed TIA/EIA-568-C.2 for Category 6, UTP cabling.

2.03 HORIZONTAL CABLE TERMINATIONS

A. Category 6 data system patch panels:

1. Terminations of horizontal distribution cable for data and telephone systems shall be made at Category 6, 1U, 24 port panels.
2. Terminations in communication closets shall be Panduit #CP48BLY or CP24BLY Modular Path Panels or approved equal.

2.04 MISCELLANEOUS COMPONENTS:

A. Velcro cable ties:
   1. All bundled cables shall be held together with Velcro band or equivalent, and not with nylon cable ties.
   2. Width: 0.75”.
   3. Color: Velcro cable ties the same color as the cable to which it is applied.

B. Plenum cable ties:
   1. Suitable for use in plenums or air handling spaces.
   2. Color: Maroon or other distinctive non-white color.

2.05 CABLE TESTING EQUIPMENT

A. Equipment shall meet TIA/EIA-568-D requirements for Level III accuracy, as applicable for cable type specified herein.

B. Test standards: ISO/IEC 11801 Class C and D; ISO/IEC 11801-2000 Class C and D, 1000Base-Y, 100Base-TX; IEEE 802.3 10Base-T; ANSI TP-PMD; IEEE 802.5.

C. Areas of test measurement (minimum):
   1. Wire Map.
   2. Length.
   3. Insertion Loss.
   4. The following at both master unit and remote unit:
      a. Near End Crosstalk (NEXT) loss.
      b. Power Sum NEXT (PSNEXT) loss.
      c. Equal Level Far End Crosstalk (ELFEXT).
      d. Power Sum ELFEXT.
      e. Return Loss (RL).
      f. Attenuation-to-Crosstalk Ratio (ACR).
      g. Power Sum ACR (PSACR).
   5. Propagation Delay and Delay Skew.
   6. Characteristic Impedance.
   7. DC Loop Resistance.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Contractor shall thoroughly examine Project site conditions for acceptance of the telecommunication cabling system installation to verify conformance with manufacturer and specification tolerances. Do not commence with installation until all conditions are made satisfactory.

B. Verify that pathways and supporting devices are properly and completely installed prior to cable installation.

C. Verify dimensions of pathways to include length, i.e. “true tape” conduit runs.

D. Prior to installation, verify that equipment rooms are ready to accept cables and terminations.

3.02 INSTALLATION

A. Accessories: Provide all accessories as required for a complete installation.

B. Horizontal twisted pair cabling:

1. Horizontal cable installation and routing:

a. Cable runs shall have continuous sheath continuity, homogenous in nature with no splicing.

b. Cabling shall not exceed a cable length of 295’ (90m) from the termination point at the Telecom room to the termination at the workstation outlet, including service slack, when measured using test equipment. The cable length shall be determined by the contractor prior to installing cable with a true tape. Cable lengths exceeding the 295-foot maximum length, shall be brought to the attention of the engineer of record (EOR).

c. Place cables within the designated pathways, such as cable tray or basket tray, cable runway, cable hangers, etc. Do not fasten, support or attach cables to other building infrastructures (i.e. ducts, pipes, conduits, etc.), other systems (i.e. ceiling support wires, wall studs, etc.), or to the outside of conduits, cable trays and non-approved pathway systems.

d. Place and suspend cables during installation and termination in a manner to protect them from physical damage or interference. Place cables with no kinks, twists, or impact damage to the sheath. Replace cables damaged during installation or termination at no additional cost.

e. Route cables at 90-degree angles, allowing for bending radius.

f. Do not exceed pulling tension of 25-lbs.

g. Do not use cable-pulling compounds.

h. Do not exceed a minimum bend radius of 6 times the cable diameter during and after installation.

i. Route cables beneath other building infrastructures (i.e. ducts, pipes, conduits, etc.) in above ceiling applications. Do not route cables over building infrastructure/s. The installation shall result in easy accessibility to the cables in the future.

j. Place cables 6” minimum away from power sources to reduce interference from EMI.

k. Do not set 360-degree service loops in place for slack storage. Instead, set slack as forward-and-back or as figure eights.

l. Place a pull string along with cables where run in conduits and spare capacity in conduit remains. Tie off ends of the pull string to prevent the string from falling onto the conduit.

m. When exiting the primary pathway, such as cable or basket tray, to the workstation outlets, exit via the top of the pathway. Secure the cables to the pathway using an approved Velcro cable tie.

n. Maintain 18” clearance of cable/cable bundle above drop-ceiling and lighting fixtures.

o. All cables shall be run perpendicular and parallel to walls – no diagonal runs allowed. All cable runs shall be routed along serviceable areas, such as corridors, hallways, and away from modular office furniture whenever possible.

p. All cable runs shall be installed based on the TIA/EIA 568B wiring scheme. Modular jacks shall be Panduit Mini-Com PAN-CJ688TP orange color CAT6 modular jack or approved equal. Cables shall be terminated to a Panduit jack wired as a T568B wiring scheme at each end. Cable sheaths shall extend 1/8 inch or more into the strain relief area of Panduit Mini-Jack module. All terminations shall meet or exceed TIA/EIA Category 6 and County of Nevada specifications.

2. Cable routing and dressing within telecommunications rooms:

a. Within rooms, only use Velcro type straps on bundles.

b. Individual bindles of cable shall not exceed 48 cables to minimize heating of cables that use PoE. Bundles of cables shall be per 48-port patch panel.

c. Place cables within the overhead cable support system. When routing vertically on walls, fasten the cables onto vertical supports every 24” on center.

d. Provide 12” minimum sheath cable slack, length not to exceed permanent link maximum length requirement. Place the slack in the overhead cable support system.

e. At the rack bay, route, and neatly dress cables from the overhead cable support system into the back of the vertical management sections. Divide the cables equally between both sides of an equipment rack such that a cable does not travel past the midpoint of the rack prior to termination. Fasten the cables to the cable support bar at the back of the patch panel using approved ties.

3. Termination in the telecommunications rooms:

a. Provide termination apparatus and accessories required for a complete installation. Install and assemble termination apparatus, accessories, and associated management apparatus according to the manufacturer’s instructions.

b. Properly relieve strain from the cables to and at termination points per manufacturer's instructions. Provide a strain relief bar at the back of the modular patch panels for proper strain relief.

c. Terminate cables and twisted pairs in accordance with manufacturer's latest installation requirements and TIA/EIA-568-R standard installation practices. Terminate cable pairs onto the termination apparatus compliant to T568B wiring.

d. Modular patch panels and horizontal management panels:

1) Provide quantity of patch panels to support the terminations of cables served from respective Telecom Room.

2) Install and assemble patch panels and wire management panels according to the manufacturer's instructions.

3) Install the termination hardware and cable management as shown on the Drawings.

4) Terminate cables in sequential order using the link's identifier starting at the top left and completing a block before moving to the next block below.

4. Cable routing and dressing at workstations:

a. Provide 18" cable slack at each workstation outlet, length not to exceed permanent link maximum length requirement. Place the slack within ceiling space neatly on a cable hanger or other approved cable support device.

5. Termination at the workstation outlets:

a. Provide device components, connectors, and accessories required for a complete installation. Install and assemble connectors, jacks, adapters, termination apparatus, accessories, and associated management apparatus according to the manufacturer's instructions.

b. Provide blue connectors for data links.

c. Wall mounted standard devices:

1) Install devices at heights indicated on drawings.

2) Mount faceplates plumb, square and at the same level as adjacent power receptacles.

3) Patch gaps around faceplates so that faceplate covers the entire wall opening.

d. Terminate cables and twisted pairs in accordance with the manufacturer's latest installation requirements and TIA/EIA-568-D standard installation practices. Terminate cable pairs onto the connector compliant to T568B wiring.

6. Patching and cross connecting:

a. In equipment rooms, provide one modular patch cord for each connector jack in each workstation outlet. Install from the horizontal termination field to the network switches/equipment. Neatly dress patch cords within the horizontal and vertical cable management components. Cords lengths shall be coordinated with the Owners IT representative.

b. At workstations, provide one modular patch cord for each cable jack installed in each workstation outlet. Cord lengths shall be 10’ and each shall be labeled.

C. General requirements:

1. Labeling, label colors, and identifier assignments shall conform to EIA/EIA-606-C Administration Standards and as approved by the Owner.

2. Provide permanent and machine-generated labels. Handwritten labels will not be accepted.

D. Horizontal twisted pair labeling:

1. Labeling shall be per the Owners standards in lieu of the following requirements. Coordinate with the Owners IT representative prior to the labeling phase of the cable installation to determine the Owners labeling requirements.

2. Cables:

a. Text color shall be black, #10 font size.

b. Label installation:

1) Provide labels on both ends of cable.

2) Install labels such that they are visible by technician from a normal stance.

3) Fully wrap label around the cable jacket (self-lamination).

4) Provide one label within 4” of the termination apparatus.

3. Modular patch panels:

a. Text color shall be black, #10 font size.

b. Label installation: Provide a Letter designation for each panel (A, B, C etc.). Patch Panel port number will match the cable designation at the station end.

4. Outlets:

a. Text color shall be black, #10 font size.

b. Label installation:

1) At faceplates, provide labels above and below jacks.

2) At surface boxes, provide labels on the top of the box.

3.03 FIELD QUALITY CONTROL AND TESTING

A. General:

1. Calibrate test sets and associated equipment per the manufacturer's instructions at the beginning of each day’s testing and after each battery charge. Fully charge the test sets prior to each day’s testing to ensure proper operation.

2. Ensure test equipment and test cords are clean and undamaged during testing activities. Per the Engineer’s discretion, halt testing activity and clean testing equipment, test cords and related apparatus.

3. Permanently record test results electronically within test equipment at the time of testing.

B. Twisted pair testing:

Each conductor in multi-pair cables shall be tested for continuity, transpositions, shorts, grounds/FAMF (Foreign Electromotive Force). Contractor shall perform Category 6 Testing of all cable runs. All cable runs must meet or exceed the TIA/EIA Category 6 standards. Printed and data-disk based verification and results of this test shall be submitted to County Information Systems upon job completion.

Cable installation including craftsmanship and materials shall carry a 100% unconditional lifetime warranty from the Contractor. The installing contractor shall bear the total cost of labor and materials for the failed component(s). Exclusions are normal wear and tear, or misuse.

1. Test for UTP cabling as follows:

TESTS FOR CATEGORY 6 CABLING TABLE				
Subsystem	Type	Test	Configuration	Notes
Horizontal	Category 6	Category 6	Permanent Link	Per TIA/EIA-568-C.2

2. Precautions:
   a. Adhere to the equipment manufacturer's instructions during all testing.
   b. Prior to any testing activity or any measurements taken, ensure the test equipment is at room temperature, approximately 70-degrees F.
   c. Fully charge power sources before each day's testing activity.
3. Horizontal twisted pair testing:
   a. Test equipment set-up:
      1) Set-up the tester to perform a full Category 6 test, as a Permanent Link configuration.
      2) If the tester has the capability, set the cable type as product specific setting. If not, set as generic Category 6 cable.
      3) Set the tester to save the full test results (all test points, graphs, etc.).
      4) Save the test results with associated cable link identifier.
      5) Calibrate the test set per the manufacturer's instructions.
   b. Acceptable test results measurements:
      1) Overall test results:
         a) Links which report a Fail, Fail or Pass for any of the individual tests shall result in an overall link Fail. All individual test results must result in a Pass to achieve an overall Pass.
         b) Any reconfiguration of link components required because of a test Fail, must be re-tested for conformance.

c) Remove and replace any cabling links failing to meet the criteria described in this Specification, at no cost to the Owner, with cables that prove to meet the minimum requirements.

2) Wire map: Provide continuous pairs and terminate all the cabling links correctly at both ends, no exceptions taken.

3) Length: One hundred meters (328 feet) is the maximum acceptable electrical length measurements for any cabling link measured under a Permanent Link configuration, including test cords.

4) Insertion loss: The acceptable insertion loss measurements for any horizontal cabling link is that which is no greater than that listed in TIA/EIA-568-C.2.

5) Worst pair-to-pair near end crosstalk (NEXT) loss: The acceptable worst pair-to-pair NEXT loss for any horizontal cable is that which is no greater than that listed in TIA/EIA-568-C.2.

6) Power sum NEXT loss: The acceptable power sum PS-NEXT loss for any horizontal cable is that which is no greater than that listed in TIA/EIA-568-C.2.

7) Worst pair-to-pair ELFEXT and FEXT loss: The acceptable worst pair-to-pair ELFEXT and FEXT loss for any horizontal cable is that which is no greater than that listed in TIA/EIA-568-C.2.

8) Power sum ELFEXT and FEXT loss: The acceptable PS-ELFEXT and PS-FEXT loss for any horizontal cable is that which is no greater than that listed in TIA/EIA-568-C.2.

9) Return loss: The acceptable return loss measurements for any horizontal cabling link is that which is no greater than that listed in TIA/EIA-568-C.2.

10) Propagation delay and delay skew: The acceptable propagation delay and delay skew measurements for any horizontal cabling link is that which is no greater than that listed in TIA/EIA-568-C.2.

C. Record documents:

1. Permanently record all test results.
2. Export test results' numerical values to a single Microsoft Excel spreadsheet.
3. Submit test results in a format acceptable to the Owner, Owner's Representative, and the Engineer before system acceptance.
4. Cable and pair identifiers of the test reports shall match the identifiers as labeled in the field, i.e. use the same ID on the cable/termination label as what appears on the test report.
5. Measurements shall carry a precision through one significant decimal place, minimum.
6. Use feet for the units for measurements shown on the print of the test measurements.
7. Print report such that fiber strands of a given cabling link have matching axis scales. The "X" and the "Y" axis shall be the same from report-to-report.

8. The trace of the printed test report shall show the launch cord.
9. For each cabling link, include either a schematic graphic or a brief narrative accurately describing the test set-up. The description shall include test/launch cord (with length), expected events (connectors, slices, etc.) with expected distances, etc. This information will eliminate many questions the Engineer will have while reviewing the reports.
10. For each twisted pair horizontal cable test, report shall contain the following information:
    a. Project name and address.
    b. Test company's and Operator's name.
    c. Date measurements were taken.
    d. Test equipment type to include model and serial numbers.
    e. Cable identification number and pair number.
    f. Measurement results.
    g. Pass/Fail

3.04 INSPECTION AND ADJUSTMENTS

A. Contractor shall inspect all installed Work in conjunction with the General Contractor and develop a "punchlist" for all items needing correction. Provide punchlist to the Engineer prior to their final walk of Project.

B. Punchlist work and the required remediation shall be performed prior to system final acceptance.

C. Replace or repair work completed by others that was defaced or destroyed during the installation of the telecommunication cabling system by this contractor.

D. Make changes to adjust the system to optimum operation for final use. Contractor is responsible for making changes to the system such that any defects in workmanship are correct and all cables and the associated termination hardware passes the minimum test requirements.

3.05 CLEANING

A. Remove all unused, excess, and left-over products, to include debris, spills, and installation equipment.

B. Leave finished work and adjacent surfaces in neat, clean conditions with no evidence of damage.

C. Legally dispose of debris.

D. Clean installed products in accordance with manufacturer's instructions prior to final punch list.

3.06 TRAINING

A. At the completion of all Work, a period of not less than 1-hours shall be allocated by the Contractor for instruction and training for the Owner's Representative. The Cabling Contractor will need to describe how the cable from each cover plate is

separated between different patch panels and 110 blocks, how cross-connects are made and other basic cable plant management skills.

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

END OF SECTION