

SECTION 16050 - BASIC MATERIALS AND METHODS

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Labor, material, equipment, and services necessary to construct and install a complete electrical system as shown on the plans and as specified herein. All General Conditions and Requirements outlined elsewhere in these specifications or drawings shall be applied to this electrical section.
- B. Materials and equipment shall be furnished and installed in support of electrical work described in these plans and specifications including but not limited to, raceways, boxes, enclosures, feeders, branch circuiting, supports, terminal cabinets, sleeves, gutters, panels, transformers, switchgear, lighting fixtures, controls, relays, contactors, in order to complete and make fully functional the systems described.
- C. Provide fire alarm system design at new space and connect to existing fire alarm system and submit for approval by the AHJ.
- D. Lighting systems, both interior and exterior as shown on the plans and as specified herein, including controls, occupancy sensors, lumen sensors, photocell controls, lamps, dimmers, racks, dimming ballasts, supports, fasteners, straps, and miscellaneous mounting hardware and support structures for such equipment.
- E. HVAC and plumbing electrical: Conduit, conductors and terminations for all line voltage power, line voltage controls and fusible and/or non-fusible safety disconnect switches for HVAC equipment, including but not limited to air conditioners, furnaces, fans, heat pumps, cooling towers, system pumps, condensing units. Provide protective equipment unless otherwise noted, etc. including protective devices.
- F. Plumbing Electrical: Conduit, conductors and terminations for plumbing equipment with power requirements including necessary fusible and/or non-fusible safety disconnect devices. Provide motor starters where required unless provided by mechanical specification.
- G. Power and Lighting Distribution: Furnish and install power and lighting distribution systems including but not limited to panels, feeders, transformers, branch circuits, devices, fixtures, disconnect switches, contactors, controls, etc. for a complete working system.
- H. Data systems infrastructure including all boxes, raceways, cable tray, wire basket tray, dedicated branch circuits, sleeves and penetrations, etc. as described and as shown in plans, EIA/TIA standards and/or required for a complete and operating system.
- I. Lighting acceptance testing, documentation and completion of required forms as specified in Section 16970, LIGHTING ACCEPTANCE TESTING.
- J. Allocation of time to adequately train the Owner on the use and operation of all systems installed within the facility or on the property. Minimum two week advance

notice shall be coordinated with the Owner and his representatives. Training shall be as outlined in individual system specifications identified to follow.

1.2 RELATED SECTIONS UNDER OTHER DIVISIONS

- A. Mechanical Wiring: Control circuit wiring, energy management controls and interlocks for mechanical equipment shall be installed by Mechanical Contractor.
- B. Painting of electrical equipment where exposed and required by the Architect to be painted as described elsewhere in the specification.
- C. HVAC Control Raceway: Raceways, boxes, and control wiring for thermostats, temperature sensors and control components specified within the mechanical specifications, shall be furnished and installed as required by Division 15 and installed in accordance with the minimum wiring methods allowed for branch circuit wiring in Division 16 .
- D. Smoke Fire Dampers: Coordination with Mechanical plans for exact locations and points of connection for power and fire alarm system connections (power and fire alarm connection shall be by Electrical Contractor).
- E. Duct mounted smoke detectors: Coordination with Mechanical plans for exact locations and points of connection for power and fire alarm system connections (power and fire alarm connection shall be by Electrical Contractor).
- F. Security System: Shall be installed by Owner's vendor. Contractor shall provide conduits, boxes, stubs to accessible ceilings, dedicated circuit(s) for alarm panel, access control system (key pads, electric locks), etc. as shown and/or required by the Owner's vendor.

1.3 SYSTEM DESCRIPTION

- A. The electrical plans indicate the general layout and arrangement; the architectural drawings and field conditions shall determine exact locations. Field verify all conditions and modify as required to satisfy design requirements as well as code minimums. Maintain all required working clearances as described in CEC Article 110 as well as other applicable articles.
- B. Discrepancies shall be brought immediately to the attention of the Architect for clarification. The Architect shall approve any changes. Prior to rough-in, refer to architectural plans that shall take precedence over electrical plans with respect to locations.
- C. Verify all power and communications utility company requirements prior to commencement of utility work. Make proper adjustments to the construction to satisfy the serving utility requirements if they differ from the construction documents. It shall be the Contractor's responsibility to contact each utility company for obtaining finalized utility design drawings and/or approval, and for scheduling inspection of utility infrastructure installations.

- D. Charges imposed by the electric and communications utility companies shall be paid by Owner directly to utility companies.

1.4 **SUBMITTALS AND SHOP DRAWINGS**

- A. Before construction, submit in (accordance with the General Conditions of this Specification) a complete list of all materials proposed to be furnished and installed under this section. Any material procured without review and approval of the engineer and/or owner's representative, will solely be at the contractor's risk.
- B. Manufacturer's specifications, catalog cuts and shop drawings as required to demonstrate compliance with the specifications. Identify specific intended use for each component where submittal may be ambiguous. Submit entire bound submittal at one time; partial submittals will not be accepted. At a minimum, submittals will be required for the following:
 - 1. Site work equipment including, conduits, fittings, boxes, vaults, trench racks, accessories, etc.
 - 2. Distribution equipment including, transformers, distribution panels and breakers, motor controls, distribution and branch circuit panels, grounding, surge protection devices, etc.
 - 3. Electrical equipment including disconnects, fuses, raceways, straps and racks, fittings, conductors, boxes, gutters, devices, plates, etc.
 - 4. Lighting equipment per fixture schedule.
 - 5. Lighting control equipment including low voltage switching system, dimmer switchbank / accessories, occupancy sensing equipment, time clocks, contactors, photocells, lumen sensors, etc.
 - 6. Constructability review letter/comments for lighting acceptance testing as required by Section 16970, LIGHTING ACCEPTANCE TESTING.
 - 7. Conduit including all fittings, etc.
 - 8. Wiring and cable, terminations, etc.
 - 9. Fire rating penetration materials, details, etc.
- C. The intent of these specifications is to establish a standard of quality for materials and equipment. Therefore, some items are identified by manufacturer or trade name designation. Substitutions shall be subject to the Architect's approval. Samples of the proposed and substitute materials may be required for inspection prior to approval. Costs, if any, for evaluation of substitutions shall be the Contractor's responsibility. The decision of the Architect shall be final. Where the substitution will affect other trades, coordinate all changes with those trades concerned and pay any additional costs incurred by them as a result of this substitution. Approval of substitutions shall not relieve the Contractor from providing an operational system in accordance with all applicable codes and ordinances.
- D. SUPPORTING DEVICES
 - 1. Provide all details of suspension and support for ceiling hung equipment.
 - 2. Where walls, floor, slabs or supplementary steel work are used for seismic restraint locations, details of acceptable attachment methods for ducts, conduit and pipe must be included and approved before the submittals must include spacing, static loads and seismic loads at all attachment and support points.
 - 3. Provide seismic details of seismic restraints and anchors; including number, size and locations for each piece of equipment.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Storage of equipment for the job is the responsibility of the Electrical Contractor and shall be scheduled for delivery to the site, as the equipment is required. Damage to the equipment delivered to the site or in transport to the job shall be the responsibility of the Electrical Contractor.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Materials shall be new and bear the label of or be listed by a nationally recognized testing laboratory. The quality and suitability of all materials shall conform to the standards and practices of this trade.
- B. Supplied materials shall be of a current manufactured product line. Discontinued products are not acceptable. Where products are identified on the contract documents by part number, supply the current product model or series which meets the specification and intended use of the specified component.

2.2 SUPPORTING DEVICES

- A. Hangers: Kindorf B-905-2A Channel, H-119-D washer, C105 strap, 3/8" rod with ceiling flange.
- B. Concrete Inserts: Kindorf D-255, cast in concrete for support fasteners for loads up to 800 lbs.
- C. Pipe Straps: Two-hole galvanized or malleable iron.
- D. Luminaire Chain: Campbell Chain 75031, 90-lb. test with steel hooks.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Professionalism and appearance of installations shall be in accordance with accepted practices of this trade. Installation methods shall conform to manufacturer's specifications and recommendations. The Contractor shall man the job with qualified journeymen and helpers in this trade for the duration of the job. It is the Contractor's responsibility to communicate with and keep the job superintendent apprised of changes or clarifications, etc.
- B. Employment of any person on any job in the capacity of an electrician is not permitted unless such person has qualified for and holds a valid Journeyman Electrician Pocket Card or General Journeyman Electrician Certificate issued by the State of California Division of Apprenticeship Standards. Exception: Contractor may employ electrical helpers or apprentices on any job of electrical construction, new or existing, when the

work of such helpers or apprentices is performed under the direct and constant personal supervision of a journeyman electrician holding a valid Pocket Card accepted by the State of California Division of Apprenticeship Standards.

1. Each Pocket Card carrying journeyman electrician will be permitted to be responsible for the quality of workmanship for a maximum of one helper or apprentice during any same time period, provided the nature of work is such that good supervision can be maintained and the quality of workmanship is the best, as expected by Owner and implied by the latest edition of the National Electrical Code.
 2. Before each journeyman electrician commences work, deliver to Owner at the project site, a photocopy of the journeyman's valid Pocket Card.
- C. Materials shall be installed in accordance with the manufacturer's specification and recommendations. They must conform to the approval AHJ adopted codes and standards, but not less than the CEC and all applicable codes and standards, including but not necessarily limited to California Code of Regulations Title 24, NFPA, National Electrical Manufacturers Association, ANSI, CBC, and any other adopted ordinances of applicable agencies having jurisdiction. Refer to general conditions of specifications.
- D. Electrical Contractor shall lay work out in advance in order to avoid unnecessary cutting, chasing, and drilling of floors, walls, ceilings and other surfaces. Work of this nature shall be carefully done so as not to damage work already performed by other trades. Any damage which results must be properly repaired at no extra cost to the Owner. Such alterations shall not depreciate the integrity of the structure. Approval for cuts or penetrations in structural members shall be by the Architect.
- E. Supporting Devices:
1. Verify mounting height of all luminaires or items prior to installation when heights are not detailed.
 2. Install vertical support members for equipment and luminaires, straight and parallel to building walls. Provide independent supports to structural member for electrical luminaires, materials, or equipment installed in or on ceiling, walls or in void spaces or over furred or suspended ceilings.
 3. Do not use other trade's fastening devices as supporting means for electrical equipment, materials or luminaires. Do not use supports or fastening devices to support other than one particular item.
 4. Support conduits within 18" of outlets, boxes, panels, cabinets and deflections. Maximum distance between supports not to exceed 8' spacing.
 5. Securely suspend all junction boxes, pull boxes or other conduit terminating housings located above suspended ceiling from the floor above or roof structure to prevent sagging and swaying.
 6. Provide seismic bracing per UBC requirements for this building location.
- F. Coordinate work with other trades as required to eliminate any delays during construction. Coordinate changes with other prime contractors to avoid construction conflicts.
- G. Engineer's Field Observation: Site visits during construction for field observations and reports will be conducted by electrical engineer when directed by the Architect. A list of items that need to be addressed will be submitted to the Architect for forwarding to the Contractor. A written response to all items shall be submitted for Owner's review once complete. When Electrical Engineering representative performs a field

observation, the Electrical Contractor shall be present and available to remove equipment covers as needed.

- H. Drawings of Record: Provide a full and accurate set of field record drawings marked up in a neat and understandable manner submitted to the Owner Representative, Construction Manager, or Architect upon completion of the work and prior to issuance of a certificate of completion. The drawings shall dimension all electrical facilities including but not limited to underground conduit, vaults, boxes as well as conduit routing scaled to within 12" of actual field conditions and shall be kept up to date on a daily basis reflecting changes or deviations. Electrical facilities shall be accurately drawn on the plan to scale. Refer to the general conditions of these specifications for additional requirements. Record drawings shall be required to identify both horizontal and vertical dimensions to visible and fixed points such as concrete, asphalt, buildings, sidewalks, etc.
- I. Identification: Provide engraved laminated plastic nameplates for all switchboards, panelboards, fire alarm terminal cabinets, telephone and cable television backboards, main devices, control panels, time clocks, contactors and safety disconnect switches accurately identifying each device. Labels shall be attached to the equipment by means of screws or rivets. Self-adhering labels will not be acceptable. Refer to Section 16141, EQUIPMENT LABELS AND NAMEPLATES AND WARNING SIGNS.
- J. Safety: The Electrical Contractor is responsible to maintain equipment in a safe and responsible manner. Keep dead front equipment in place while equipment is energized. Conduct construction operations in a safe manner for employees as well as other work persons or anyone visiting the job site. Provide barriers, trench plates, flags, tape, etc. The Contractor shall hold all parties harmless of negligent safety practices that may cause injury to others on or near the job site.
- K. Guarantees: Equipment and labor shall be guaranteed and warranted free of defects, unless otherwise stated to be more restrictive, for a period of one year from the date of final acceptance by the Owner. A written warranty shall be presented to the Architect at the time of completion prior to final acceptance. Equipment deemed to be damaged, broken or failed should be repaired or replaced at no additional cost to the Owner. Materials or system requiring longer than a one-year warranty as described herein shall be separately warranted in separate letters of guarantee stating the duration of warranty.
- L. Operating and Installation Manuals: Provide two copies each of manuals, operating and installation instructions for equipment indicated in submittal packages. Instruct the Owner's representative as to the operation and location of equipment necessary to allow them to operate the facility upon final acceptance. This instruction period shall be prearranged with the Owner's representative prior to occupancy of the facility and the weeks prior to training scheduled.
- M. Lighting Acceptance Testing: Provide two copies of lighting acceptance testing results and equipment operating manuals as specified in Section 16970, LIGHTING ACCEPTANCE TESTING. Instruct the Owner on operation of control systems.

END OF SECTION 16050

SECTION 16060 – SELECTIVE ELECTRICAL DEMOLITION

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Electrical demolition.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

- A. Materials and equipment for patching and extending work shall be as specified in individual sections.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Contractor to walk job to observe existing conditions and account for variance as needed.
- B. Verify field measurements and circuiting arrangements as shown on drawings.
- C. Verify that abandoned wiring and equipment serve only abandoned facilities.
- D. Demolition Drawings are based on limited field observation and existing record documents. Report discrepancies to Owner/Architect before disturbing existing installation.

3.2 PREPARATION

- A. Disconnect electrical systems in walls, floors, and ceilings scheduled for removal.
- B. Coordinate utility service outages with utility company.
- C. Provide temporary wiring and connections to maintain existing systems in service during construction. When work must be performed on energized equipment or circuits, observe provisions of NFPA 70E and CALOSHA, use personnel experienced in such operations.
- D. Existing Electrical Service: Maintain existing system in service until new system is complete and ready for service. Disable system only to make switchovers and connections. Obtain permission from Owner at least 48 hours before partially or

completely disabling system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area as required.

- E. Existing Fire Alarm System: Maintain existing system in service until new system is accepted. Disable system only to make switchovers and connections. Coordinate outages with Owner and local fire service. Notify Owner/Owner's representative at least 48 hours before partially or completely disabling system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area.
- F. Existing Telephone System: Maintain existing system in service until new system is complete and ready for service. Disable system only to make switchovers and connections. Notify Owner at least 48 hours before partially or completely disabling system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area.

3.3 DEMOLITION AND EXTENSION OF EXISTING ELECTRICAL WORK

- A. Demolish and extend existing electrical work under provisions of this section.
- B. Remove, relocate, and extend existing installations to accommodate new construction.
- C. Allow the owner first right to retain ownership of salvaged materials, otherwise the Electrical Contractor is responsible for its removal from the site and proper disposal or recycling.
- D. Remove abandoned wiring to source of supply.
- E. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes. Cut conduit flush with walls and floors, and patch surfaces.
- F. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit servicing them is abandoned and removed. Provide blank cover for abandoned outlets which are not removed.
- G. Disconnect and remove abandoned panelboards and distribution equipment.
- H. Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.
- I. Disconnect and remove abandoned luminaires. Remove brackets, stems, hangers, and other accessories.
- J. Discarded electrical components and lamps containing hazardous waste (i.e., mercury in fluorescent lamps) shall be disposed of as required by the State Laws and Local Ordinances regarding hazardous materials.
- K. Repair adjacent construction and finishes damaged during demolition and extension work.

- L. Maintain access to existing electrical installations which remain active. Modify installation or provide access panel as appropriate.
- M. Extend existing installations using materials and methods compatible with existing electrical installations, or as specified.

3.4 **CLEANING AND REPAIR**

- A. Clean and repair existing materials and equipment which remain or are to be reused.
- B. Panelboards: Clean exposed surfaces and check tightness of electrical connections. Replace damaged circuit breakers and provide closure plates for vacant positions. Provide typed circuit directory showing revised circuiting arrangement.

3.5 **INSTALLATION**

- A. Install relocated materials and equipment as shown and/or as required.

END OF SECTION 16060

SECTION 16110 - RACEWAYS

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Installation of all wire, cable, conductor, pull ropes, fiber optic cable raceway, conduit, innerduct, cable sleeve and duct as described on the plans and/or as specified here-in. This scope shall include pathways to be installed underground on site and offsite, underslab, above grade, both concealed and exposed, overhead concealed and exposed as appropriately applied. Raceways shall be installed in accordance with their intended and allowed uses and as specified here-in whichever is more restrictive. Size and capacity of all raceway shall be as specified here-in or as depicted on the drawings, but shall not be less than that required by code. Larger raceway sizes may be specified than code would permit. The specifications shall govern.
- B. Listed products for termination, coupling, extending, benching supports of raceways shall be used.
- C. Raceways described by this section shall include, but not be limited to, power for site utilities and lighting, site and building communications, controls, fire alarm, security, access control, data system, power distribution, lighting, lighting controls, video, voice communications, HVAC and other building low voltage/communications systems controls as may be required.
- D. Protection of and cleanliness of pathways and raceways must be assured during the construction process in order to eliminate the possibility of debris entering the conduit, duct, pathway resulting in decreased wire capacity and potential damage to installed conductors and cables.
- E. Pathways are shown in a diagrammatic way and are generally accurate as to routing, however, it is the Contractor's responsibility as a means and methods process to coordinate with all other trades that require space within a building. The Contractor shall obtain approval for installation of raceways routing through structural footings, retaining walls, columns, beams, perlins, grade beams, etc.
- F. It is the Contractor's responsibility to insure that all raceway and pathway systems penetrate fire assemblies and sound rated assemblies in an approved manner using the appropriate and listed products for the purpose.
- G. Trenching and backfilling for all underground conduit systems installed by the Electrical Contractor shall be the responsibility of the Contractor. Conduits shall have minimum cover requirement of 24" below finish grade minimum. More stringent depth requirements may be imposed by the local agency and utility company and shall be adhered to, and / or this specification or as detailed on the plans. Joint trenching may be utilized where practicable and were permitted by this specification. Concrete, native material and sand shall be used as backfill material and shall be compacted in accordance with and coordinated with the grading and site preparation requirements. Conduits shall rest in a minimum of 4" bed of sand prior to backfill and compaction.

Locations of existing underground (UG) utility systems shall be determined by calling Underground Service Alert (USA) at least 48 hours prior to any excavation.

- H. Minimum conduit size shall be 1/2" except if plan shows or code requires larger size. Exception: Use minimum 3/4" for underslab and below grade applications outside of building exterior walls.
- I. All electrical, control, communications systems shall be installed in metallic conduit system. This shall include but not be limited to all systems described in Section C above except for voice and data systems which shall be installed as described on these plans and as specified here-in but shall not be less than the recommendations of EIA/TIA standards.
- J. All line voltage wiring within the building shall be installed in metallic conduit.
- K. All conduit, concrete pads, underground concrete or fiberglass substructures shall be furnished and installed with the approved materials and type for the application. Provide proper traffic control during construction as well as barriers and protection of all excavations and trenching.
- L. Empty or future conduits shall be properly plugged with plastic caps or inserts with a 3/8" polyethylene pull rope. Plastic or "duct" tape will not be acceptable.
- M. Exterior installations: After conductors are installed, seal conduit ends to prevent entrance of foreign material using pliable duct seal, caps or waterproof expanding foam.
- N. All low voltage systems including intercom, fire alarm, public address, etc. shall be in dedicated conduit systems. Voice / Data and Direct Digital Control (DDC) systems for HVAC cabling shall be routed as specified in Section 16741, INTERCOMMUNICATIONS SYSTEMS and as recommended by EIA/TIA standards. It shall be the contractor's responsibility to provide raceway down walls to outlet boxes and to provide sleeves across inaccessible ceiling spaces.
- O. Underground conduits entering building shall have the open end of conduit within building above the elevation of the conduit outside the building such that water cannot enter building through conduit. If such a condition exists, a pull box outside of building footprint shall be installed in conduit route before conduit enters building whereby top of pull box is below finish floor of building and moisture may exit box before entering building.
- P. No single conduit run of any type shall exceed 300 degrees of radius bend from termination box to termination box.
- Q. Separate Raceway System: Provide a separate dedicated raceway system for each system installed, do not combine different systems into a raceway or cable tray system, unless otherwise noted or allowed.
- R. Spare, Future Conduits: Conduits labeled conduit only, spare, or for future use, shall be provided with a pullrope, capped at each end, labeled as spare with destination marked, and turned over to the Owner in an unused state. Contractor shall not utilize these conduits for the installation of cabling or conductors as part of this scope of work.

Contractor to verify and install at no additional cost to the Owner, additional conduits as required for the installation of the systems being installed.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Heavy wall Rigid Non-Metallic Conduit, shall be PVC schedule 40 manufactured in accordance with NEMA Standard TC-2, UL-651 and WC 1094A specifications. Approved manufacturers are Carlon, Certainteed, R&G Sloane or equal.
- B. Extra heavy wall non-metallic conduit, shall be PVC schedule 80 manufactured in accordance with NEMA Standard TC-2, UL-651 and WC 1094A specifications. Approved manufacturers are Carlon, Certainteed, R&G Sloane or equal.
- C. Galvanized Rigid Steel (GRS) conduit shall be hot dipped galvanized, zinc coated and shall comply with Underwriters Laboratories UL-6, ANSI Specification C-80.1 and Federal Specification WW-C-581E.
- D. Electrical Metallic Tubing (EMT) shall be zinc coated, with a protective coating applied to the inside surface and shall comply with Underwriter Laboratories UL-797 ANSI Specification C-80.3 and Federal Specification WW-C-563A.
- E. Electrical Non-Metallic Tubing (ENT), not allowed.
- F. Flexible Metal Conduit (FMC) shall be continuous wound reduced wall galvanized steel produced to UL standards as manufactured by Alflex, American Flexible Conduit or equal.
- G. Liquid tight flexible metal conduit shall have a thermoplastic cover over a galvanized steel core containing an integral copper ground in sizes to 1 1/4" and shall be in compliance with UL standards and CEC Article 350. Approved manufacturers are Anaconda (type UA), Electri-flex Liquatite or equal.

2.2 INSTALLATION

- A. Conduit systems listed below are for use in installations where they are permitted to be used by CEC and/or other occupancy restrictions. The below installation methods do not intend to suggest that these materials be installed in conflict with any applicable code. Special attention to applications shall be made in building types such as Educational, Health Care, wet location, hazardous locations, assembly occupancy and multi-story, but not limited to these. Requirements which are more restrictive than the CEC may be called for by the drawings and / or these specifications. These requirements must be adhered to. The Electrical Contractor shall be responsible to use the proper conduit system for the application. Exposed conduit is not allowed below ceilings or above slab of floor, without the permission and approval of the Architect. All conduits shall be concealed except in electrical and telecommunication rooms or where shown to be surface mounted. Exposed conduit (where allowed) shall be run square and plumb with building lines in an approved manner. Support roofmount conduits, where allowed, with minimum 12" wide redwood blocks set in mastic unless

otherwise detailed in roof requirements or as specified in roofing specification, by the Architect. Strap conduits to blocks with proper sized conduit straps. Spacing of support shall be a minimum as provided for in the CEC. All exposed conduit mounted below 8' above finished grade shall be strapped at a minimum of 5' spacing.

- B. Non-Metallic Rigid Conduit shall be used in concrete slabs, below concrete slabs on grade, or underground outside of a building slab or foundation. Maintain minimum depth requirements and cover with appropriate fill material. Minimum 4" of bedding and cover of backfill material 1/4" size grain and smaller maximum. Conduit shall be heavy wall Schedule 40 or 80, rigid PVC only. Rigid utility P&C duct shall not be used in any application. Properly sized grounding conductors shall be installed per CEC article 250, in all non-metallic conduit branch circuit and feeder runs. PVC conduit shall be formed or field bent only with the use of properly approved bending tools such as to not decrease the internal bore of the conduit. All conduits shall be cut square and reamed of burrs. Approved and compatible glue shall be used on all PVC fittings to attain watertight joints. All non-metallic conduit runs over 150' in length and over 1 1/4" trade size conduit shall utilize galvanized rigid steel elbows.
- C. Galvanized Rigid Steel (GRS) conduit shall be used where exposed less than 8' – 0" above finished grade to 18" below finished grade and where subject to physical damage. Conduits shall be cut square and reamed to remove burrs and sharp edges. Strap conduit below 8' above grade at 5' intervals. Unless otherwise noted, threadless setscrew and threadless weathertight fittings may be used in lieu of threaded fittings. All threaded ends entering a junction box of any type shall require one locknut on the inside and one on the outside of the enclosure and be provided with a plastic bushing or grounding bushing where necessary for proper grounding. Where exposed to moisture, a watertight hub or other approved method shall be required. All conduits shall be stubbed up straight and uniform into junction boxes, panels, cabinets, etc., and shall be GRS properly supported and strapped. All GRS conduit located below grade, shall be tape wrapped.
- D. Electrical Metallic Tubing (EMT) shall be used as allowed by code and as permitted by this specification. It shall not be in contact with soil or the concrete slab on the ground floor of any structure. Connectors and couplings shall be steel/insulated set screw type where installed in indoor dry locations not subject to moisture. Where the potential for moisture is present, compression type weathertight fittings are required. One hole conduit straps are permitted from 1/2" to 1" and two hole conduit straps are required for size 1-1/4" and larger. EMT shall not be allowed in areas subject to severe physical damage. Install copper ground wire sized per CEC 250-122 in all EMT conduits.
- E. Flexible conduit may be used where concealed in building construction or above dropped ceilings, but shall meet the following criteria: No individual circuit path from distribution panel to last device shall exceed a cumulative length of 30' of flexible conduit from start to end. Flexible conduit shall not exceed a total directional change of 270 bending degrees in any one run between conduit terminations. Squeeze type or Jake type steel flex fittings of a grounding type are required. Flexible conduit must be supported in accordance with CEC. Where exposed to the weather, moisture, or spray down flexible conduit shall be of the liquidtight type. Fittings shall be manufactured for use with liquidtight flexible conduit. All motor connections shall be made with liquidtight flex. Flexible conduit may not be used where exposed except for last 2' of equipment connection and unless otherwise noted or approved. A copper ground wire sized per CEC 250-122 shall be installed in all flexible conduit runs. Flexible conduit

may not be used exposed. Weatherproof liquid tight conduit shall not be used at roof level for equipment connections with lengths exceeding 24" nor shall it be used to circumvent a rigid conduit system in a horizontal direction. Connect recessed lighting fixtures to conduit runs with a maximum of 6' of flexible metal conduit extending from junction box to fixture. "Master" "Slave" fixtures are permitted to use manufactured flexible cable of longer dimension up to 12' between "Master" and "Slave" only and only as a U.L. listed system component.

- F. Underground conduits and transition to above grade/slab shall be as follows:
 - 1. PVC elbows allowed if top of elbow is minimum 18" BFG or below top of slab, otherwise GRS elbows are required.
 - 2. GRS elbows are required if conduit run is 150' or greater.
 - 3. GRS risers are required from elbow below grade to equipment (device, outlet, panel, cabinet, etc.) above grade.
 - 4. GRS elbows/risers to be PVC coated or 10 MIL taped wrapped (1/2" lapped) to 3" above finish grade or top of slab.
- G. Conduit Supports: Conduit runs may be supported by one hole and two hole straps or supports as manufactured by Unistrut, Minerallac, Caddy or equals. Supports may be fastened by means of anchors, shields, beam clamps, toggle bolts, or other approved methods appropriate for the application and size of conduit. Pipe nailers (J-hooks) may only be used for 1" conduit and smaller and only in wood frame construction. Conduit support methods are subject to review by the engineer and authority having jurisdiction for adequacy. Installations deemed inadequate shall be corrected by the contractor at no cost to the Owner.
- H. Bends and offsets shall be made with approved tools for the type of conduit being utilized. Bends shall be made without kinking or destroying the smooth bore of the conduit. Parallel conduits shall be run straight and true with bends uniform and symmetrical. Minimum radii shall be per CEC 344-24.
- I. Conduit Stub-outs below grade shall be capped with plastic cap, and identified by placing a pull box marked with correctly identified utility such as "Elec", "Tel", etc. Dimension for exact location on field record drawings. Provide lids for proper field application (i.e. traffic, incidental, pedestrian).
- J. Conduit Seals: Where below grade conduits enter structure through slab or retaining wall of building or basement, seal the inside of each conduit as follows:
 - 1. Provide damming material around conductors 3" into conduit.
 - 2. Fill 3" of conduit with 3M #2123 sealing compound.
 - 3. Wrap conductors where they exit the conduit with 3M #2229 "Scotch Seal" mastic tape. Lap tape to approximate diameter of the raceway and wrap outside of conduit opening with (minimum) one turn.
 - 4. Use conduit sealing bushings type CSB (O-Z/Gedney) or equal.
 - 5. Empty conduits shall be sealed with standard non-hardening duct seal compound and then capped to prevent entrance of moisture and gases and to meet fire resistance requirements.
 - 6. Provide cable drip loop minimum 12" high.
- K. Marker tape: Place plastic yellow marker tape at 12" below finish grade along and above buried conduits. Label tape "CAUTION: ELECTRICAL LINES BELOW" or similar wording.

- L. Electrical and communications systems raceways routed underground shall not occupy the same trench as plumbing utilities such as sewer, water, storm drain, gas or other wet or dry gaseous utility system. A minimum of 12" of undisturbed earth is required. Where utilities must cross in closer proximity to each other due to physical constraints, 6" minimum crossing distances are allowed, however 18" on all sides of a utility crossing must be concrete encased.
- M. Conduits, routed below footings, slabs, grade beams, columns, and other structural elements shall be installed in strict compliance with structural details and criteria shown on structural plans. Clearances below structural elements and sleeves through structural elements must be carefully planned to avoid conflict and must be approved by the structural engineer if conflict arises.
- N. All conduit or raceways passing through fire rated walls, floors, or ceilings shall be installed with a listed penetration method which protects the opening to the same rating as the assembly and is non hardening.
- O. Expansion Joints
 1. Conduits 3" and larger, that are secured to the building structure on opposite sides of a building expansion joint, require expansion and deflection couplings. Install the couplings in accordance with the manufacturer's recommendations.
 2. Provide conduits smaller than 3" with junction boxes on both sides of the expansion joint. Connect conduits to junction boxes with sufficient slack of flexible conduit to produce 5" vertical drop midway between the end. All conduit shall have a copper green grounding bonding conductor installed.
- P. Seismic Joints
 1. At seismic joints, provide conduits rigidly secured to the building structure on opposite sides of a building expansion joint with junction boxes or approved fittings, on both sides of the joint. Connect conduits to junction boxes with sufficient slack flexible conduit such that these slack conduits are 1 1/2 times the distance between conduit ends. Flexible conduit shall have a copper green ground bonding jumper installed.

END OF SECTION 16110

SECTION 16120 – POWER WIRE, CABLE AND CONDUCTORS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Wires and cables.
 - 2. Connectors.
 - 3. Lugs and pads.
 - 4. MC cable.

1.2 SYSTEM DESCRIPTION

- A. Provide wires, cables, connectors, lugs, strain reliefs, racking insulators for a complete and operational electrical system.

1.3 SUBMITTALS

- A. Provide product data for the following equipment:
 - 1. Wires.
 - 2. Cables.
 - 3. Connectors.
 - 4. Lugs.
 - 5. Splice Kits.
 - 6. Strain Relief Fittings.
 - 7. Cable Racking and Insulators.
- B. Provide the insulation cable testing report in the project closeout documentation, refer to Closeout Requirements in the General Conditions portion of this specification.

1.4 REGULATORY REQUIREMENTS

- A. Conform to requirements of the CEC, latest adopted version with amendments by local Authority Having Jurisdiction (AHJ).
- B. Furnish products listed by UL or other testing firm acceptable to AHJ.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Wires and Cables: General Cable, Okonite, Southwire, or approved equal.
- B. Connectors: Burndy, IlSCO, Thomas & Betts, or approved equal.

- C. Wire connectors shall be minimum 75 degree centigrade rated and properly sized for the number of conductors being connected, terminated, spliced etc. All above grade connectors shall be solderless lug or plastic wire nut type, screw on, pressure cable type (wire nut or spring nut type), 600 volt, 105 degree C, with skirt to cover all portions of stripped wires. Connector shall be U.L. rated for number and size of conductors being joined together as a splice.
- D. Splices:
 1. Branch Circuit Splices: Ideal, Scotch-Lock, 3M, or approved.
 2. Feeder Splices: Compression barrel splice with two layers Scotch 23 and four layers of Scotch 33+ as vapor barrier.
 3. Screw Terminal Lugs.
 4. Kearney Split Bolt.
- E. MC Cable: Alfex, AFC, or approved and shall meet all CEC Article 330 provisions.

2.2 WIRES AND CABLES FOR LINE VOLTAGE SYSTEM AND CONTROLS. WIRE AND CABLE SHALL BE:

- A. Copper, 600 volt rated throughout. Conductors 14AWG to 10AWG, solid or stranded. Conductors 8AWG and larger, stranded.
- B. Phase color to be consistent at all feeder terminations; A-B-C, top to bottom, left to right, front to back. Phasing tape shall be permitted on sizes #6 and larger.
- C. Color Code Conductors as Follows:

Phase	208 VOLT	240 VOLT DELTA	480 VOLT
A	Black	Black	Brown
B	Red	Orange (High Leg)	Orange
C	Blue	Blue	Yellow
Neutral	White	White	[Gray] [White W/ Colored Strip]
Ground	Green	Green	Green
Isolated Ground	Green	Green w/ yellow trace	N/A
		w/ yellow trace	
- D. All conductors shall be copper unless otherwise noted. Minimum size for individual conductors shall be #12 AWG unless otherwise noted. Sizes #8 AWG and larger shall be stranded conductor. Individual conductors shall be insulated with type, XHHW, THW, THHN/THWN 600-volt insulation unless otherwise noted. Control, signal, communication conductors shall be as dictated by the vendor of that equipment or as specified herein. Proper insulation type shall be used for the proper environmental application (i.e., waterproof, wet location, plenum, temperature rated). If a condition exists where the application is uncertain, contact the Engineer for direction. Contractor is responsible to follow specific cabling requirements described in other sections of this specification relative to various communications and controls systems as well as the respective riser diagrams shown on plans. If a discrepancy occurs, communicate such discrepancy to the Architect and Engineer immediately for resolution.
- E. Insulation types THWN, THHN or XHHW. Minimum insulation rating of 90C for branch circuits.

- F. MC Cable: High strength galvanized steel or aluminum flexible armor. Full length minimum size No. 12 copper ground wire, THHN 90C conductors, full length tape marker. Overall PVC or nylon cable tape. Short circuit throat insulators, mechanical compression termination. Manufacturers: Alfex, AFC.
- G. Refer to signal and communications Specification Sections for cable requirements.

2.3 CONNECTORS

- A. Copper Pads: Drilled and tapped for multiple conductor terminals.
- B. Lugs: Indent/compression type for use with stranded branch circuit or control conductors.
- C. Solid Conductor Branch Circuits: Spring connectors, wire nuts, for conductors 18 through 8AWG.

2.4 LUGS AND PADS

- A. Ampacity: Cross-sectional area of pad for multiple conductor terminations to match ampere rating of panelboard bus or equipment line terminals.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation: Conductors shall not be installed until after conduit systems are permanently in place. Use an approved non hardening type wire pulling lubricant if lubricant is to be used. Maintain all conduits and wire pulls free from foreign material. If due to field conditions, more than a total of 300 degrees of bend are required; a pull box shall be furnished and installed for ease of installation. Said pull boxes must be sized and rated for the appropriate application and must remain easily accessible upon completion of the project (approval of the location shall be obtained from the Architect prior to installation). Show these pullboxes on the field record drawings. Conductors installed in underground raceways on site shall be duct sealed and taped where they exit the raceway to prevent the entrance of foreign material and moisture after the conductors are installed. Proper drainage shall be provided for underground pull and splice boxes.
- B. Insulation: Use proper insulation types where temperature and environment are a factor.
- C. Splices at or below grade level shall be made with wet location rated and approved mechanical connectors and shall be encapsulated in epoxy or plastic molded poured kits. The connections must be assured to be watertight. Splices at or below grade shall always be avoided and minimized. Prior approval is required for feeder splices below grade. Submit proposed materials and exhibit showing location of intended splices for Engineer's review and approval prior to commencing with the work.

- D. Labeling: All conductors in panels, switchboards, terminal cabinets, vaults, pull boxes, and junction boxes shall be labeled with tape number markers indicating circuit number and identifying system. All labeling shall be permanent. In manholes and vaults, provide embossed brass tags identifying system serviced and function. See Section 16141, EQUIPMENT LABELS AND NAMEPLATES AND WARNING SIGNS.
- E. All conductors, wiring, cable where installed below floor, slab or underground shall be considered wet locations, and shall be rated accordingly. Non waterproof cabling is not allowed in any below grade or wet application.
- F. Cables routed together in cable tray shall be stacked, organized and tie wrapped together in a neat and workman like manner. Random cable routing is not acceptable.
- G. Cable and conductors routed through pull boxes and vaults shall be properly supported on porcelain or equal insulators mounted on steel rack inserts. Bend radius of cable or conductor shall not be less than six times the overall cable diameter.
- H. Wires and Cables:
 - 1. Conductor Installation:
 - a. Install conductors in raceways having adequate, code size cross-sectional area for wires indicated.
 - b. Install conductors with care to avoid damage to insulation.
 - c. Do not apply greater tension on conductors than recommended by manufacturer during installation.
 - d. Use of pulling compounds is permitted. Clean residue from exposed conductors and raceway entrances after conductor installation.
 - 2. Conductor Size and Quantity:
 - a. Install no conductors smaller than 12AWG unless otherwise shown.
 - b. Provide all required conductors for a fully operable system.
 - 3. Provide dedicated neutrals (one neutral conductor for each phase conductor) in the following single phase circuits:
 - a. Dimmer controlled circuits.
 - b. 120v circuits
 - c. Ground fault and arc fault protected circuits where a GFI and arc fault breakers are used in panelboards.
 - 4. MC Cable shall be allowed for lighting branch circuiting only in non-exposed but accessible ceiling areas and undercabinet lighting connection. Ceilings that are not accessible by definition shall not allow MC cable use. Power feeders, and electrical branch circuit wiring shall utilize raceways as specified and allowed by Section 16110, RACEWAYS.
 - 5. Conductors in Cabinets:
 - a. Cable and train all wires in panels and cabinets for power and control neatly and uniformly. Use plastic ties in panels and cabinets.
 - b. Tie and bundle feeder conductors in wireways of panelboards.
 - c. Hold conductors away from sharp metal edges.
 - d. Connectors: Retighten mechanical type lugs and connectors for conductors to equipment prior to Notice of Completion.

3.2 FIELD QUALITY CONTROL

- A. Tests:

1. Test conductor insulation on feeders of 400 amp and greater for conformity with 1000 volt megohmmeter. Use Insulated Cable Engineers Association testing procedures. Minimum insulation resistance acceptable is 1 megohm for systems 600 volts and below.
2. Test Report: Prepare a typed tabular report indicating the testing instrument, the feeder tested, amperage rating of the feeder, insulation type, voltage, the approximate length of the feeder, conduit type, and the measured resistance of the megohmmeter test. Submit report with operating and maintenance manual.

END OF SECTION 16120

SECTION 16130 - BOXES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Outlet boxes.
 - 2. Weatherproof outlet boxes.
 - 3. Junction and pull boxes.
 - 4. Floor boxes.
 - 5. Exterior in-grade boxes.

1.2 SYSTEM DESCRIPTION

- A. Outlet System: Provide electrical boxes and fittings as required for a complete installation. Include but not limited to outlet boxes, junction boxes, pull boxes, bushings, locknuts, and all other necessary components.
- B. Code Compliance: Comply with CEC as applicable to construction and installation of electrical boxes and fittings and size boxes according to CEC 312, 314 and 366 except as noted otherwise.
- C. Flush Outlets in Insulated Spaces: Maintain integrity of insulation and vapor barrier.

1.3 SUBMITTALS

- A. Provide Shop Drawings and Product Data for the Following Equipment:
 - 1. Outlet boxes.
 - 2. Weatherproof outlet boxes.
 - 3. Junction and pull boxes.
 - 4. Floor boxes.
 - 5. Cabinets, termination cabinets.
 - 6. Gutters.
 - 7. Concrete boxes and vaults.

1.4 REGULATORY REQUIREMENTS

- A. Conform to requirements of the CEC, latest adopted version with amendments by local AHJs.
- B. Furnish products listed by UL or other independent and nationally recognized testing firm.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Outlet Boxes: Bowers, Raco, Steel City or approved.
- B. Weatherproof Outlet Boxes: Bell, Red Dot, Carlon, or approved.
- C. Junction and Pull Boxes: Circle AW, Hoffman, Wireguard or approved.
- D. Box Extension Adapter: Bell, Red Dot, Carlon, or approved.
- E. Conduit Fittings: O-Z Gedney, Thomas & Betts, or approved.
- F. Vaults: Christy, Brooks, Utility Vault or approved equal.

2.2 OUTLET BOXES

- A. NEMA 1 gutter, junction and pull boxes shall be fabricated from code gage steel finished in grey enamel with screw cover fronts and concentric knockouts in all sides.
- B. NEMA 3R gutter, junction and pull boxes shall be fabricated from code gage galvanized steel with screw cover fronts and concentric knockouts in the bottom only. Any penetrations to the side, top or back shall be weatherproofed in an approved manner such as "MYERS" gasketed type hub or equal.
- C. Steel outlet boxes and plaster rings shall be galvanized rigid assemblies, either one piece pressed or factory welded construction containing the size and number of knockouts required. Steel outlet boxes shall be manufactured, sized and installed in accordance with CEC Article 314. Device Outlet: Installation of one or two devices at common location, minimum 4 inch square, minimum 1 ½ inches deep. Single or 2 gang flush device plaster ring. Raco Series 681 and 686 or equal.
- D. Luminaire Outlet: minimum 4" square with correct plaster ring depth, minimum 1-1/2" deep with 3/8-inch luminaire stud if required. Provide proper depth plaster ring on bracket outlets and on ceiling outlets.
- E. Multiple Devices: Three or more devices at common location. Install 1 piece gang boxes with 1 piece device plastering. Install one device per gang unless otherwise allowed.
- F. Construction: Provide galvanized steel interior outlet wiring boxes, of the type, shape and size, including depth of box, to suit each respective location and installation; constructed with stamped knockouts in back and sides, and with threaded holes with screws for securing box covers or wiring devices. Boxes shall be properly secured to the structure such that they are flush with the finish surface. Boxes shall be made structurally secure by means of the proper fastening devices.
- G. Accessories: Provide outlet box accessories as required for each installation, including mounting brackets, wallboard hangers, extension rings, plaster rings, luminaire studs,

cable clamps and metal straps for supporting outlet boxes, compatible with outlet boxes being used and meeting requirements of individual wiring situations.

2.3 WEATHERPROOF OUTLET BOXES

- A. Cover plates on outlet boxes mounted flush in the wall shall be gasketed to the wall in a watertight manner. Weatherproof boxes in wet locations as described in CEC 406.8 (B) shall be provided with a "while-in-use" cover; red dot 'CK' Series of aluminum die-cast construction, NEMA 3R, with lacquer finish.

2.4 JUNCTION AND PULL BOXES

- A. Construction: Provide galvanized sheet steel junction and pull boxes, with screw-on covers; of the type shape and size, to suit each respective location and installation; with welded seams and equipped with steel nuts, bolts, screws and washers.
- B. Location:
 - 1. Install junction boxes above accessible ceilings for drops into walls for receptacle outlets from overhead.
 - 2. Install junction boxes and pull boxes as required to facilitate the installation of conductors and limiting the accumulated angular sum of bends between boxes, cabinets and appliances to 300 degrees.
 - 3. Locations: Junction boxes shall be located only where necessary and only in equipment rooms, closets, and accessible attic and underfloor spaces. A horizontal distance of 24 inches shall separate outlet boxes on opposite sides of occupancy separation walls, fire-rated walls or partitions.
 - 4. Labeling: Junction box covers shall be marked with indelible ink indicated the circuit numbers passing through the box.

2.5 BOX EXTENSION ADAPTER

- A. Construction: Diecast aluminum.
- B. Location: Install over flush wall outlet boxes to permit flexible raceway extension from flush outlet to fixed or movable equipment. Bell 940 Series, Red Dot IHE4 Series.

2.6 CONDUIT FITTINGS

- A. Requirements: Provide corrosion-resistant punched-steel box knockout closures, conduit locknuts and plastic conduit bushings of the type and size to suit each respective use and installation.

2.7 EXTERIOR IN-GRADE BOXES FOR NON-UTILITY COMPANY USE SHALL BE:

- A. Precast concrete or polymer concrete type with full bottoms and draining into gravel drywell. Acceptable manufacturers are Utility Vault and Christy.
- B. Flushmount in hardscape and 1" above grade in softscape.

- C. Provided with correct traffic type lid, i.e., full vehicular, intermediate vehicular or pedestrian-rated as applicable stamped with "ELECTRIC", "LIGHTING", "COMMUNICATIONS", etc. cover identification as shown on the drawings or as applicable.
- D. Provided with brass hold-down bolts in cover.
- E. Provided with necessary box extensions to gain proper depth.
- F. Provide properly rated covers for application, i.e., pedestrian, incidental traffic, and/or traffic rated. All boxes or vaults located in streets, driveways, sidewalks wider than 8 feet, and turf areas where mowing takes place shall be traffic rated.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Location: Locate boxes and conduit bodies so as to ensure accessibility of electrical wiring.
- B. Anchoring: Secure boxes rigidly to the substrate upon which they are being mounted, or solidly embed boxes in concrete or masonry.
- C. Special Application: Provide weatherproof outlets for locations exposed to weather or moisture.
- D. Knockout Closures: Provide knockout closures to cap unused knockout holes where blanks have been removed.
- E. Mount outlet boxes, unless otherwise required by ADA, or noted on drawings, the following distances above the finished floor:
 - 1. Receptacles, Telephone, TV & Data outlets. (measured to bottom of outlet box): +15".
 - 2. Outlet above counter (measured to top of outlet box): +46".
 - 3. Control (light) Switches. (measured to top of outlet box): +48".
 - 4. Fire Alarm Manual Pull Stations, T-stats. (measured to top of outlet box): +48".
 - 5. Fire Alarm Visuals: the lower of +80" to bottom of lens, or 6" below ceiling.
 - 6. Other Outlets: As indicated in other sections of specifications or as detailed on drawings.
- F. Coordinate all electrical device locations with the architectural floor plan and interior and exterior elevations to prevent mounting devices within elements that they may conflict such as cabinetry, mirrors, planters, etc.

END OF SECTION 16130

SECTION 16140 - WIRING DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation and connection of wiring devices.

1.2 RELATED WORK

- A. Section 16050, BASIC MATERIALS AND METHODS.
- B. Section 16110, RACEWAYS.
- C. Section 16120, POWER WIRE, CABLE AND CONDUCTORS.
- D. Section 16450, GROUNDING.

PART 2 - PRODUCTS

2.1 RECEPTACLES

- A. General: All receptacles shall be listed by Underwriters Laboratories, Inc.
 - 1. Mounting straps shall be plated steel, with break-off plaster ears and shall include a self-grounding feature (this feature does not substitute for a grounding conductor terminated on grounding strap of device). Terminal screws shall be brass, brass plated or a copper alloy metal.
 - 2. Receptacles shall be of a screw terminal type, "pressure type quick wire" terminations are not allowed.
 - 3. 20 ampere, 125-volt and 250-volt non-locking receptacles shall be tamper resistant type receptacles unless the application is specifically listed as an exception to CEC 406.12.
- B. Duplex receptacles shall be Style Line/Decora single phase, 20 ampere, 120 volts, 2-pole, 3-wire, and conform to the NEMA 5-20R configuration in NEMA WD 6. The duplex type shall have bussing break-off feature for two-circuit operation. The ungrounded pole of each receptacle shall be provided with a separate terminal.
 - 1. Bodies shall be white in color. Contractor to verify device color with Architect prior to procurement.
 - 2. Switched duplex receptacles shall be wired so that only the top receptacle is switched. The remaining receptacle shall be unswitched.
 - 3. Ground Fault Interrupter Duplex Receptacles: Shall be an integral unit suitable for mounting in a standard outlet box.
 - a. Ground fault interrupter shall be commercial grade and consist of a differential current transformer, solid state sensing circuitry and a circuit interrupter switch. It shall be rated for operation on a 60 Hz, 120 volt, 20-ampere branch circuit. Device shall meet CEC requirements. Device shall

have a minimum nominal tripping time of 1/30th of a second. Devices shall meet UL 943.

- C. Receptacles; 20, 30 and 50 ampere, 250 volts: Shall be complete and match with appropriate cord grip plug. Devices shall meet UL 231.
- D. Weatherproof Receptacles: Shall consist of a listed weather resistant duplex receptacle, mounted in box with a gasketed, while in use weatherproof, cast metal cover plate and cap receptacle opening. The cap shall be permanently attached to the cover plate by a spring-hinged flap. Approved manufacturers: Intermatic WP10 Series, Thomas & Betts/Red Dot 2CK Series, or engineer approved equal.

2.2 **SWITCHES AND DIMMERS**

- A. Style Line/Decora rocker switches shall be totally enclosed tumbler type with bodies of phenolic compound. Toggle handles color to match receptacle device color unless otherwise specified.
 - 1. Shall be single unit toggle, butt contact, quiet AC type, heavy-duty general-purpose use with an integral self grounding mounting strap with break-off plaster ears and be of a screw terminal type.
 - 2. Shall be color coded for current rating, listed by Underwriters Laboratories, Inc., and meet the requirements of NEMA WD 1, Heavy-Duty and UL 20.
 - 3. Ratings:
 - a. 120 volt circuits: 20 amperes at 120-277 volts AC.
 - b. 277 volt circuits: 20 amperes at 277 volts AC.
 - 4. The switches shall be mounted on the strike plate side of doors.
 - 5. Incorporate barriers between switches with multi-gang outlet boxes where required by the CEC.
 - 6. All toggle switches shall be of the same manufacturer.
- B. Dimmers: Incandescent lamp loads. Wall-mounted incandescent dimmers shall be specification grade with capability of raising and lowering the lighting from completely off to full intensity. Dimmers shall maintain full load rating even when two or more units are installed adjacent to one another. All wall-mounted dimmers shall be of the same manufacturer and of a "slide" type. Color shall match all other wiring devices on project.
- C. Dimmers: Fluorescent lamp loads. Wall-mounted fluorescent lamp dimmers shall be specification grade and shall be capable of raising and lowering the lighting from five percent light output. Dimmers shall have low end intensity adjustment and maintain full load rating even when two or more units are installed adjacent to one another. All wall-mounted dimmers shall be of the same manufacturer and of a "slide" type. Dimming ballast shall be provided for each lamp or pair of lamps. Dimmers shall have adequate capacity for the load served and the environment in which installed.

2.3 **WALL PLATES**

- A. Wall plates for switches and receptacles shall be thermo plastic.

- B. Standard NEMA design, so that products of different manufacturers will be interchangeable. Dimensions for openings in wall plates shall be accordance with NEMA WD1.
- C. For receptacles or switches ganged together, wall plates shall be a single ganged plate.
- D. Wall plates for data, telephone or other communication outlets shall be as specified in the associated specification.
- E. Surface mounted boxes, NEMA1, shall be industrial grade raised galvanized steel covers. In shop areas all receptacles shall be dust proof and or waterproof where applicable.
- F. Waterproof device covers shall be cast iron, 4-corner screw type, for FS and FD type mounting. Device covers shall be zinc galvanized finish. Weatherproof covers shall be lockable.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Switches installed in hazardous areas shall be explosion proof type in accordance with the CEC and as shown on the drawings.
- B. Installation shall be in accordance with the CEC, NECA "Standard of Installation", and as shown as on the drawings.
- C. Ground terminal of each receptacle shall be bonded to the outlet box with an approved green bonding jumper, and also be connected to the green equipment grounding conductor.
- D. General: Devices shall be of the type specified herein. All devices shall be installed with "pigtailed" leads from the outlet box. No device shall be used in the "feed through" application. Screw terminals shall be used to connect all devices to the circuit and shall be grounded by means of a ground wire where grounding terminals are provided in the device.
- E. Installation: Devices and plates shall be installed in a "plumb" condition and must be flush with the finish surface of the wall where boxes are recessed.
- F. Mounting heights: All control and convenience devices shall comply with California Code of Regulations Title 24 and ADA with respect to accessibility requirements. Mounting heights indicated on plans shall have precedence.
- G. Install switches with the off position down.
- H. Clean debris from outlet boxes.
- I. Provide extension rings as required to bring outlet boxes flush with finished surface or casework.

J. Test each receptacle device for proper polarity.

END OF SECTION 16140

SECTION 16141 – EQUIPMENT LABELS AND NAMEPLATES AND WARNING SIGNS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Provide all labor materials and equipment necessary for nameplates and warning signs where specified herein and as shown on contract documents including the following:
 - 1. Nameplates and warning signs permanently installed on all electrical equipment and devices including, but not limited to, the following items:
 - a. Enclosures for transformers, switchboards, motor control, panels, pullboxes, cabinets, motors, generators, transfer switches.
 - b. Enclosures for all separately enclosed devices including, but not limited to, disconnect switches, circuit breakers, contactors, time switches, control stations and relays, fire alarm panels and lighting control panel.
 - c. Wall switches not within sight of outlet controlled.
 - d. Special systems such as, but not limited to, telephone, fire alarm, warning and signal systems. Identification shall be at each equipment rack, terminal cabinet, control panel, annunciator and pullbox.
 - e. Devices mounted within and part of equipment including circuit breakers, switches, control devices, control transformers, relays, indication devices and instruments.
 - 2. Conductor and Cable Identification.

1.2 RELATED WORK

- A. Section 16050, BASIC MATERIALS AND METHODS.
- B. Section 16120, POWER WIRE, CABLE AND CONDUCTORS.
- C. Section 16160, PANELBOARDS.
- D. Section 16170, SWITCHES, DISCONNECT AND SAFETY.
- E. Section 16460, TRANSFORMERS.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABEL DESIGNATIONS

- A. Equipment labels indicating equipment designations both emergency and normal. Designation data per drawings or to be supplied with Shop Drawings approval.
- B. Panelboard labels showing panel designation, voltage, phase and source.

- C. In accordance with CEC 110.16, provide arc flash protection warning labels on all switchboards, panelboards, distribution panels, transformers, safety switches, transfer equipment, etc. Labels shall be per ANSI Z535.4 guidelines.

2.2 MATERIALS

- A. For Labels: Three layer laminated plastic or micarta with engraved white letters over black background.
- B. For Emergency Equipment: Use engraved white letters over red background.
- C. For Warning Signs: Minimum 18 gauge steel with red lettering on white porcelain enamel finish.
- D. Arc flash labels shall be provided as required by CEC Article 70E.
- E. Conductor tape number markers: TayMac MX4280 Series non-fading permanent adhesive.

PART 3 - EXECUTION

3.1 MOUNTING

- A. Equipment labels shall be mounted by self-tapping, threaded screws and bolts, or by rivets. Adhesive types are not acceptable unless specifically noted in this section.
- B. Conductor tape markers shall be consistently placed for ready conductor identification.

3.2 HEIGHTS ON LABELS

- A. Panelboards, Switchboards and Motor Control Centers and Special Systems Enclosures: 1/4" identify equipment designation; 1/8" identify voltage rating and source.
- B. Individual Circuit Breakers, Switches, and Motor Starters in Panelboards, Switchboards, and Motor Control Centers: 3/16" identify circuit and load served, including location of equipment.
- C. Enclosed Circuit Breakers, Enclosed Switches, and Motor Starters: 3/16" identify load served.
- D. Transformers: 3/16" identify equipment designation; 1/8" identify primary and secondary voltages, primary source and secondary load. Include location of primary source or secondary load if remote from transformer.

3.3 WARNING SIGNS

- A. Warning signs shall be permanently mounted with cadmium plated steel screws or nickel-plated brass bolts.
- B. Warning signs to read "DANGER - HIGH VOLTAGE", with letters 1 1/2" high, 3/16" stroke minimum.
- C. Provide warning sign on all doors or immediately next to door for equipment rooms, enclosures or closets containing equipment energized above 150 volts to ground as per CEC, and/or as directed by the Architect. For interior finish spaces and interior doors, signage shall be coordinated and approved with the Architect in advance of installation.

END OF SECTION 16141

SECTION 16160 – PANELBOARDS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation and connection of panelboards.
- B. Manufacturer shall provide certification that the equipment supplied under this Section has been reviewed and certified to meet the current criteria for special seismic certification. Include seismic companion anchorage requirements from the testing and as approved by the manufacturer.

1.2 RELATED WORK

- A. Painting Section: Identification and painting of panelboards.
- B. Section 16050, BASIC MATERIALS AND METHODS.
- C. Section 16051 ELECTRICAL SYSTEM PROTECTIVE DEVICE STUDY: Requirements for the over current protective devices to be installed to ensure proper equipment and personnel protection.
- D. Section 16110, RACEWAYS.
- E. Section 16120, POWER WIRE, CABLES AND CONDUCTORS (600 VOLTS AND BELOW): Cables and wiring.
- F. Section 16450, GROUNDING: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.

1.3 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by the basic designation only.
- B. Underwriters Laboratories, Inc. (UL):
 - 1. No. 50 Enclosures for Electrical Equipment
 - 2. No. 67 Panelboards
 - 3. No. 489 Molded Case Circuit Breakers and Circuit Breaker enclosures
- C. National Fire Protection Association (NFPA):
 - 1. No. 70-2010 California Electrical Code (CEC)
- D. National Electrical Manufacturers Association (NEMA):
 - 1. No. PB-1 Panelboards.
 - 2. No. AB-3 Molded Case Circuit Breakers and Their Application.

PART 2 - PRODUCTS

2.1 PANELBOARDS

- A. Panelboards shall be in accordance with UL, NEMA, NEC, CEC and as shown on the drawings. Approved manufacturers are Cutler Hammer and Square D,
- B. Panelboards shall be standard manufactured products. All components of the panelboards shall be the product and assembly of the same manufacturer. All similar units of all panelboards to be of the same manufacturer.
- C. All panelboards shall be dead front safety type. Arrange sections for easy removal without disturbing other sections.
- D. All panelboards shall be completely factory assembled with molded case circuit breakers. All factory wiring shall be checked for correct tightness and visually inspected to insure that bussing and terminations have not become loose in transit to job site.
- E. Panelboards shall have main breaker or main lugs, bus size, voltage, phase, top or bottom feed, and flush or surface mounting as scheduled on the drawings. Refer to single line diagram and panel schedules on drawings. Terminals shall be minimum 75 degree rated. Back fed main circuit breakers are not allowed. Main circuit breakers shall be vertically mounted.
- F. Panelboards shall have the following features:
 - 1. Nonreduced size copper bus bars, and connection straps bolted together and rigidly supported on molded insulators. Bus bar taps for panels with single pole branches shall be arranged for sequence phasing of branch circuit devices.
 - 2. Full size neutral bar, mounted on insulated supports.
 - 3. Ground bar and isolation ground bar (where called for in panel schedule) with sufficient terminals for all grounding wires. Buses braced for the available short circuit current.
 - 4. All breakers and phase bus connections shall be arranged so that it will be possible to substitute a 2-pole breaker for two single pole breakers, and a 3-pole breaker for three single pole breakers, when trip is 30 amps or less and frame size is 100 amperes or less, without having to drill and tap the main bus bars at bus straps. Where used for heating and air conditioning, and refrigeration equipment, use only HACR type U.L. listed circuit breakers.
 - 5. Design interior so that protective devices can be replaced without removing adjacent units, main bus connectors, and without drilling or tapping.
 - 6. Where designated on panel schedule as "space", include all necessary bussing, device support and connections. Provide blank cover for each space.
 - 7. In two section panelboards, the main bus in each section shall be full size. The first section shall be furnished with subfeed lugs on the line side with cable connections to the second section. Panelboard sections with tapped bus or crossover bus are not acceptable.
 - 8. Series rated panelboards are not permitted.
 - 9. Label all panels in accordance with Section 16141, EQUIPMENT LABELS AND NAMEPLATES AND WARNING SIGNS.
 - 10. Recessed panel space conduit: Provide (1) 3/4" spare conduit stubbed to accessible ceiling space and/or interstitial space below floor for every (5) spaces and spares indicated on panel schedules.

- G. Panelboards serving as building mains shall be "service entrance rated" and UL Listed as "service equipment".

2.2 CABINETS AND TRIMS

A. Cabinets:

1. Provide galvanized steel cabinets to house panelboards. Cabinets for outdoor panels shall be factory primed and suitably treated with a corrosion-resisting paint finish meeting UL standard for outdoor applications.
2. All ventilated openings in panelboards and switchboards, shall be furnished with dust filters to prevent entrance of dust and debris.
3. Cabinets for panelboards may be of one piece formed steel or of formed sheet steel with end and side panels welded, riveted, or bolted as required.
4. Provide necessary hardware for "in" and "out" adjustment of panel interior.
5. Cabinets for two section panelboards shall be arranged side by side, and shall be the same height. Flush mounted cabinets should be 1 1/2" apart and coupled by conduit nipple if necessary.
6. Gutter size in panel boxes, on all sides, shall be in accordance with the CEC. Penetrations through gutter to live area of the panelboard shall incorporate approved non-metallic-grommet type of insulation to protect wire passing through.

B. Trims:

1. Fabricate trim of sheet steel consisting of frame with door attached by concealed hinges. Provide flush or surface trim as shown on the drawings.
2. Flush trims shall overlap the box by at least 3/4" all around.
3. Surface trim shall have the same width and height as the box.
4. Flush or surface trims shall not have ventilating openings.
5. Secure trims to back boxes by indicating trim clamps.
6. Provide a welded angle on rear of trim to support and align trim to cabinet.
7. Provide separate trims for each section of multiple section panelboards. Trims and doors of sections shall be of the same height.

C. Doors:

1. Provide doors with flush type latch and manufacturer's standard lock. Doors over 48" in height shall have a vault handle and a three-point catch, arranged to fasten door at top, bottom, and center.
2. In making switching devices accessible, doors shall not uncover any live parts.
3. Provide concealed hinges welded to the doors and trims.
4. For lighting or power contactors incorporated in panelboards, provide separate doors for the contactors.
5. Provide keyed alike system for all panelboards.
6. Provide a directory card, metal holder, and transparent cover. Permanently mount holders on inside of doors.

D. Painting:

1. Thoroughly clean and paint trims and doors at the factory with primer and manufacturer's standard finish.

2.3 MOLDED CASE CIRCUIT BREAKERS FOR PANELBOARDS

- A. Breakers shall be UL listed and labeled, in accordance with the CEC, as shown on the drawings, and as specified.
- B. Circuit breakers in panelboards shall be bolt on type on phase bus bar or branch circuit bar.
 - 1. Molded case circuit breakers for lighting and appliance branch circuit panelboards shall have minimum interrupting rating as indicated or as dictated by system Protective Study: Section 16051.
 - 2. Molded case circuit breakers shall have automatic, trip free, non-adjustable, inverse time, and instantaneous magnetic trips for 100 ampere frame or less. Magnetic trip shall be adjustable from 3 times to 10 times for breakers with 600 ampere frames and higher. Factory setting shall be HI, unless otherwise noted.
- C. Breaker features shall be as follows:
 - 1. Integral housing of molded insulating material.
 - 2. Silver alloy contacts.
 - 3. Arc quenchers and phase barriers for each pole.
 - 4. Quick-make, quick-break, operating mechanisms.
 - 5. A trip element for each pole, thermal magnetic type with long time delay and instantaneous characteristics, a common trip bar for all poles and a single operator.
 - 6. Electrically and mechanically trip free.
 - 7. An operating handle which indicates ON, TRIPPED, and OFF positions.
 - a. Line connections shall be bolted.
 - b. Interrupting rating shall not be less than the maximum short circuit current available at the line terminals as indicated on the drawings, and as shown on the electrical system protective device study as required in Section 16051. The interrupting rating shall not be less than the minimum identified requirement.
 - 8. An overload on one pole of a multipole breaker shall automatically cause all the poles of the breaker to open.

2.4 SEPARATELY ENCLOSED MOLDED CASE CIRCUIT BREAKERS

- A. Where separately enclosed molded case circuit breakers are shown on the drawings, provide circuit breakers in accordance with the applicable requirements of those specified for panelboards.
- B. Enclosures are to be of the NEMA types shown on the drawings. Where the types are not shown, they are to be the NEMA type most suitable for the environmental conditions where the breakers are being installed.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be in accordance with CEC, as shown on the drawings, and as specified.

- B. Locate panelboards so that the present and future conduits can be conveniently connected. Coordinate the sizes and layout of cabinets within the designated spaces. All equipment must be dimensioned in order to physically fit in the spaces provided and to comply with all code required clearances.
- C. Install a typewritten schedule of circuits in each panelboard. Include the room numbers (as finally described by the Owner) and items served on the cards. Obtain final room numbers from Architect prior to creating schedule.
- D. Mount the panelboard so that maximum height of the top circuit breaker above finished floor shall not exceed 78".
- E. For panelboards located in areas accessible to the public, paint the exposed surfaces of the trims, doors, and boxes with finishes to match surrounding surfaces after the panelboards have been installed.
- F. Circuit numbers shall correspond to the approved panel schedule. Provide as-built drawings showing the actual circuit numbers being used for each device on each branch circuit if changes are required.
- G. Verify depth of all flushmounted enclosures in walls to be certain wall depth will accommodate panel depth prior to installation.
- H. All openings in switchgear and panelboards that are unused shall be sealed with bolts and washers. Use caulking where holes or openings cannot be sealed by way of a washer, or bolts or conduit seals.
- I. Contractor shall include the services of an independent testing company to test GFI circuit breakers in distribution and main panelboards.

END OF SECTION 16160

SECTION 16170 – SWITCHES, DISCONNECT AND SAFETY

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Provide all labor materials and equipment necessary for disconnect and safety switches where shown on the contract drawings and specified herein.

1.2 RELATED WORK

- A. Work of this Section shall comply with the Contract Documents including, but not necessarily limited to, General Conditions and the General Requirements.
- B. Section 16141, EQUIPMENT LABELS AND NAMEPLATES AND WARNING SIGNS.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Approved Manufacturers: Cutler Hammer, General Electric, ITE-Siemens and Square-D.
- B. Disconnect Switches: Provide with devices enabling the switch to be locked in the open or closed positions.
- C. Manual Motor Switches: Tumbler type rated 3HP, 240 Volts with or without overload heaters as required to protect equipment served.
- D. Externally Operable Safety Switches: To have quick-make, quick-break mechanism, capable of switching 10 times switch rating, with cover interlock to prevent opening with switch in ON position and defeat mechanism for maintenance.
- E. Switches: Shall be general duty (GD) for 240 volt and below and heavy duty (HD) for 277/480 volt type unless otherwise indicated. Provide NEMA 1 enclosures for interior locations and NEMA 3R enclosures for exterior or wet locations. Provide with number of poles, ampacity, voltage and HP rating, fusible or nonfusible as indicated. Copper blades shall be visible in off position.
- F. Fusible Switches: Equip them with rejection clips for UL Class R fuses. Switches having a dual rating when used with dual element fuses shall have a rating so indicated and shall be confirmed by equipment vendor being connected.
- G. 600 Amperes or Less Fuses: UL Class RK1 with a minimum interrupting rating of 200,000 Amperes, Bussmann "Low-Peak Type" or equal.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

- A. Locations: Install switches, disconnects and safety where indicated on the Contract Drawings or as required by CEC.
- B. Fastenings: Securely fasten switches to structural members or unistrut support as directed by the manufacturer.
- C. Manual Motor Switches: Install flush mounted in finished areas.
- D. Manual Motor Switches: Install surface mounted in equipment rooms and non-finished areas. Where installed above inaccessible ceilings provide access panels.
- E. Label all disconnect switches in accordance with Section 16141, EQUIPMENT LABELS AND NAMEPLATES AND WARNING SIGNS.
- F. Fuse: All fuses shall be as indicated on the plan or as required by the equipment. Verify fuse size with equipment manufacturer requirements, prior to installation. Use current limiting fuses as indicated on plan. Provide one spare fuse cabinet in each electrical room with one complete set of spare fuses for all sizes of main fuses, subpanel fuses, HVAC equipment fuses and fire alarm.
- G. Terminals shall be minimum 75 degree rated.

END OF SECTION 16170

SECTION 16450 - GROUNDING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies general grounding and bonding requirements of electrical installations for personnel safety and to provide a low impedance path for possible ground fault currents as described in CEC Article 250.
- B. "Grounding electrode system" refers to all electrodes required by CEC, as well as including made, supplementary, lightning protection system and telecommunications system grounding electrodes.
- C. The terms "connect" and "bond" are used interchangeably in this specification and have the same meaning.

1.2 RELATED WORK

- A. Section 16050, BASIC MATERIALS AND METHODS.
- B. Section 16120, POWER WIRE, CABLES AND CONDUCTORS.

PART 2 - PRODUCTS

2.1 GROUNDING AND BONDING CONDUCTORS

- A. Equipment grounding conductors shall be UL 83 insulated stranded copper, except that sizes No. 10 AWG and smaller shall be solid copper. Insulation color shall be continuous green for all equipment grounding conductors, except that wire sizes No. 4 AWG and larger shall be permitted to be identified per CEC.
- B. Bonding conductors shall be ASTM B8 bare stranded copper, except that sizes No. 10 AWG and smaller shall be ASTM B1 solid bare copper wire.
- C. Conductor sizes shall not be less than what is shown on the drawings and not less than required by the CEC, whichever is greater.

2.2 GROUND RODS

- A. Copperclad steel, 5/8" diameter by 8' long, conforming to UL 467 unless otherwise noted on drawings and details.
- B. Quantity of rods shall be as required to obtain the specified ground resistance or additional rods shall be driven to obtain specified resistance or less.

2.3 SPLICES AND TERMINATION COMPONENTS

- A. Components shall meet or exceed UL 467 and be clearly marked with the manufacturer, catalog number, and permitted conductor size(s).

PART 3 - EXECUTION

3.1 GENERAL

- A. Ground in accordance with the CEC, as shown on drawings, and as hereinafter specified.
- B. System Grounding:
 - 1. Secondary service neutrals: Ground at the supply side of the secondary disconnecting means and at the related transformers.
 - 2. Separately derived systems (transformers downstream from the service entrance): Ground the secondary neutral.
- C. Equipment Grounding: Metallic structures (including ductwork and building steel), enclosures, fire sprinklers, plumbing piping, raceways, junction boxes, outlet boxes, cabinets, machine frames, and other conductive items in close proximity with electrical circuits shall be bonded and grounded.

3.2 INACCESSIBLE GROUNDING CONNECTIONS

- A. Make grounding connections which are buried or otherwise normally inaccessible (except connections for which periodic testing access is required) by exothermic weld.

3.3 SECONDARY EQUIPMENT AND CIRCUITS

- A. Main Bonding Jumper: Bond the secondary service neutral to the ground bus in the service equipment.
- B. Metallic Piping, Building Steel, and Supplemental Electrode(s):
 - 1. Provide a grounding electrode conductor sized per CEC between the service equipment ground bus and all metallic water and gas pipe systems, building steel, and supplemental or made electrodes. Jumper insulating joints in the metallic piping. All connections to electrodes shall be made with fittings that conform to UL 467.
 - 2. Provide a supplemental ground electrode and bond to the grounding electrode system.
- C. Service Disconnect: Provide a ground bar bolted to the enclosure with lugs for connecting the various grounding conductors.
- D. Transformers:
 - 1. Exterior: Exterior transformers supplying interior service equipment shall have the neutral grounded at the transformer secondary. Provide a grounding electrode at the transformer.

2. Separately derived systems (transformers downstream from service equipment): Ground the secondary neutral at the transformer. Provide a grounding electrode conductor from the transformer to nearest component of the grounding electrode system and the ground bar at the service equipment.
- E. Conduit Systems:
1. Ground all metallic conduit systems. All metallic conduit systems shall contain an equipment grounding conductor sized per CEC.
 2. Non metallic conduit systems shall contain an equipment grounding conductor.
 3. Metal conduit containing only a grounding conductor, and which is provided for mechanical protection of the conductor, shall be bonded to that conductor at the entrance and exit from the conduit.
- F. Feeders and Branch Circuits: Install equipment grounding conductors with all feeders, power and lighting branch circuits.
- G. Boxes, Cabinets, Enclosures, and Panelboards:
1. Bond the equipment grounding conductor to each pullbox, junction box, outlet box, device box, cabinets, and other enclosures through which the conductor passes.
 2. Provide lugs in each box and enclosure for equipment grounding conductor termination.
 3. Provide ground bars in panelboards, bolted to the housing, with sufficient lugs to terminate the equipment grounding conductors.
- H. Motors and Starters: Provide lugs in motor terminal box and starter housing or motor control center compartment to terminate equipment grounding conductors.
- I. Receptacles shall not be grounded through their mounting screws. Ground with a jumper from the receptacle green ground terminal to the device box ground screw and the branch circuit equipment grounding conductor.
- J. Ground lighting fixtures to the equipment grounding conductor of the wiring system when the green ground is provided; otherwise, ground the fixtures through the conduit systems. Fixtures connected with flexible conduit shall have a green ground wire included with the power wires from the fixture through the flexible conduit to the first outlet box.
- K. Fixed electrical appliances and equipment shall be provided with a ground lug for termination of the equipment grounding conductor.
- L. Raised Floors: Provide bonding of all raised floor components.
- M. Panelboard Bonding: The equipment grounding terminal buses of the normal and emergency branch circuit panelboards shall be bonded together with an insulated continuous copper conductor not less than No. 8 AWG where panels are in same room together or within 25' of each other. These conductors shall be installed in rigid metal conduit.

3.4 CONDUCTIVE PIPING

- A. Bond all conductive piping systems, interior and exterior, to the building to the grounding electrode system. Bonding connections shall be made as close as practical to the equipment ground bus.

3.5 TELECOMMUNICATIONS SYSTEM

- A. Bond telecommunications system grounding equipment to the electrical grounding electrode system.

3.6 GROUND RESISTANCE

- A. Grounding system resistance to ground shall not exceed 25 ohms. Make necessary modifications or additions to the grounding electrode system for compliance without additional cost to the Owner. Final tests shall assure that this requirement is met and test results shall be submitted to the Owner with final close out documents.
- B. Resistance of the grounding electrode system shall be measured using a four-terminal fall-of-potential method as defined in IEEE Standard 81. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not less than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes must still be provided.
- C. Below-grade connections shall be visually inspected by the IOR prior to backfilling. The Contractor shall notify the IOR 24 hours before the connections are ready for inspection.
- D. Furnish a copy of tests to Owner at completion of project.

3.7 GROUND ROD INSTALLATION

- A. Drive each rod vertically in the earth, not less than 7.5' in depth.
- B. Where permanently concealed ground connections are required, make the connections by the exothermic process to form solid metal joints. Make accessible ground connections with mechanical pressure type ground connectors.
- C. Where rock prevents the driving of vertical ground rods, install angled ground rods or grounding electrodes in horizontal trenches to achieve the specified resistance.

3.8 GROUNDING FOR RF/EMI CONTROL

- A. Install bonding jumpers to bond all conduit, cable trays, sleeves and equipment for low voltage signaling and data communications circuits. Bonding jumpers shall consist of 4"

wide copper strip or two No. 10 copper conductors spaced minimum 4" apart. Use No. 6 copper where exposed and subject to damage.

- B. Comply with the following when shielded cable is used for communication circuits.
 - 1. Shields shall be continuous throughout each circuit.
 - 2. Connect shield drain wires together at each circuit connection point and insulate from ground. Do not ground the shield.
 - 3. Do not connect shields from different circuits together.
 - 4. Shield shall be connected at one end only. Connect shield to signal reference at the origin of the circuit. Consult with equipment manufacturer to determine signal reference.

END OF SECTION 16450

SECTION 16460 - TRANSFORMERS (GENERAL PURPOSE)

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation and connection of the dry type general purpose transformers rated 600 volts and below.
- B. Manufacturer shall provide certification that the equipment supplied under this Section has been reviewed and certified to meet the current criteria for special seismic certification. Include seismic companion anchorage requirements from the testing and as approved by the manufacturer.

1.2 RELATED WORK

- A. Section 16050, BASIC MATERIALS AND METHODS.
- B. Section 16110, RACEWAYS: Conduits.
- C. Section 16130, BOXES AND GUTTERS.
- D. Section 16450, GROUNDING: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.

1.3 SUBMITTALS

- A. Submit in accordance with Section 16050, BASIC MATERIALS AND METHODS.
- B. Shop Drawings:
 - 1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
 - 2. Include electrical rating, impedance, dimensions, weight, mounting details and materials, decibel rating, terminations, temperature rise, no load and full load losses, and connection diagrams.
 - 3. Complete nameplate data including manufacturer's name and catalog number.
- C. Manuals:
 - 1. Submit, simultaneously with the shop drawings, companion copies of complete operating and maintenance manuals including technical data sheets and wiring diagrams.

1.4 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. National Fire Protection Association (NFPA):
 - 1. 70-2007 California Electrical Code (CEC)
- C. National Electrical Manufacturers Association (NEMA):
 - 1. ST 20-1992 Dry-Type Transformers for General Applications
 - 2. TP-1-1996 Energy Efficient Transformers

PART 2 - PRODUCTS

2.1 GENERAL PURPOSE DRY TYPE TRANSFORMERS

- A. Unless otherwise specified, dry type transformers shall be in accordance with NEMA, CEC and as shown on the drawings. Transformers shall be UL listed or labeled. All transformers shall comply with NEMA TP-1 energy efficiency standards as adopted by the State of California. Efficiency shall be tested in accordance with NEMA TP2.
- B. Dry type transformers shall have the following features:
 - 1. Self-cooled by natural convection, isolating windings, indoor, dry type. Autotransformers shall not be accepted unless otherwise stated.
 - 2. Rating and winding connections shall be as shown on the drawings.
 - 3. Ratings shown on the drawings are for continuous-duty without the use of cooling fans.
 - 4. Insulation systems:
 - a. Transformers 30 KVA and larger: UL rated 220 degree C system having an average maximum rise by resistance of 80 degree C in a maximum ambient of 40 degree C.
 - b. Transformers below 30 KVA: Same as for 30 KVA and larger or UL rated 185 degree C system having an average maximum rise by resistance of 80 degree C in a maximum ambient of 40 degree C.
 - 5. Core and coil assemblies:
 - a. Rigidly braced to withstand the stresses caused by short circuit currents and rough handling during shipment.
 - b. Cores shall be grain oriented, non-aging, silicon steel.
 - c. Coils shall be continuous windings without splices except for taps.
 - d. Coil loss and core loss shall be optimum for efficient operation. NEMA TP-1 type.
 - e. Primary and secondary tap connections shall be brazed or pressure type.
 - f. Coil windings shall have end fillers or tie downs for maximum strength.
 - g. Terminals shall be rated 75 degrees C minimum.
 - 6. Certified sound levels determined in accordance with NEMA, that do not exceed the following:

Transformer Rating

Sound Level Rating

0 - 9 KVA	40dB
10 - 50 KVA	45 dB
51 - 150 KVA	50 dB
151 - 300 KVA	55 dB
301 - 500 KVA	60 dB

7. Nominal impedance shall be as permitted by NEMA.
8. Single phase transformers rated 15 KVA through 25 KVA shall have two, 5 percent full capacity taps below normal rated primary voltage. All transformers rated 30 KVA and larger shall have two, 2-1/2 percent full capacity taps above, and four, 2-1/2 percent full capacity taps below normal rated primary voltage.
9. Core assemblies shall be grounded to their enclosures by adequate flexible ground straps.
10. Enclosures:
 - a. Temperature rise at hottest spot shall conform to NEMA Standards, and shall not bake and peel off the enclosure paint after the transformer has been placed in service.
 - b. Ventilation openings shall prevent accidental access to live components.
 - c. Thoroughly clean and paint at the factory with manufacturer's prime coat and standard finish.
11. Standard NEMA features and accessories including ground pad, lifting provisions and nameplate with the wiring diagram and sound level indicated on it.
12. Dimensions and configurations shall conform to the spaces designated for their installations.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be in accordance with the CEC, and as shown on the drawings.
- B. Install the transformers with adequate clearance at a minimum 6" or more from wall and adjacent equipment for air circulation to remove the heat produced by transformers and as recommended by the manufacturer to achieve U.L. listing.
- C. Install transformers on vibration pads designed to suppress transformer noise and vibrations.
- D. Use flexible metal sealtight conduit to contain the conductors from the transformer to the raceway system.
- E. Transformers shall be secured to meet CBC seismic zone 4 requirements.

END OF SECTION 16460

SECTION 16510 – INTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of this Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section Includes:
 - 1. Interior lighting systems, including luminaires, ballasts, lamps and emergency lighting equipment.
- B. Related Work:
 - 1. Section 16050, BASIC MATERIALS AND METHODS.
 - 2. Section 16110, RACEWAYS: Conduits, fittings, and boxes for raceway systems.
 - 3. Section 16120, POWER WIRE CABLES AND CONDUCTORS (600 VOLTS AND BELOW): Low voltage power and lighting wiring.
 - 4. Section 16450, GROUNDING: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
 - 5. Section 16970, LIGHTING ACCEPTANCE TESTING.

1.3 SUBMITTALS

- A. Submit in accordance with Section 16050, BASIC MATERIALS AND METHODS.
- B. Shop Drawings:
 - 1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
 - 2. Include electrical ratings, dimensions, mounting, details, materials, terminations, wiring and connection diagrams, photometric data, ballasts, luminaires, lamps and controls.

1.4 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements) form a part of this specification to the extent referenced. Publications are referenced in the text by the basic designation only.
- B. American Society for Testing and Materials (ASTM).
- C. American National Standards Institute (ANSI).
- D. Aluminum Association Inc. (AA).

- E. Illuminating Engineering Society of North America (IESNA).
- F. National Electrical Manufacturers Association (NEMA).
- G. National Fire Protection Association (NFPA).
- H. Underwriters Laboratories, Inc. (UL).

1.5 DEFINITIONS

- A. Lighting terminology used herein is defined in IES
- B. Exception: The term "driver" is used herein to cover both drivers and power supplies, where applicable.
- C. Clarification: The term "LED light source(s)" is used herein per IES to cover LED package(s), module(s), and array(s).

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

- A. Materials and equipment shall be in accordance with CEC, UL, ANSI, and as shown on the drawings and specified.

2.2 LIGHTING FIXTURES (LUMINAIRES)

- A. Shall be in accordance with NFPA 70, UL 1598 and shall be as shown on drawings and as specified. All luminaires shall have been certified to the California Energy Commission by its manufacturer to comply with the efficiency standards as per California Code of Regulations Title 24, Part 6, Section 111 referencing the Appliance Efficiency Regulations in Title 20. Post certification with building permit.
- B. Sheet Metal:
 - 1. Shall be formed to prevent warping and sagging. Housing, trim and lens frame shall be true, straight (unless intentionally curved) and parallel to each other as designed.
 - 2. Wireways and fittings shall be free of burrs and sharp edges and shall accommodate internal and branch circuit wiring without damage to the wiring.
 - 3. When installed, any exposed fixture housing surface, trim frame, door frame and lens frame shall be free of light leaks; lens doors shall close in a light tight manner.
 - a. Hinged door closure frames shall operate smoothly without binding when the fixture is in the installed position, and latches shall function easily by finger action without the use of tools.
- C. Ballasts shall be serviceable while the fixture is in its normally installed position, and shall not be mounted to removable reflectors or wireway covers.
- D. Lamp Sockets:

1. Fluorescent: Lampholder contacts shall be the biting edge type or phosphorous bronze with silver flash contact surface type and shall conform to the applicable requirements of UL 542. Contacts for recessed double contact lampholders and for slimline lampholders shall be silver plated. Lampholders for bi pin lamps, with the exception of those for "U" type lamps, shall be of the telescoping compression type, or of the single slot entry type requiring a one quarter turn of the lamp after insertion.
- E. Recessed fixtures shall be of the type approved for the ceiling and insulation conditions and appropriate for the installation location. Insulation must be held back from the fixture to provide manufacturers' recommended clearances for proper operation. Thermal tripping shall be the installer's responsibility to correct. Where installed in fire rated ceilings, coordinate installation of fire rated enclosures around the ceiling penetrations. Fixtures shall contain the proper through wiring capacity for that which is shown on the plans.
- F. Recessed fixtures shall be provided with the appropriate trims and hardware compatible with the ceiling type shown. Plaster frames are required where plaster or gypsum board ceilings are encountered.
- G. Fluorescent fixtures with louvers or light transmitting panels shall have hinges, latches and safety catches to facilitate safe, convenient cleaning and relamping. Vapor tight fixtures shall have pressure clamping devices in lieu of the latches.
- H. Mechanical Safety: Lighting fixture closures (lens doors, trim frame, hinged housings, etc.) shall be retained in a secure manner by captive screws, chains, captive hinges or fasteners such that they cannot be accidentally dislodged during normal operation or routine maintenance.
- I. Metal Finishes:
 1. The manufacturer shall apply standard finish (unless otherwise specified) over a corrosion resistant primer, after cleaning to free the metal surfaces of rust, grease, dirt and other deposits. Edges of pre-finished sheet metal exposed during forming, stamping or shearing processes shall be finished in a similar corrosion resistant manner to match the adjacent surface(s). Fixture finish shall be free of stains or evidence of rusting, blistering, or flaking.
 2. Interior light reflecting finishes shall be white with not less than 85 percent reflectances, except where otherwise specified on the drawing.
 3. Exterior finishes shall be as shown on the drawings.
- J. Provide all lighting fixtures with a specific means for grounding metallic wireways and housings to an equipment grounding conductor.
- K. Light Transmitting Components for Fluorescent Fixtures:
 1. Shall be 100 percent virgin acrylic plastic or water white, annealed, crystal glass.
 2. Flat lens panels shall have not less than 1/8 inch of average thickness. The average thickness shall be determined by adding the maximum thickness to the minimum unpenetrated thickness and dividing the sum by 2.
 3. Unless otherwise specified, lenses, diffusers and louvers shall be retained firmly in a metal frame by clips or clamping ring in such a manner as to allow expansion and contraction of the lens without distortion or cracking.
- L. Provide wire lamp guard on all exposed lamp fixture/luminaires.

- M. Provide fixtures with a U.L. listing for shower or shower rating above shower or tub areas.

2.3 LED LUMINAIRE REQUIREMENTS

- A. General Requirements:
 - 1. Luminaire shall have an external label per ANSI C136.15
 - 2. Luminaire shall have an internal label per ANSI C136.22.
 - 3. Luminaires shall start and operate in -20°C to +40°C ambient.
 - 4. LED light source(s) and driver(s) shall be RoHS compliant.
- B. Driver
 - 1. Rated case temperature shall be suitable for operation in the luminaire operating in the ambient temperatures as indicated.
 - 2. Shall accept the voltage or voltage range indicated, and shall operate normally for input voltage fluctuations of plus or minus 10 percent. Consistent with NEMA SSL 1.
 - 3. Shall have a minimum Power Factor (PF) of 0.90 at full input power and across specified voltage range.
- C. Electromagnetic interference
 - 1. Shall have a maximum Total Harmonic Distortion (THD) of 20% at full input power and across specified voltage range.
 - 2. Shall comply with FCC 47 CFR part 15 non-consumer RFI/EMI standards.
- D. The following shall be in accordance with corresponding sections of ANSI C136.37
 - 1. Wiring and grounding
 - 2. All internal components shall be assembled and pre-wired using modular electrical connections.
 - 3. Mounting provisions
 - 4. Terminal blocks for incoming AC lines
 - 5. Latching and hinging
 - 6. Ingress protection

2.4 LAMPS

- A. Provide lamps for all luminaires.
- B. LED LIGHT SOURCE
 - 1. Minimum Color Rendering Index (CRI): 60.
 - 2. Correlated Color Temperature (CCT)
 - a. CCT shall be as listed in Table 1 below:

Table 1. Allowable CCT

Manufacturer-Rated Nominal CCT (K)	Allowable LM-79 Chromaticity Values Measured CCT (K)
2700	2580 to 2870
3000	2870 to 3220
3500	3220 to 3710
4000	3710 to 4260
4500	4260 to 4746

5000
5700
6500

4745 to 5311
5310 to 6020
6020 to 7040

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation and furnishing of lighting fixtures shall be in accordance with the CEC, manufacturer's instructions and as shown on the drawings or specified. Fixtures damaged in transit and storage prior to completion shall be replaced at Contractor's expense.
- B. Align, mount and level the lighting fixtures uniformly.
- C. Avoid interference with and provide clearance for equipment. Where the indicated locations for the lighting fixtures conflict with the locations for equipment, change the locations for the lighting fixtures by the minimum distances necessary as approved by the Architect. The Architectural reflected ceiling plan will take precedence over electrical plans.
- D. For suspended lighting fixtures, the mounting heights shall provide the clearances between the bottoms of the fixtures and the finished floors as shown on the drawings.
- E. Lighting Fixture Supports:
 - 1. Contractor shall provide support for all of the fixtures independent of suspended ceilings. Supports may be anchored to channels of the ceiling construction, to the structural slab or to structural members within a partition, or above a suspended ceiling.
 - 2. Shall maintain the fixture positions after cleaning and relamping.
 - 3. Shall support the lighting fixtures without causing the ceiling or partition to deflect.
 - 4. Hardware for recessed fluorescent fixtures:
 - 5. Fixtures shall be supported as detailed on drawings and as required by DSA standards.
 - 6. Installation: Fixtures shall be securely mounted on ceilings and walls with appropriate fastening devices. "Drop-in" type T-bar fixtures shall be secured with #12 gauge safety "earthquake wires" as described by California Code of Regulations Title 24 Part 2, Chapter 47. "Earthquake clips" will be required for fastening to the T-bar system in addition to safety wire. Surface mounted fluorescent fixtures shall be solidly screwed or clipped into framing above drywall with 4-#10 sheet metal screws into each fixture. Provide blocking for screw supports behind all surface mounted lighting fixtures weighing more than 15 lbs.
 - 7. Surface mounted lighting fixtures:
 - a. Fixtures shall be bolted against the ceiling independent of the outlet box at four points spaced near the corners of each unit. The bolts shall be minimum ¼-20 bolt, secured to structural ceiling. Non-turning studs may be attached to the building structure by 12 gauge safety hangers.
 - 8. Fixtures mounted in open construction shall be secured directly to the building structure with approved bolting and clamping devices.
 - 9. Single or double pendent mounted lighting fixtures:

- a. Each stem shall be supported by an approved outlet box, mounted swivel joint and canopy which holds the stem captive and provides spring load (or approved equivalent) dampening of fixture oscillations. Outlet box shall be supported vertically from the building structure and be allowed to swing to a 45 degree angle.
10. Outlet boxes for support of lighting fixtures (where permitted) shall be secured directly to the building structure with approved devices or supported vertically in a hung ceiling from the building structure with a nine gauge wire hanger, and be secured by an approved device to a main ceiling runner or cross runner to prevent any horizontal movement relative to the ceiling.
- F. Furnish and install the specified lamps for all lighting fixtures as part of this project.
 - G. Coordinate between the electrical and ceiling trades to ascertain that approved lighting fixtures are furnished in the proper sizes and installed with the proper devices (hangers, clips, trim frames, flanges), to match the ceiling system being installed.
 - H. Bond lighting fixtures and metal accessories to the grounding system as specified in Section 16450, GROUNDING.
 - I. At completion of project, relamp all fixtures which have failed/burned-out lamps. Clean all fixtures, lenses, diffusers and louvers that have accumulated dust/dirt during construction.
 - J. Provide unswitched leg of interior lighting branch circuit to integral emergency battery pack light fixtures, exit signs and night lights as applicable per lighting plans.
 - K. Wallmount fixtures in walkway areas shall not project more than 4 inches from wall when projection occurs lower than 80 inches.

END OF SECTION 16510

SECTION 16612 - UNINTERRUPTIBLE POWER SYSTEM, THREE PHASE

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Provide all labor materials and equipment necessary for three phase uninterruptible power system where shown on the contract drawings and specified herein.
- B. Related Work:
 - 1. Work of this Section shall comply with the Contract Documents including, but not necessarily limited to, General Conditions and the General Requirements.

1.2 **LEGAL REQUIREMENTS AND STANDARDS**

- A. Comply with applicable Codes and Standards noted in Section 16050 BASIC MATERIALS AND METHODS and the following additional commercial standards:
 - 1. ANSI/IEEE 241 Electric Power Systems in Commercial Buildings, Recommended Practice for.
 - 2. ANSI/NEMA 250 Enclosures for Electrical Equipment.
 - 3. EIA Electronic Industries Association Standards.
 - 4. IEEE-587 Standards for Surge Withstandability.
 - 5. NEC National Electrical Code; Article 700 Emergency Systems.
 - 6. NEMA PB2 Panelboard.
 - 7. UL 1012 Underwriter's Laboratory Listing.

1.3 **SUBMITTALS**

- A. General: Conform to applicable provisions of Section 16050, BASIC MATERIALS AND METHODS.
- B. Shop Drawings and Catalogue Data: Required to provide sufficient information to indicate scope and quality of the UPS System installation as follows:
 - 1. Block diagram showing system relationships of major components and quantities and interconnecting cable requirements.
 - 2. Control console and panel arrangements, equipment outlet devices, and special mounting details.
 - 3. Wiring diagrams showing terminal identification for field-installed wiring.
 - 4. Catalog literature.
 - 5. Operating and services manuals. The manuals shall be bound in flexible binders and all data contained therein shall be printed or typewritten. Each manual shall include all instruction necessary for proper operation and receiving of the system, and shall include a complete block diagram of the system, a complete circuit diagnosis of the system, and a wiring designation schedule for each amplifier as well as other major components, and a replacement parts list.

1.4 QUALITY ASSURANCE

- A. General: Conform to applicable provisions noted in Section 16050, BASIC MATERIALS AND METHODS.
- B. Uninterruptible power system components shall be manufactured by firms that are regularly engaged in the production of UPS system including auxiliary equipment similar to that required for this project and that have been in satisfactory service for at least 10 years.
- C. Operation of the uninterruptible power system shall be demonstrated to the Engineer to prove that under normal conditions UPS will provide power to the designated load without interruptions of functions and loss of stored information.

1.5 MAINTENANCE

- A. Required: The Contractor shall respond to trouble calls with a competent repair person at the project site within 24 hours; Contractor shall also maintain a full inventory of replacement parts so that all routine repairs can be completed within 24 hours.

PART 2 - PRODUCTS

2.1 THE SYSTEM

- A. General Description: This specification describes a continuous duty, three-phase solid-state uninterruptible power supply system, hereafter referred to as the UPS. The UPS shall operate in conjunction with the utility power distribution system to provide quality power for electronic equipment loads. The system shall consist of multiple power processors, including a solid-state inverter, and a rectifier/battery charger; storage battery or batteries; system metering; and a static transfer switch and bypass, as described in the following specification. The configuration of the system is shown on the system one-line diagram and includes the following major equipment:
 - 1. Power Processors, including Rectifier/Chargers and Inverters.
 - 2. UPS Battery Bank(s), common source for all processors, including battery racks.
 - 3. UPS Bypass Switchgear.
 - 4. System Metering.
 - 5. Remote Monitor Panel.
- B. Required: The UPS initially being furnished shall have provisions for all necessary interface connection and accessory items to ensure that it can be easily and economically expanded at a for increased capacity.

2.2 MODES OF OPERATION

- A. Modes of the On-Line Fully Reverse Transfer System:
 - 1. Normal: The critical load is continuously controlled supplied by the inverters. The rectifier/battery chargers derive power from the commercial ac source and supply dc power to the inverters while simultaneously float charging the batteries.

2. Emergency: Upon failure of the commercial ac power, the critical load is supplied by the inverters, which without any switching, obtain power from the storage battery. There shall be no interruption to the critical load upon failure or restoration of the commercial ac source.
3. Recharge: Upon restoration of the commercial ac source, the inverter/chargers power the inverters and simultaneously recharge the batteries. This shall be an automatic function and shall cause no interruption to the critical load.
4. Bypass Mode: If the UPS must be taken out of service for maintenance or repair of multiple internal failures, the static switch transfers the load to the alternate source without an interruption. The static switch shall be provided as a draw-out assembly so that the static switch can be electrically isolated for maintenance once the load has been transferred to the alternate source. The static switch shall also be capable of providing fault clearing current to the load when the bypass source is available. Retransfer of the shall be accomplished by automatically synchronizing the UPS to the alternate source, paralleling the inverters with the alternate source, and then disconnecting the alternate source.
5. Downgrade: If the batteries alone are taken out of service for maintenance, they are disconnected from the rectifier/chargers and the inverters by means of circuit breakers. The UPS shall continue to function and meet all of the performance criteria specified herein, except for the reserve time capability.
6. Non-Redundant (Redundant Systems Only): If one or more power processors are taken off line, but the load demand does not exceed the capacity of the processors remaining on-line, the UPS shall continue to furnish conditioned power from the inverters and operate in a non-redundant mode. Emergency and bypass modes shall operate as described above.

2.3 UPS PERFORMANCE CHARACTERISTICS

- A. The UPS shall have and be compatible with the following electrical characteristics per single line diagram.

2.4 GENERAL UPS MODULES REQUIREMENTS

- A. Semiconductor Fusing: All power semiconductor switching circuits, excluding the static switch, shall be fused to prevent cascading or sequential semiconductor failures. Indicator lamps denoting blown fuse conditions shall be provided.
- B. Components: All active electronic devices shall be solid-state. All semiconductor devices shall be sealed. Vacuum tubes shall not be used. All relays shall be provided with dust covers.
- C. Noise: Noise generated by the UPS under any condition of normal operation shall not exceed a sound pressure level of 75 dBA measured five feet from the surface of the UPS. Decibel reference pressure is 0.0002 dynes per square centimeter.
- D. Grounding: The UPS output ac neutral bus shall be electrically isolated from the UPS chassis. The UPS chassis and signal ground systems shall be connected together and to a common ground point. The UPS output ac neutral bus shall be connected to the power neutral ground bus in the facility.

- E. Conductors: All power cables and buses shall be copper for maximum system performance.
- F. Power Transformers: Input and output transformers shall be designed and manufactured for high efficiency. The efficiency of the power transformers shall not be less than 98 percent. Windings shall be copper for reliability and efficiency. The output transformers shall have electrostatic shields for noise suppression and isolation of the UPS. Insulation type shall have a temperature rating that is at minimum the highest winding temperature calculated during UPS operation. Transformers shall be mounted directly on the bottom of the UPS frame to provide a low center of gravity.
- G. Materials: All materials and parts comprising the UPS shall be new, of current manufacture, and shall not have been in prior service, except as required during factory testing.
- H. EMI Suppression: Electromagnetic effects shall be minimized to ensure that the computer systems on the output bus shall neither adversely affect, nor be affected adversely by, the UPS.
- I. Surge Protection: The UPS shall have built-in protection against undervoltage, overcurrent, and overvoltage, including low energy lightning surges introduced on the primary ac source, and voltage and current surges on the output.
- J. Printed Circuit Board Interlock: All plug-in printed circuit boards shall have mechanical interlocks to prohibit a board from being plugged into the wrong place and electrical interlocks to prohibit system operation if all boards are not properly installed.
- K. Module Control Panels: A module control panel shall be furnished for each module equipped with the following meters, controls, and indicators. (All status indicators shall use light-emitting diodes for long life.)
 - 1. Metering (2 percent accuracy) of the following functions:
 - a. AC Input Voltage
 - b. AC Input Current
 - c. Battery Current (zero-center)
 - d. DC Voltage
 - e. AC Output Voltage
 - f. AC Output Current
 - g. Elapsed Time
 - h. Frequency Meter (3 percent accuracy)
 - 2. Controls:
 - a. AC Input Breaker
 - b. DC Battery Breaker
 - c. AC Output Breaker
 - d. UPS Module On
 - e. UPS Module Off
 - f. Lamp Test
 - g. Horn Silence
 - 3. Status Indicator:
 - a. AC Input Breaker Open (yellow)
 - b. AC Input Breaker Closed (green)
 - c. DC Battery Breaker Open (yellow, flashing when the inverter is on)
 - d. DC Battery Breaker Closed (green)

- e. AC Output Breaker Open (yellow)
 - f. AC Output Breaker Closed (green)
 - g. UPS Module On (green)
 - h. UPS Module Off (yellow)
 - i. UPS Module OK (green)
 - j. UPS Module Alarm (yellow)
 - k. UPS Module Tripped (red)
 - l. Utility Synchronized OK (green)
 - m. OK to Close Output Breaker (yes, green; no, yellow)
4. Alarm Indication:
- a. Charger Fuse Blown (red)
 - b. Charger Logic Failure (red)
 - c. Charger Overtemperature (red)
 - d. Battery Ground (yellow)
 - e. Battery Discharge (yellow)
 - f. Battery Undervoltage (yellow)
 - g. Inverter Fuse Blown (red)
 - h. Inverter Overtemperature (red)
5. Audible Alarm: A horn shall be located on the control panel, which is activated upon any UPS alarm or when the inverter is on and the battery breaker is open.
- L. Logic Power Supplies: Dual control logic power supplies shall be used per processor, that incorporate an "either/or" concept with the utility and the inverter as dual sources of logic power, backed up by sealed, lead-acid batteries, which provide a third level of redundancy and as support for annunciation circuits in the case of a complete system shutdown. Redundancy of power supplies shall be available without any switching.

2.5 RECTIFIER/CHARGER

- A. General: Incoming ac power shall be converted to regulated dc output by the rectifier/chargers. The rectifier/chargers shall be twelve pulse, phase controlled, solid-state type with constant voltage/constant current control circuitry.
- B. Voltage Regulation: The rectifier/charger output voltage shall not deviate by more than ± 1 percent due to primary input voltage and frequency variations up to the limits stated and ambient temperature variations.
- C. Current Limit: Each rectifier/charger shall be capable of supplying an overload current not less than 125 percent of full load current (FLC). The rectifiers shall be current limited against greater demand. The input current limit shall be adjustable over the range of 100 to 125 percent of the full load input under nominal operating conditions.
- D. Input Harmonic Suppression: Each rectifier/charger shall be designed per Paragraph A to limit the input harmonic current feedback into the source to a maximum of 12 percent total harmonic distortion (THD) with nominal input voltage and rated load on the inverter.
- E. Walk-In: Each rectifier/charger shall contain a timed walk-in circuit that causes the unit to assume the load gradually after the input voltage is applied. The dc voltage walk-in shall be delayed a minimum of 4 seconds (not to exceed 10 seconds) increasing to battery open-circuit voltage over a period of 15 seconds. Current shall increase

gradually from zero to 100 percent over a 5-second period after the battery open-circuit voltage has been reached.

- F. Magnetization Inrush Limiting: The initial magnetization inrush surge shall be limited to 600 percent of the rectifier/charger full-load current.
- G. Power Factor: the rectifier/charger shall have a minimum power factor of 0.85 with nominal input voltage and frequency and the inverter operating at full-rated load.
- H. Overload Protection and Disconnect: Each module shall be provided with an input circuit breaker and fuses for disconnecting the rectifier/chargers and overload protection. The overload devices shall not be activated when the rectifier/charger is started under any of the operating conditions listed.
- I. Capacity: Each rectifier/charger shall have sufficient capacity to support a fully loaded inverter and recharge the battery to 95 percent of its full capacity within 12 times the discharge time when input current limit is set at 125 percent of full load.

2.6 **INVERTERS**

- A. General: The inverters shall be the step-wave type, which generates 3-phase ac power. Each inverter shall be capable of providing the specified quality output power while operating from any dc source voltage within the battery operating range.
- B. Output: The output voltage and capacity of the inverters shall be as specified in the electrical characteristics, herein, and shall operate in accordance with the following requirements:
 - 1. Voltage Regulation: The inverter steady-state output voltage shall not deviate by more than ± 1 percent due to ambient temperature variations and minimum to maximum dc bus voltage. The inverter voltage shall remain within the 1 percent specified band when inverter "drop" onto battery with full-rated load on its output or retransfer of rated load from the alternate source to the inverters.
 - 2. Frequency Regulation: The free-running, steady-state output frequency of the inverters shall not deviate by more than ± 0.1 percent due to ambient temperature variation and minimum to maximum dc bus voltage. The inverter output shall have zero frequency transients for the system disturbances under voltage regulation.
 - 3. Harmonic Distortion: The inverter shall provide harmonic neutralization and filtering necessary to limit the total harmonic distortion (for linear loads) of the output voltage to 5 percent and single harmonics to 3 percent over the entire load range.
 - 4. Surge Response: The inverter surge voltage shall not exceed ± 8 percent due to a 50 percent step load application and rejection with zero initial load and 50 percent initial load, transfer of rated load to the alternate source, and any failure to the redundant rectifier/charger or inverter while the system is supporting the rated system load and the failed unit is being cleared from the system.
 - 5. The output voltage shall return to within +2 percent of the steady-state value within 25 milliseconds and to +1 percent of the steady-state value within 50 milliseconds, for any of the conditions listed above.
 - 6. Overload: Each inverter shall be capable of supplying currents and regulated voltage for overloads exceeding 103 percent and up to 125 percent of full load current for a selected period between zero and 10 minutes. A flashing warning

- lamp and audible alarm shall indicate overload operation. The inverter shall transfer the load to bypass when the overload period expires.
7. Fault Clearing and Current Limit: Each inverter shall be capable of supplying an overload current of 150 percent of its full-load rating for 30 seconds, 200 percent of its full-load rating for phase-to-phase faults, and 300 percent for phase-to-neutral faults instantaneously for 10 cycles for fault clearing.
 8. Voltage Adjustments: Each inverter shall have a control to manually adjust the output voltage +5 percent from the rated value.
 9. Inverter Shutdown: For instantaneous removal of the inverter from the critical load upon an internal failure, the inverter electronics shall contain a commutating circuit for instantaneously shutting off the inverter silicon controlled rectifiers (SCRs). In a nonredundant mode, the static switch shall gate on simultaneously to provide continuous power to the critical load. In a redundant mode, the inverter shall remove itself from the system, without disturbing the critical bus. The remaining inverters support the critical load.
 10. Line Drop Compensation: The inverters shall be provided with circuitry so that their output voltage rises linearly with output current. The rise shall be adjustable from zero to five percent. No external voltage sensing shall be required to achieve this function, and it shall not interfere with other requirements of this specification. The purpose of this feature is to compensate for varying line drop voltage between the inverter and the critical load.
 11. Inverter dc Protection: The inverters shall be protected by the following alarms and trips, which shall be independently adjustable for maximum system flexibility.
 - a. DC Overvoltage Trip
 - b. DC Undervoltage Warning
 12. The dc undervoltage trip shall be load dependent to protect the battery from possible damage due to a slow discharge under light loading.
 13. Output Circuit Breaker: Each inverter shall be mechanically connected and disconnected from the critical load by a non-automatic, molded-case circuit breaker located inside each module. External circuit breakers shall not be required.
 14. Overcurrent Protection: The inverters shall be protected from excessive overloads, including faults and reverse currents with current limiting fuses. An automatic circuit breaker is not acceptable for this purpose. The fuses shall be properly sized so that they will not interrupt the specified inverter overload capability.

2.7 STATIC SWITCH AND BYPASS

- A. General: A static switch and bypass shall be provided as an integral part of the UPS. The system metering cabinet shall contain the control logic that senses the status of inverter logic signals and alarm conditions to provide an uninterrupted transfer of the load to the alternate source without exceeding the surge limits specified herein when a non-redundant malfunction occurs in the UPS. The static switch shall be a draw-out type for ease of maintenance and shall be completely removable during bypass operation with no interruption to the critical load.
- B. Static Switch: The static switch shall be a naturally commutated, high-speed, static transfer device. The bypass switch shall be paralleled with a circuit breaker that is activated at the same time as the static switch to provide positive connection of the load to the alternate source that is not dependent on internal UPS logic or control level

power supplies. The static switch shall be a non-continuous rated device designed to carry continuous current only in a shorted condition in the event that the bypass breaker fails.

- C. Bypass Breaker: A non-automatic, shunt-tripped circuit breaker shall be incorporated in the UPS switchgear that shall allow for maintenance of the UPS and static switch. The bypass breaker shall be electrically closed whenever the static switch is gated on.
- D. Operation: The static and bypass switches shall be connected to the bypass source and assume the critical load when required, and have the following features:
 - 1. Uninterrupted Transfer: The static bypass switch shall automatically gate on assuming the critical load within 150 microseconds after the inverter logic senses one of the following conditions:
 - a. Inverter overload period expired
 - b. Critical bus overvoltage or undervoltage
 - c. Battery protection period expired (dcUV)
 - d. Critical bus overcurrent (surge in-rush) (103 percent)
 - e. UPS failure
 - 2. Uninterrupted Automatic Retransfer: If the transfer control switch is set for automatic retransfer, the UPS shall be capable of retransferring the critical load to the inverter when the overload is removed, or the critical bus voltage stabilizes. The control panel shall indicate when automatic retransfer is possible. The inverter shall automatically walk-up smoothly to the output bus voltage, parallel and share the load with the bypass source, and assume the load in a bumpless manner prior to disconnection of the bypass source for a maximum of 20 cycles.
 - 3. Uninterrupted Manual Retransfer: Retransfer of the critical load to the inverter shall occur upon manual command when the transfer control switch is in the manual position and the control panel indicates retransfer is possible. Retransfer operation shall be as described by automatic retransfer except manually initiated.
 - 4. Transfer Lockout: The static switch logic shall not allow a transfer to bypass if one of the following conditions exists:
 - a. Bypass overvoltage/undervoltage (+10 percent of nominal voltage)
 - b. Bypass frequency out of limits (+0.5 to 1.0 Hz, adjustable)
 - c. Bypass out of synchronization
 - d. Voltage difference (+10 percent of bypass voltage)
- E. Switchgear Cabinet: A separate, free-standing cabinet shall be provided to house the static switch and bypass switchgear. Protective devices and the equipment shall be sized for the system capacity [and any additional future capacity, as specified herein]. All buses shall be braced for 50,000 amperes symmetrical current. The switchgear cabinet shall be provided in accordance with the mechanical and electrical specifications cited herein.
 - 1. General Description: The Switchboard shall be of the specified number of vertical sections bolted to form one metal enclosed, rigid switchboard, which is designed for indoor installation. The sides and top shall be covered with removable screw-on covers. The rear shall be covered with removable screw-on covers. The rear shall be covered with hinged doors. All steel surfaces shall be chemically cleaned and treated to provide a bond between paint and metal surfaces to aid in preventing the entrance of moisture and formation of rust under the paint film. The switchboard finish paint shall be identical to the UPS modules.

2. All buses shall be copper and shall be sized on the basis of not more than 1,000 amperes per square inch current density and plated at each joint with silver. The bus bars shall be mounted on supports of high-impact, non-tracking insulating material, and braced to withstand mechanical forces exerted during short circuit conditions of the specified magnitude. All hardware used on conductors shall have a high tensile strength and suitable protective finish.
3. A copper ground bus shall be furnished secured to each vertical section and shall be joined at each section to provide a continuous bus the length of the entire switchboard.
4. All wiring, necessary fuse blocks, fuses, and terminal blocks within the switchboard shall be furnished. All groups of control wires leaving the switchboard shall be provided with terminal blocks with clearly numbered and marked terminal points. Where practical, bypass sensing terminal blocks shall be centralized in one compartment with access from the front and isolation from buses.
5. The switchboard shall be provided with an adequate means for lifting and shall be able to be rolled, or moved with a forklift into installation position and bolted directly to the floor.
6. All power connections shall be made in the rear to the bus stubs or directly to breaker lugs. Terminal lugs on bus stubs are not provided unless specified. Cable entry shall be from the [top] [bottom] of the switchboard, as specified.
7. Devices: The switchboard shall include all protective devices shown on the one-line, with necessary interconnections and control wiring.
8. Breakers shall be stationary mounted. Circuit breakers and other protective devices shall be individually mounted, behind front-cover plates to achieve dead front switchboard construction. Bolted front cover plates shall be used for stationary mounted devices, and hinged doors for front removable or draw-out devices.
9. Breaker compartments shall be labeled with white core, bakelite plates stating the function and current rating of the device it contains.

F. System Metering:

1. General: System metering shall be provided to enable system level monitoring. It shall be similar in appearance to the UPS modules.
2. Meter Panels: Meters shall be mounted on black panels at the uppermost section of the cabinet face. Meters to be furnished are:
 - a. Inverter/Bypass Voltage with selector switch (2 percent panel type)
 - b. Critical Bus Current with selector switch (2 percent panel type)
3. Module Annunciation Panels: Lamps, indicating status of system modules, shall be mounted vertically and be color coded. Indication shall include:
 - a. Module ON (green)
 - b. Battery Breaker Closed (green)
 - c. Output Breaker Closed (green)
 - d. Module Alarm (yellow)
 - e. Battery Discharge (yellow)
 - f. Low Battery (yellow)
 - g. Module Fail (red)
4. System Status and Alarm Panel: The following color-coded lamps shall be provided:
 - a. Status:
 - 1) Utility Source (green)
 - 2) Alternate Source (yellow)
 - 3) Generator and Utility Sync Disabled (yellow)

- 4) Generator Sync Disabled (yellow)
 - 5) System Bus Breaker Open (yellow)
 - 6) System Bus Breaker Closed (green)
 - 7) Bypass Breaker Open (green)
 - 8) Bypass Breaker Closed (yellow)
 - 9) Critical Bus Available (green)
 - 10) Load Exceeds UPS On Line (yellow)
 - 11) Phase Lock (green)
 - 12) Voltage Difference (yellow)
 - b. Manual Maintenance Actuators:
 - 1) Transfer to UPS (pushbutton)
 - 2) Transfer to Bypass (pushbutton)
 - 3) Manual-Automatic Transfer (selector switch)
 - 4) Horn Silence
 - 5) Summary Alarm (reset)
 - 6) Lamp Test
 - 7) Emergency Shutdown
 - 8) System Voltage Adjust (push pot)
 - c. Alarms (All Red Lamps):
 - 1) Bypass Out of Limits
 - 2) UPS Input Fail
 - 3) Bypass Input Fail
 - 4) Logic Fail
 - 5) Transfer Fail
 - 6) Bypass Breaker Fail
 - 7) System Overvoltage
 - 8) System Undervoltage
 - 9) System Overload
 - 10) On Bypass
5. Audible Alarm: A horn shall be located on the alarm panel, which is activated upon any module or system alarm.

2.8 **MECHANICAL DESIGN UPS POWER PROCESSORS**

- A. Enclosures: Each Power processor shall be housed in free-standing, dead-front enclosures of a welded steel framework. Doors and panels shall be of 14 gauge steel; framework shall be of 11 gauge steel. All instruments, status indicators, and controls shall be mounted behind doors with plexiglass viewing windows. The cabinets shall be capable of being installed back-to-back and end-to-end.
- B. Ventilation: Forced-air cooling shall be provided to ensure that all components are operated within their environmental ratings. Power switching modules shall be cooled by redundant fans located on the power-switching module, directly below critical components to ensure that the cooling air path is not obstructed. Other fans shall also be redundant. Blower motors shall be equipped with sealed bearings. Fan failures shall cause annunciation and an audible alarm to sound. All air inlets shall be equipped with standard type filters, which are replaceable from outside the unit. All air inlet and exhaust openings shall be protected with expanded metal guards.
- C. Cable Entry: Cable entry shall be through the [top] [bottom] of the cabinets.

- D. Modular Construction: Each Power processor's solid-state power switching circuits and control systems shall be modular in construction for ease of maintenance and to minimize down time. The modules shall be grouped by function with interchangeability between any modules that have the same function.
- E. Power Switching Modules: All solid-state power switching modules shall be of the draw-out type removable from the front of the UPS. The vendor shall be able to demonstrate that mean-time-to-repair these modules (with manufacturer's recommended spare parts on site) does not exceed 30 minutes.
- F. Parts Placement: Each Power processor shall be designed to permit ready access to modules and assemblies. Parts, test points, and terminals shall be placed so that they are accessible for circuit checking, adjustment, and maintenance without the removal of any adjacent module or assembly.
- G. Power Connections: All power connections shall be of the bolted type for reliability. The connections shall include Belleville washers to assure long-term integrity.
- H. Personnel Safety: Each Power processor cabinet shall be constructed so that none of the controls are operable with the doors closed. A tool such as a screwdriver shall be required to open the doors. High voltage warning labels shall be clearly visible when any of the cabinet doors are opened.
- I. Painted Surfaces: Painted surfaces shall be cleaned, phosphatized, and finished with an electrostatically applied, textured enamel of a minimum 2-mil thickness of the manufacturer's standard colors.

2.9 **ENVIRONMENTAL CONDITIONS**

- A. The UPS shall be capable of withstanding any combination of the following environmental conditions in which it must operate without mechanical or electrical damage or degradation of operating characteristics.
 1. Ambient Temperature: 40 degrees C
 2. Relative Humidity: Zero to 95 percent for 10 degrees C to 40 degrees C temperature.
 3. Barometric Pressure: From sea level to 4,000 feet above sea level.
 4. Battery Room Ambient: Continuous: 20 degrees to 25 degrees C.

2.10 **BATTERY BANK**

- A. Capacity: A lead-acid, high-rate type battery shall be used as a stored energy source for the UPS. The battery shall be sized to support the inverter at rated load or the kilowatt load specified for the protection time specified in electrical requirements, herein. The battery shall consist of one or more banks of cells as required, and be a common source for each inverter.
- B. Construction: Each cell shall be a sealed 20-year life expectancy, assembled in heat-resistant, shock-absorbing, clear plastic containers with covers cemented in place to form a permanent leak-proof seal. Cell post and cover shall be sealed against seepage of electrolyte for the life of the battery. Covers shall be filled with explosion-

resistant vent caps. Cell terminal posts shall be equipped with connector bolts having acid resisting nuts. Sufficient sediment space shall be provided so that the battery will not have to be cleaned out during its normal life. Electrolyte level lines shall be marked on all four sides of the container.

- C. Rack: Steel racks, designed specifically for the battery cell type furnished, shall be provided. The racks shall be [] [tier] [step] type designed for installation in a Uniform Building Code Zone, determined by site location.
- D. Ground Protection: The battery shall have a high resistance ground and a ground detection alarm for maximum personnel safety.
- E. Battery Circuit Disconnect: A disconnect device shall be provided for each power processor for disconnecting the battery upon a battery discharge to the inverter dcUV protection level and as a manual disconnect for battery maintenance.

2.11 **FACTORY TESTING**

- A. The UPS shall be tested in accordance with the following test procedures. A test report showing that the equipment has passed the factory tests and has demonstrated the capability to support the load, as required by this specification, shall be available promptly after completion of the tests. A test battery shall be available for assuring proper operation of the UPS with a battery.
- B. System Log: Establish a log to record all tests performed and results, and record any failures and corrections made during test, should any occur.
- C. Visual Inspection:
 - 1. Check for all Quality Assurance Stamps
 - 2. Inspect interior
- D. Dielectric Tests:
 - 1. Check for charger shorts
 - 2. Check for dc shorts
- E. Efficiency Test: Measure module efficiency by dividing inverter output power by the charger input power with a fully charged battery connected and float charger. Verify compliance with specifications under the following loads:
 - 1. Half load, 1.0 power factor
 - 2. Full load, 1.0 power factor

2.12 **WARRANTY**

- A. The system warranty shall be no less than 12 months after initial startup, and must include all costs including repair, parts, labor, travel and living expenses for the manufacturer's service personnel, within the United States.
- B. The battery provided herein shall be guaranteed by the manufacturer on a pro-rata basis for twenty years, and shall deliver no less than 80 percent of its rated capacity for the full twenty year warranty period.

- C. The manufacturer shall guarantee, in writing, the stated system efficiency. If the tested system efficiency is less than that stated, the manufacturer shall refund to the user an amount based on additional power costs incurred by loss of efficiency over a 3-year operating period.

2.13 DOCUMENTATION AND TRAINING

- A. The UPS shall be supplied with sufficient documentation, including a concise operation and maintenance manual, to allow training personnel to troubleshoot and service the UPS. The UPS vendor shall make available a maintenance training school for customer personnel.
- B. Operating and Maintenance Manual: The Contractor shall furnish 6 copies of the operating and maintenance manuals. The manuals shall possess sufficient detail and clarity to enable the City's technicians to understand and operate the system equipment, and to identify replaceable parts.

PART 3 - EXECUTION

3.1 GENERAL

- A. The uninterruptible power system shall be installed as shown, shall conform with Section 16010, General Electrical Requirements and in accordance with the equipment manufacturer's installation instructions.
- B. Detailed Requirements:
 - 1. The Contractor shall receive, store, and assemble all sections of the UPS to form complete units. The Contractor shall make all internal wiring interconnections as required for complete assembly of each UPS. Where wiring connectors are not supplied by the manufacturer, the Contractor shall furnish the connectors required to complete internal wiring terminations.
 - 2. The Contractor shall take all necessary precautions to eliminate moisture and foreign material from the equipment at all times during storage and installation. Special care shall be taken to prevent corrosion of and damage to the UPS.
 - 3. Each UPS shall be set level and plumb on its floor channels furnished, installed, and grouted in by the Contractor as shown. The Contractor shall furnish all shims necessary to accomplish these requirements.

END OF SECTION 16612

SECTION 16970 - LIGHTING ACCEPTANCE TESTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of this Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section Includes:
 - 1. The Contractor shall be responsible for the Certificate of Acceptance, but coordinate with the Certified California Lighting Controls Test Technician to assure that all required documents have been filed with and approved by the enforcement agency prior to receiving a final occupancy permit. The Certificate of Acceptance will indicate that the Contractor has demonstrated acceptance requirements of the plans and specifications, that current requirements for installation certificates are met, and that currently required operating and maintenance information (as well as the Certificate of Acceptance) were provided to the building Owner.
 - 2. Testing, evaluation and calibration of lighting controls equipment provided, installed and connected in Division 16.
 - 3. Documentation of test results, completion of "Certificate of Acceptance" and "Certificate of Installation" forms and filing with the enforcement agency for approval.
 - 4. Specific Jobsite Conditions:
 - a. Acceptance testing must be tailored for each specific design, job site, and climactic conditions. While the steps for conducting each test remain consistent, the application of the tests to a particular site may vary. The Contractor shall review the construction documents and include all required time, material, testing equipment, etc. as required to complete the requirements of this section.
- B. Related Work:
 - 1. Section 16050, COMMON WORK RESULTS FOR ELECTRICAL.
 - 2. Section 16510, INTERIOR LIGHTING.

1.3 REFERENCES

- A. Acceptance Testing Criteria: 2019 Building Energy Efficiency Standards Non-Residential Compliance Manual.

1.4 SYSTEM DESCRIPTION

- A. Performance Requirements:

1. All material, equipment, labor and technical supervision to perform tests, calibrations and documentation specified herein.
- B. Scope of Testing, Evaluation and Calibration (as applicable):
 1. Automatic (master) time switches.
 2. Occupancy sensors.
 3. Automatic daylighting controls.
 4. Photo electric sensors.
 5. Daylighting controls.
 6. Outdoor astronomical time switches.
 7. Area controls.

1.5 **SUBMITTALS**

- A. Test Reports:
 1. Written record of all tests and completion of forms included in this section.
 2. At completion of project, assemble a final test report. Submit report to the enforcement agency and the Owner prior to final occupancy to include:
 - a. Summary of project.
 - b. Description of systems and equipment tested.
 - c. Visual inspection report.
 - d. Description of tests.
 - e. Test results.
 - f. Conclusions and recommendations.
 3. Report shall be bound in booklet form, include on the Contractor's letterhead the title of the report and the systems tested.
- B. Constructability Plan Review
 1. The Contractor shall review the construction drawings and specifications to understand the scope of the acceptance tests and raise critical issues that might affect the success of the acceptance tests prior to starting construction. Any constructability issues associated with the lighting system should be forwarded to the design team for review/modifications prior to equipment procurement and installation. The Contractor shall submit on company letterhead, with the lighting control equipment required by Section 16050, COMMON WORK RESULTS FOR ELECTRICAL, 1.4B, a letter confirming that the constructability review has been completed and their company has reviewed and is prepared to complete the lighting acceptance testing required by this section.

PART 2 - PRODUCTS

2.1 **FORMS**

- A. Lighting Installation forms and verification procedures for lighting systems that require acceptance testing can be downloaded from the following website:
<https://energycodeace.com/nonresidentialforms>
- B. Lighting Acceptance forms are to be provided by a Certified California Lighting Controls Acceptance Test Technician. The California Energy Commission adopted changes to the California building Efficiency Standards (Title 24, Parts 1 and 6) that

require lighting controls and devices to be certified as properly installed and operational, prior to issuance of occupancy permits. All Acceptance Technicians must be employed by an Acceptance Test employer that provides support as well as quality control. Certified California Lighting Controls Acceptance Test Technicians can be found at the following website: www.calctp.org/acceptance-technicians/contractors

- C. These completed forms will be the deliverable product to the enforcement agency and Owner as described in 1.4 of this section.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

- A. Tests:
 - 1. Contractor's Responsibilities:
 - a. Perform all required tests required by this section.
 - b. Schedule testing with building Owner.
 - c. Provide Installation forms
 - d. Acceptance forms provided by California Certified Lighting Controls Technician hired by Contractor.
 - e. Calibration of equipment such as light meters, photo electric controls, etc.
 - f. Programming of time switches (interior/exterior lighting) for operations as directed by the Owner.

3.2 ADJUSTING

- A. Final Settings: The Contractor shall be responsible for implementing all final settings and adjustments on controls equipment as required for a complete and operating system.

END OF SECTION 16970