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END OF SECTION

SECTION 07 8400 – FIRESTOPPING

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Firestopping systems.

B. Firestopping of all joints and penetrations in fire resistance rated and smoke resistant assemblies, whether indicated on drawings or not, and other openings indicated.

C. Provide firestopping in conjunction with work specified in the following Divisions:

1. Division 26: Holes or voids created to extend electrical systems through fire-rated roofs, floors, and walls.

1.02 RELATED REQUIREMENTS

A. Section 26 0500 – Common Work Results for Electrical

B. Section 26 0534 – Conduit

1.03 REFERENCES

A. ASTM E814 – Standard Test Method for Fire Tests of Through-Penetration Fire Stops.

B. UL (DIR) – Online Certifications Directory; current listings at database.ul.com.

C. UL (FRD) – Fire Resistance Directory; current edition.

1.04 SUBMITTALS

A. Comply with Section 26 0500 for additional submittal requirements and procedures.

B. Product Data: Provide data on product characteristics, performance ratings, and limitations.

C. Manufacturer's Installation Instructions: Indicate preparation and installation instructions.

D. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.

PART 2 - PRODUCTS

2.01 FIRESTOPPING - GENERAL REQUIREMENTS

A. Manufacturers:

1. A/D Fire Protection Systems Inc.
2. 3M Fire Protection Products.
3. Hilti, Inc.
4. Nelson FireStop Products.

B. Primers, Sleeves, Forms, Insulation, Packing, Stuffing, and Accessories: Type required for tested assembly design.

2.02 FIRESTOPPING ASSEMBLY REQUIREMENTS

A. Through Penetration Firestopping: Use any system that has been tested according to ASTM E814 to have fire resistance F Rating equal to required fire rating of penetrated assembly.

2.03 FIRESTOPPING PENETRATIONS THROUGH CONCRETE AND CONCRETE MASONRY CONSTRUCTION

A. Penetrations Through Walls By:

B. Uninsulated Metallic Pipe, Conduit, and Tubing:

C. 2 Hour Construction: UL System W-J-1067; Hilti FS-ONE MAX Intumescent Firestop Sealant.

2.04 FIRESTOPPING PENETRATIONS THROUGH GYPSUM BOARD WALLS

A. Penetrations By:

1. Uninsulated Metallic Pipe, Conduit, and Tubing:

a. 1 Hour Construction: UL System W-L-1054; Hilti FS-ONE MAX Intumescent Firestop Sealant.

2. Uninsulated Non-Metallic Pipe, Conduit, and Tubing:

a. 1 Hour Construction: UL System W-L-2128; Hilti FS-ONE MAX Intumescent Firestop Sealant.

2.05 FIRESTOPPING SYSTEMS

A. Firestopping: Any material meeting requirements.

B. Firestopping at Uninsulated Metallic Pipe and Conduit Penetrations, of diameter 4 inches or less: Caulk or putty.

C. Firestopping at Combustible Pipe and Conduit Penetrations, of diameter 4 inches or less: Any material meeting requirements.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify openings are ready to receive the work of this section.

3.02 PREPARATION

A. Clean substrate surfaces of dirt, dust, grease, oil, loose material, or other matter that could adversely affect bond of firestopping material.

B. Remove incompatible materials that could adversely affect bond.

3.03 INSTALLATION

A. Install materials in manner described in fire test report and in accordance with manufacturer's instructions, completely closing openings.

3.04 CLEANING

A. Clean adjacent surfaces of firestopping materials.

3.05 PROTECTION

A. Protect adjacent surfaces from damage by material installation.

END OF SECTION

SECTION 26 05 00 – COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Electrical submittals and product data.

B. Additional Electrical bid, workmanship, and installation requirements.

C. Common electrical implementation and closeout requirements.

1.02 RELATED REQUIREMENTS

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

B. This section covers general work of all Sections under Division 26.

C. The Division 26 Specifications and Drawings are complementary, what is called for by one is binding. Items shown on the Drawings are not necessarily included in the Specifications and vice versa.

D. Use the more stringent requirement when specified materials or methods exceed what is required by applicable Codes and Standards.

E. The following sections should be reviewed to insure the requirements for this project are met:

1. Section 26 0800 - Electrical Testing Requirements
2. Section 26 0801 - Commissioning of Electrical Systems

1.03 REFERENCES

A. Publications and standards listed below form a part of this specification to the extent referenced. The most recent version, adopted by the Authority Having Jurisdiction, will apply.

1. CEC - California Electrical Code, Title 24, Part 3, including all applicable Amendments and Supplements, as based on NFPA 70.
2. CBC - California Building Code, Title 24, Part 2
3. CMC - California Mechanical Code, Title 24, Part 4
4. CFC - California Fire Code, Title 24, Part 9
5. IBC – International Building Code
6. IECA - Insulated Cable Engineers Association
7. NFPA - National Fire Protection Association
8. NEMA - National Electrical Manufacturers Association
9. NECA - National Electrical Contractors Association
10. ANSI - American National Standards Institute
11. IEEE - Institute of Electrical and Electronic Engineers
12. UL - Underwriters Laboratories
13. CAL/OSHA - State of California Low-Voltage Electrical Safety Orders
14. CAL/OSHA - State of California High Voltage Electrical Safety Orders
15. Codes and regulations noted in other Sections in Division 26, applicable State and Local Codes and Ordinances.

B. If any of the requirements of the above Codes and Standards are in conflict with one another, or with the requirements of these specifications, the most stringent requirement shall govern. The Owner's Representative shall determine the most stringent requirement.

1.04 SUBMITTALS AND DEFERRED SUBMITTALS

A. Refer to Division 01 for additional requirements.

B. The project schedule shall be submitted to the Owner's Representative prior to acceptance of shop drawing submittals. The schedule shall include timeframe for mobilization, shop drawings, construction, milestone dates of critical path items to be installed, testing, adjusting, energization, commissioning, closeout documentation, and demobilization.

C. A written statement from the Contractor shall be included with each submittal that the equipment, hardware or accessory item complies with all the requirements of the project specification and associated drawings.

1. The Contractor shall submit the specification section showing compliance with each respective paragraph, specified items, and features that apply to the items included in the submittal.

2. All exceptions shall be clearly identified, in writing, by referencing respective paragraph and other requirements along with proposed alternative.

D. Submit all Division 26 shop drawings and product data grouped and referenced by the specification technical section numbers.

E. Organize submittals in same sequence as they appear in Specification Sections, articles or paragraphs.

F. Shop Drawings and Deferred Submittals

1. Provide coordination and supplemental design shop drawings in PDF and unlocked with all reference files in AutoCAD (.dwg) or Revit format drawn to scale. Confirm with the Owner's Representative the version of AutoCAD or Revit required.

2. Provide all other shop drawings in PDF format. Provide a minimum of 8.5 inches by 11 inches paper size if required by Owner's Representative.

3. Shop drawings shall contain job title and references to the applicable specification section.

4. Include installation details for equipment including proposed location, layout and arrangement, accessories, piping, and other items that must be shown to assure a coordinated installation.

5. Internal wiring diagrams of equipment shall show wiring as actually furnished with equipment installed for this project and with all optional items clearly identified as included or excluded. Clearly identify external wiring connections. Identify and obliterate superfluous material.

6. Indicate adequate clearances for working space operation, maintenance, and replacement of operating equipment devices. Identify all access provisions and requirements.

7. For each manufactured item, provide current manufacturer's descriptive literature of cataloged products, certified equipment drawings, diagrams, instruction manuals, performance and characteristic curves if applicable, and catalog cuts. Identify model, catalog number, options included, ratings, Code and UL compliance for every item submitted for review. Include sufficient information to indicate complete compliance with Contract Documents. Use highlighting and arrows to identify required information and options being provided. Line thru options not being provided.

8. If equipment is not approved, revise the submittal to show acceptable equipment and resubmit in a timely manner.

9. If paper submittals are required, prepare submittal material in accordance with the following:

   a. Insert all literature in standard 3-ring binders for 8-1/2 inch by 11 inch pages with individual tabs. Do not staple literature on different products together.

   b. Provide 3 sets of the 3-ring binders with same original manufacturer's literature.

   c. Number all binders on the outside of the cover and indicate the Specification Section. Mark Binder No. 1 Architects copy, No. 2 Engineers copy, and No. 3 Owner’s Representative copy.

   d. Provide an index with binder. This index shall follow the same sequence as the Specifications.

10. Product data, shop drawings and submittals: Submittals shall be prepared by the Contractor and delivered to the Owner’s Representative for approval and prior to purchase, fabrication, and installation for detailed product data, options, shop drawings, procedures and lists that are required in the specifications and on the plans including the following items, but not limited to:

    a. Bus bars and termination sections and cabinets.

    b. Power Distribution Panelboards.

    c. Lighting and appliance panelboards.

    d. Individually mounted circuit breakers.

    e. Isolating switches.

    f. Control panel enclosures with associated components.

    g. Uninterruptable Power Supplies.

    h. Conduit and fittings.

    i. Flexible Conduits, expandable fittings, and connection fittings.

    j. Fasteners and supports for light fixtures, equipment, conduits, tray, pullboxes, and devices.

    k. Wireways.

    l. Cabinets and boxes.

    m. Low / extra low voltage cables with associated splices and terminators.

    n. Grounding Connection Materials and accessories.

    o. Conduit duct plug seals, sealing compound, and expandable seals.

    p. Conduit penetration seals for water, fire stop, sound, air, and dust.

    q. Equipment identification, hazard labeling materials, and nameplates.

    r. Spreadsheet in Microsoft Excel of all information for each label or nameplate for power and communications equipment and cables to be submitted prior to fabrication and installation.

    s. Submit all switching procedures for all outages for all cutovers and connections of power cables and equipment.

G. Whenever more than one (1) manufacturer’s product is specified in the project documents, the first named product is the basis of design and the use of alternate-named manufacturer’s

products or substitutes by the Contractor may require modifications in that design. If such alternatives are proposed or used by the Contractor, there may be additional design work required. The architect and engineers will provide the design fees to modify the issued drawings for the work to incorporate that alternate into the documents within 15 days of receipt of the substitution request. The Contractor shall pay all costs required to make necessary revisions and modifications to the design, including all professional fees to the Architect and Engineers for the evaluation and revisions or modifications of the documents resulting from the substitution or selection of an alternate manufacturer submitted by the Contractor.

H. All submittals must be delivered to the Owner's Representative within the number of days allowed after the Notice to Proceed or contract award. Failure to submit any or all items shall not result in a delay in the schedule or a schedule extension. If more time is required to compile a specific submittal, then a formal request in writing may be submitted, requesting more time. This request should list the item or system, the specification section involved, the reason for the delay, and the date when this item will be submitted. This will be reviewed by the Owner's Representative and a response regarding schedule and time extension will be prepared within one week.

I. The Contractor shall be responsible for all equipment ordered and/or installed prior to receipt of shop drawings returned from the Owner's Representative bearing the Owner's Representative stamp of "Reviewed and Approved Without Comment", or "Approved with comment". All corrections or modifications required for equipment as noted on the shop drawings shall be made by the Contractor if equipment has been purchased or installed. Contractor shall pay all costs to remove equipment from the job site and/or returned at the request of the Owner's Representative, without additional compensation.

J. Standard Compliance: When materials or equipment provided by the Contractor must conform to the standards of organizations such as American National Standards Institute / Institute of Electrical and Electronics Engineers (ANSI / IEEE) or National Electrical Manufactures Association (NEMA), submit proof of such conformance to the Owner's Representative for approval. If an organization uses a label or listing from a Nationally Recognized Testing Laboratory (NRTL) to indicate compliance with a particular standard, the label or listing will be acceptable evidence, unless otherwise specified. In lieu of the label or listing, and where acceptable to Owner's Representative, submit a certificate from an independent testing organization, which is competent to perform acceptance testing and is approved by the Owner's Representative. Certification shall not contain statements to imply that the item does not meet requirements specified, such as "as good as"; or "achieve the same end use and results as materials formulated in accordance with the referenced publications"; or "equal or exceed the service and performance of the specified material". The certificate shall state that the item has been tested in accordance with the specified organization's test methods and that the item conforms to the specified organization's standard. Certifications shall be documents prepared specifically for this Contract, printed on the manufacturer's letterhead, and signed by the manufacturer's official authorized to sign certificates of compliance or conformance.

K. Certified Test Reports: Before delivery of materials and equipment, certified copies of all test reports specified in individual sections shall be submitted for approval.

L. Re-submittals will be reviewed for compliance with comment made on the original submittal only and should be marked with a resubmittal number and dated.

1.05 SUBSTITUTIONS

A. Coordinate with the requirements of Division 26, all applicable sections.

B. Products or systems listed as "no substitutions" or "no known equal" shall be provided as specified, "no equal".

C. Products or systems noted as "or equal": A product or system of equivalent design, construction and performance will be considered. Submit all pertinent data and product

information for review. Provide the specified products or systems if proposed substitution is found unacceptable.

1.06 MATERIALS FURNISHED

A. Refer to applicable Division 26 Sections for complete product specifications, including Manufacturers' names and model numbers used for materials, processes or equipment, the standards of quality, utility and appearance.

B. All approved switchgear, switchboards, motor control centers, transformers, panelboards and circuit breakers shall be supplied from the same manufacturer and be new manufactured material and assemblies, purchased for this project.

C. All equipment shall be delivered to the job site bearing the label of Underwriters Laboratories, or other testing laboratory acceptable to authority having jurisdiction, where listing exists for the class of equipment.

D. For equipment specified by manufacturer's catalog number, include all accessories, controls, etc., listed in catalog as standard with equipment. Furnish optional or additional accessories as specified in project documents.

E. Where no specific make of material or equipment is mentioned, use products of reputable manufacturer that conform to requirements of system and other applicable specification sections.

F. Equipment and material damaged during transportation, installation, or operation is considered as totally damaged and will be replaced by Contractor with new. Variance from this requirement shall be permitted only with written approval from the Owner’s Representative.

G. Provide an Owner’s approved and authorized representative to constantly supervise Work specified. Check all materials prior to installation for conformance with Drawings, Specifications, and reviewed Shop Drawings.

H. Each purchase order or subcontract issued by the Contractor shall include project requirements for submittal data, startup services, commissioning, Operation & Maintenance (O&M) manuals, data and training.

1.07 WARRANTY

A. Comply with the requirements of Division 01, and all other project requirements.

B. Provide a written Contractor’s one-year guarantee for all workmanship and materials installed for this project unless otherwise indicated to be longer in other Division 26 Sections. Guarantee period shall be effective from time of work acceptance or as defined in Division 01, whichever date succeeds the other.

C. Refer to project specifications for requirements to provide manufacturer’s written warranty that includes all terms, conditions, exclusions, and duration.

D. Provide the Owner with extended warranty options when requested.

1.08 DEFINITION OF TERMS

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

1. Provide: Shall mean furnish, install, connect, and test unless otherwise indicated.
2. Furnish: Shall mean purchase and deliver to project site.
3. Install: Shall mean to physically install and connect the items in-place.
4. Connect: Shall mean make final electrical connections for a complete operating piece of equipment or system.

5. Equal: Shall be of the same quality, appearance and utility to that specified, as determined by the Owner's Representative. The Contractor bears the burden of proof of equality.
6. Exposed: Shall mean exposed to view and readily accessible after construction is completed.
7. Concealed: Shall mean hidden from view after construction is completed.
8. Utility Area: Shall mean electrical, mechanical and communications equipment rooms, elevator machine room, equipment yards, and other locations where utility and utilization equipment and systems are installed.
9. As directed: Shall be as directed by the Owner's Representative.
10. As required: Shall be as required by project documents, applicable code requirements, good building practice, the conditions prevailing, the Owner, or the Owner's Representative.
11. As selected: Shall be as selected by the Owner's Representative.
12. Owner's Representative: Shall mean person/group designated by Owner to represent the Owner.
13. Inspector of Record (IOR): Shall mean the person who is responsible for inspecting and approving the installation, and the person who is the representative for the Authority Having Jurisdiction.
14. Extra low voltage: Shall mean voltages of less than 90 volts line to ground.
15. Low voltage: Shall mean voltages of over 100 volts line to neutral to maximum of 600 volts line to line.

PART 2 - INSTALLATION AND QUALITY

2.01 ELECTRICAL WORKMANSHIP AND QUALIFICATIONS REQUIREMENTS

A. The electrical project includes the entire scope of work included and referenced in the project documents including complete installation of equipment, cable, and materials required for a complete and operable system after completion of testing, energization, and commissioning of the new equipment. Contactor shall include all costs to achieve these requirements in Contract bid price.

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, except, 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 the work is such that good supervision can be maintained and the quality of workmanship achieved is the best and as required by the latest edition of the California Electric Code.
2. Before each journeyman electrician commences work, deliver to Owner’s Representative at the project site, a photocopy of the journeyman's valid Pocket Card.
3. All splicing and termination work on systems operating in excess of 600V shall be performed exclusively by a Journeyman electrician with a minimum of 5 years

verifiable work experience making the types of splices and terminations required in the project scope of work. The Journeyman electrician shall possess and provide evidence of training through completion of a certification program for making splices and terminations. The Contractor shall submit resumes and training certificates to the Owner's Representative for review and approval for all Journeyman electricians, who will be making splices and terminations, 30 days in advance of any work activity.

C. Make installation in a neat, finished and safe manner, according to the latest published NECA Standard of Installation under competent supervision.

2.02 SCHEDULE OF WORK

A. Coordinate with the requirements of Division 26, all applicable sections.

B. Provide full-time supervisory staff to coordinate and maintain work force for project work sequencing requirements as detailed in the Owner approved project schedule.

C. When requested by the Owner, submit a project recovery schedule to return the project to the approved completion dates.

2.03 SITE VISITATION

A. Coordinate with the requirements of Bidding and Contract Requirements, Instruction to Bidders.

B. Visit the site prior to bidding and become familiar with existing conditions and other factors that may affect the execution of work. Include all related costs in the initial bid proposal.

C. Contractor shall visit the site and verify dimensions and scale shown on the plans and details prior to submitting a bid. Scale and dimensions shown are diagrammatic and shall not be used in preparing a bid estimate or for ordering material and equipment.

2.04 SAFETY

A. The electrical installation shall comply with all regulations on safety aspects issued by the Labor Department and other authorities from time to time. These include but are not limited to the following:

1. Construction Sites (Safety) Regulations including California Code of Regulations, Title 8, Division 1, Department of Industrial Relations.1.
2. Factories and Industries Undertakings Electricity Regulations.
3. IEC 60364-7-704: Construction and Demolition Site Installation.
4. Electricity Ordinances.
5. Construction Site Safety Manuals and Cal-OSHA requirements.

B. Coordinate and provide all barriers, fences, covers, warning tape, and plaques required to warn and protect workers and the public from all hazardous conditions during performance of the Work.

C. The Contractor shall ensure that all workers utilize Personal Protective Equipment required for each task necessary to complete the scope of work.

D. Provide all training and job site safety instructions for Contractor and Owner's personnel prior to performing construction activities. Conduct safety meetings prior to implementing switching procedures required for electrical system shutdowns and energization.

E. The Contractor shall designate a safety officer who will conduct daily observation of workplace activity to assure compliance with safe work practices required to safeguard workers and the public from hazards. Provide the Owner with weekly written reports on job site safety. Report any and all incidents to the Owner's Representative immediately.

2.05 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. Comply with NECA 1.

B. Examine site related work and surfaces before starting work of any Section.

C. Report to Owner's Representative, in writing, conditions which will prevent proper execution of this work.

D. Beginning work of any Section without reporting unsuitable conditions to Owner's Representative constitutes acceptance of conditions by Contractor. Perform any required removal, repair or replacement of this work caused by unsuitable conditions at no additional cost to Owner.

E. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall- mounting items, unless indicated otherwise.

F. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom and working space consistent with these requirements.

G. Equipment: Install equipment and materials to facilitate service, maintenance, and repair or replacement of both electrical equipment and other nearby installations and systems. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

H. Right of Way: Give right of way to gravity and piping systems installed at a required slope.

I. Install work uniform, level and plumb, in relationship to lines of the building. Do not install any diagonal or otherwise irregular work unless so indicated on the drawings or approved by the Owner's Representative.

2.06 INSTALLATION

A. Provide a complete properly operating system for each item of equipment called for under this work. Installation shall be in accordance to equipment manufacturer's instructions, the best industry practices and the contract documents.

B. Review Shop Drawings for work done by other trades.

C. For the purposes of clarity and legibility the contract drawings are essentially diagrammatic. Verify all dimensions by field measurements.

D. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the work.

E. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to comply with the Codes and coordinate installation with other systems and appurtenances.

F. Install systems, materials, and equipment to comply with approved submittal data, approved deferred submittal and coordination drawings, to greatest extent possible. Comply with arrangements indicated by the Contract Documents, recognizing that portions of the work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer the conflict to the Architect and/or Engineer.

G. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations. Rearrangement or relocation of electrical work that block access to mechanical duct inspection or servicing panels, valves, fire damper actuators and similar apparatus shall be done at Contractor's own expense.

H. Access to Equipment: Locate switches, trapeze hangers, and pullboxes to provide easy access for operation, repair, and maintenance, and if concealed, provide access doors and assist with layout. Access doors shall be installed by the framer and supplied by Electrical Contractor.

I. Where housekeeping pad is noted on drawings provide minimum 3-1/2 inch / maximum 4-inch high concrete housekeeping pads for floor mounted electrical equipment. Housekeeping pad should extend no more than 2-inches beyond the equipment enclosure unless otherwise noted.

J. Conduit Systems

1. Worked into complete, integrated arrangement with like elements to make work neat appearing, finished.

2. Where exposed, install parallel with walls or structural elements: vertical runs plumb; horizontal runs level or parallel with structure as appropriate: groups racked together neatly with straight runs and bends both parallel and uniformly spaced.

3. Install as high as practicable to maintain adequate head room shown or required. Coordinate with Work of other Divisions to achieve proper headroom. Arrange conduits to maximize space to install future raceways.

4. Clearance: Do not obstruct spaces required by code in front of electrical equipment, access doors, etc.

5. It shall be unacceptable to combine circuits, conduits, cables, pull boxes, or junction boxes of extra low voltage systems and low voltage systems. No combining of communications systems with power systems will be permitted, unless the combination is necessary for termination within an equipment assembly.

2.07 COORDINATION

A. Arrange and coordinate the electrical system installation with other trades to provide inserts, chases, slots, and openings in other building components during progress of construction, to allow for electrical installations. Do any cutting and patching required due to improperly located or omitted openings with the approval of the Owner's Representative, who must also approve any additional changes resulting from relocation or omission of openings. Cutting or drilling in any structural member is prohibited without prior written approval of the Owner.

B. Coordinate arrangement, mounting, and support of electrical equipment:

1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.

2. To provide for ease of disconnecting the equipment with minimum interference to other installations.

3. To allow right of way priority for piping and conduit installed at required slope

4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

5. To allow for clearance of electrical systems, equipment, and materials installations with other building components.

C. Coordinate installation of required supporting devices, sleeves, and openings in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

D. Coordinate installing large equipment requiring positioning before closing in the building.

E. Coordinate the exact placement of all concrete foundations or related concrete pads with concrete contractor that relate to electrical equipment.

F. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed.

G. Coordinate work of this Division 26 with work of all other divisions. Conduct work in a manner to cooperate with all other trades for proper installation of all items of equipment. Consult the Drawings of all other trades or crafts to avoid conflicts with cabinets, counters, equipment, structural members and mechanical and plumbing work. In general, the architectural drawings govern but resolve conflicts with the Architect and/or Engineer prior to rough - in. Coordinate rough-in and wiring requirements for all mechanical, kitchen, and medical equipment with equipment supplier and installer. Make installation in accordance with rough-in and wiring diagrams provided for Contractors use.

H. Verify the physical dimension of each item of electrical equipment to fit the available space. Contractor is responsible for coordinating electrical equipment space requirements with the allotted space provisions, and access for determining routes through the construction area for final installation.

I. Coordinate underground work with other contractors working on the site. Perform coordination with contractors installing storm sewer, sanitary sewer, water and irrigation lines, to avoid conflicts. Common trenches may be used with other trades, providing clearances required by codes, ordinances, and project requirements are maintained.

J. Perform tracing and identification of existing underground utilities before trenching and excavation. Make adjustments to conduit and duct bank routes and pullbox, handhole and vault locations and all electrical equipment as necessary to avoid interference and in order to complete the installation.

K. All underground duct banks shall be photographed and surveyed before backfill. Provide GPS coordinate data, based on the Owner's coordinate system, for all duct bank sections installed for the project. The GPS survey shall include manholes, location of utility system crossings, width and extents of duct bank, locations of bends, location of lateral ducts, and other features. Provide the GPS coordinates on the Contractor as-built plans during construction. Provide all GPS data in a Microsoft Excel spreadsheet and include drawing reference and location for each survey point.

L. Coordinate all aspects of the electrical power, telephone and other utility services with the appropriate serving utility or Owner as applicable.

2.08 DRAWINGS AND COORDINATION WITH OTHER WORK

A. Exact routing of wiring and locations of outlets, panels, etc., shall be governed by structural conditions, obstructions and existing conditions. Architect / Engineer reserves right, at no increase in price, to make any reasonable change in locations of electrical items, exposed at ceiling and/or on walls, to group them into orderly relationships and/or increase their utility. Contractor shall verify Architects / Engineer requirements in this regard prior to roughing-in.

B. Dimensions, location of doors, partitions, and similar physical features shall be taken from architectural drawings for exact location of outlets to center with Architectural features, panels, etc., at the approximate location shown on Electrical Drawings.

C. Verify dimensions and the correct location of equipment and coordinate with other trades for any requirement, notify Owner's Representative of all changes of location requirements before proceeding with the roughing-in of connection.

D. Mounting heights of brackets, outlets, etc., shall be as required to suit equipment served.

E. Drawings indicate, generally, routes of all branch circuits. All runs to panels are indicated as starting from nearest outlet, pointing in direction of panel. Continue all such circuits to panel as though routes were indicated in their entirety.

F. All scaled and figured dimensions are approximate of typical equipment of the class indicated. Before proceeding with any Work, carefully check and verify all dimensions, sizes, and

mounting requirements with the approved submittals and drawings to see that the equipment being installed will fit into the spaces provided.

G. The Contractor shall be responsible for verifying that equipment being provided will fit dimensionally in locations shown on Drawings.

2.09 CONNECTIONS TO EXISTING WORK

A. Install new work and connect to existing work with minimum interference or interruption to existing facilities and systems.

B. Provide temporary power where indicated as being required to be provided by the Contractor during shutdowns of existing services.

C. Schedule all outages with written consent of Owner. Perform this work at no additional charges and at times authorized that do not interfere with normal operation of existing facilities.

D. Maintain continuous operation of existing facilities as required with temporary utility connections between new and existing work or with temporary generators.

E. Do not interrupt alarm and emergency systems without consent of Owner. Provide temporary systems to maintain alarms and emergency systems when required for occupancy.

F. Connect new work to existing work in neat and acceptable manner.

G. Restore existing disturbed work to original condition including finish, enclosure integrity, maintenance, continuity of wiring, and operability as required.

2.10 TEMPORARY FACILITIES

A. Provide temporary light, power, alarm, and detection services as necessary during the construction period and as required to maintain operation of existing systems and occupancy of facilities.

B. Existing building distribution equipment, devices, circuits, and power shall not be used for construction without written permission of the Owner.

C. Contractor shall provide temporary power apparatus, wiring, and outlets required for use for construction. Contractor shall provide and install temporary power meters and disconnects when connection to the Owner’s utility source is permitted by the Owner. Owner shall be reimbursed for the direct cost of energy used by the Contractor.

2.11 NOISE CONTROL

A. Contractor shall refer to the project documents and identify locations where operating equipment and device noise, vibration restrictions, and limits are to be complied with based on Codes, Ordinances, or Owner’s criteria.

B. Perform necessary sound rated wall sealing for the electrical work in compliance with project requirements.

C. Back to back or straight through boxes in walls are not permitted unless specifically noted on the drawings.

D. Route raceways along corridors or other noncritical noise space to minimize penetrations through sound rated walls. Seal raceway penetrations through sound rated walls.

E. Do not install noise and vibration producing devices on walls common to occupied spaces unless specifically noted on the drawings. Where such devices must be mounted on common walls, install using shock mounted or vibration and noise isolated methods to prevent the transmission of device inherent noise and vibration to the occupied space.

F. Ballasts, contactors, starters, transformers and like equipment which are found to be noticeably noisier than other similar equipment installed for the project will be deemed defective and shall be replaced.

2.12 EQUIPMENT

A. Equipment Installation

1. Follow manufacturer's directions and recommendations in all cases where the apparatus and devices used on this contract are provided with directions covering points not shown on the drawings or covered in these specifications.
2. Provide complete electrical connections, and interconnections, for all items of equipment including incidental wiring, materials, devices and labor necessary for a finished working installation.
3. Where equipment ratings differ from those shown in the project documents, the Contractor shall be responsible to provide the required changes to supply the load. Submit all changes to the Owner's Representative for approval prior to installation.
4. Verify the location and method for connecting to each item of equipment prior to roughing-in.
5. Check voltage and phase of each item of equipment before connection.
6. Furnish all code required disconnects, whether or not specifically shown in the contract documents and manufacturer's literature.

B. Equipment Support and Seismic Restraint

1. Install equipment seismic anchorage in compliance with the IBC and California Amendments and requirements from the local agency having jurisdiction.
2. Securely fasten to the structural floor, and provide lateral bracing if required, for all freestanding electrical equipment such as transformers, switchboards, distribution boards, transfer switches and so forth.
3. Securely support fixtures from the building structure. Provide bracing and seismic restraints to limit motion during a seismic event.
4. Support all junction boxes, pull boxes, or other raceway terminating housings located above the suspended ceiling from the floor above, roof or penthouse floor structure to prevent sagging or swaying as shown on drawing details.
5. Securely support conduits and raceways from the building structure.
6. Minimum support capacity for all equipment devices: Not less than four times the ultimate weight of the object being supported from the building structure or anchored to the structural floor, or structural engineer's specified supports based on structural engineer's calculations and details
7. Seismic Protection Criteria: Electrical equipment installations shall be protected from earthquakes. Seismic anchorage requirements of the CBC apply to this project. Protection criteria shall be a Horizontal Force Factor as prescribed by the CBC multiplied by the equipment weight considered passing through the machinery center of gravity in any horizontal direction.
    a. Unless vibration isolation is required to protect equipment against structure transmitted noise and/or vibration, equipment shall be protected from earthquakes by rigid structurally sound attachment to the load supporting structure. The force factor and anchorage shall be determined by calculations performed by a registered California Structural engineer whether the isolators are present or not.
    b. Vibration isolated equipment shall be protected by protected spring isolators. Seismic snubbers and protected spring isolators shall be seismic protection rated in three principal axes by independent laboratory testing or analysis by an independent licensed structural engineer.

c. Construction of all electrical gear, and equipment such as switchgear, switchboard, motor control center, panelboard, transformer and similar equipment shall meet seismic requirements per the CBC and IBC.

d. If structural plans and details do not call out the seismic supports or has changed the method of attachment per plans then the Contractor shall be responsible for the design of his own seismic restraint systems. Contractor shall provide structural calculation and shop drawings for electrical equipment support. These drawing and calculations shall be prepared, sealed and signed by a Registered California Structural Engineer, and submitted for review and approval.

e. Seismic protection, labor, materials and design shall be included in the Contract bid price.

C. Equipment Alignment

1. Install panels, cabinets and equipment level and plumb, parallel with structural building lines. Join switchgear, panels and electrical enclosures so that they fit neatly together without gaps, openings or distortion.

2. Fit surface panels, devices and outlets with neat, appropriate trims, plates or covers, without over-hanging edges, protruding corners or raw edges, to leave a finished appearance.

3. Install to facilitate service, maintenance, repair or replacement of components and in compliance with CEC clearances and other articles as appropriate. Connect for ease of disconnecting, with minimum interference with other installations. Removable elements shall move freely, without binding, when being installed or removed.

2.13 POWER AND COMMUNICATIONS SWITCHING

A. Confine the extent of each service interruption to the smallest collection of equipment necessary to safely perform testing, tie-in and cut-over.

B. Coordinate with Owner for interruption of services necessary to accomplish the Work.

C. Coordinate with utility company and Owner all work associated with utility company power and communications distribution systems.

D. Coordinate with Owner for interruption of services and connections to other projects on campus.

E. Placing equipment in service: Electrical equipment shall not be energized or placed in service until all pre-energization tests and inspections are complete and approved by the Owner and IOR. Where equipment to be placed in service involves service or connection from another contractor or Owner, notify Owner in writing when equipment will be ready. Notify Owner, and all interested parties, 2 weeks in advance of the date various items of equipment will be complete. Cleaning and all pre testing shall be completed and approved before energizing.

F. Prepare and submit switching procedures for all outages for all cutovers and connections of power and communications cables and equipment. Submit these switching procedures for Owner's review and approval 30 days before work is required. Only approved switching procedures shall be performed. All switching procedures are the responsibility of the Contractor. Each switching plan shall contain the following information as a minimum:

1. A switching plan shall be prepared for each work sequence that requires installation of new supply conductors, interruption of normal service to a building or individual loads.

2. Include in switching procedure the Owner's and all third party required activities to ensure close coordination and safety.

3. Switching plan is to identify the work area designation where work will be taking place and all loads and systems that will be affected.

4. Switching plan to identify requirements for cable and equipment testing or other tests to be performed in the sequence they are required to occur.

5. Where new cable and equipment is involved, switching plan is to identify that all cable and equipment acceptance testing has been completed and accepted prior to proceeding with the procedure.

6. Identify measures for verification by voltage testing where circuits are required to be de-energized for work.

7. Identify measures for verification of conductor voltage phase sequence by phase testing.

8. All circuits shall be tested for proper phasing upon energization and prior to supplying loads or interconnection of existing circuits. Phasing of new circuits shall match existing phasing of all existing circuits and sources.

9. The switching plan is a safety measure and also used as a check list to account for each required step. Specific switch ID and switch position status for each switch or circuit breaker that requires a specific status must be identified.

10. On reaching the completion of work to complete the work in the procedure, the switching plan will include the switching necessary to restore the power system to “normal” conditions, or operating state required by the Owner upon completion of the procedure.

11. A signature/initials column is required on the switching plan for verification/acknowledgement of each complete step by the Person-In-Charge. Without signature/initials of a completed step the next step is not allowed to be performed.

2.14 CUTTING AND PATCHING

A. Coordinate necessary cutting and patching for the electrical work in compliance with Division 26.

B. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces required to permit electrical installations. Perform cutting by skilled mechanics of trades involved.

C. Neatly patch and finish any surface damaged by this work to match adjacent undisturbed surfaces; for instance, repair surfaces where raceways pass through finished floors or walls. Install new fireproofing where existing firestopping has been disturbed. Clean and remove all dirt and debris. Perform this work to the satisfaction of the Owner’s Representative.

D. Where equipment installations or connections require the installation of an access panel, provide a properly sized and installed access panel similar to those used for mechanical equipment access.

2.15 PROTECTION OF WORK

A. Protect all electrical work and equipment against damage by other trades, weather conditions or any other causes. Equipment found damaged or in other than new condition will be rejected as defective.

B. Keep all electrical equipment covered or closed to exclude dust, dirt and splashes of plaster, cement or paint and shall be free of all such contamination before acceptance. Keep enclosures and trims in new condition, free of rust, scratches and other finish defects. If damaged, properly refinish in a manner acceptable to the Owner’s Representative.

C. Provide a temporary source of power to energize circuits, such as heaters and battery systems that are required to protect the equipment from damage or other deteriorating agents.

PART 3 - EXECUTION

3.01 EQUIPMENT IDENTIFICATION AND LABELING

A. Refer to Section 26 0553 - Identification for Electrical Systems for identification requirements, including Arc Flash Hazard Labels.

B. Refer to Section 26 0573 – Electrical Power System Study for Arc Flash Hazard label printing requirements.

3.02 CLEANING AND PAINTING

A. Clean interior and exterior surfaces of equipment and raceways of all dirt, cement, plaster, and other debris. Protect interior of equipment from dirt during construction and clean thoroughly before energizing.

B. Clean out cracks, corners and surfaces on equipment to be painted, remove grease and oil spots so that paint may be applied without further preparation. Include surface preparations, priming, and finish coating for electrical cabinets, exposed conduit, pull and junction boxes.

C. Refinish and touch up paint:

1. Clean damaged and disturbed surface areas and apply primer, intermediate, and finish coats to suit the degree of damage at each location.

2. Follow paint manufacturer's written instructions for surface preparation and for timing and application of successive coats.

3. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer. Paint color to match existing color.

4. Repair damage to PVC surfaces or paint finishes with matching touchup coating recommended by manufacturer.

D. Refinish or replace Work supplied with final finish equivalent to new condition if damaged to satisfaction of Owner‘s Representative.

E. After other Work is accomplished, thoroughly clean exposed conduit, panels (interiors and exteriors), fixtures, and equipment and leave in satisfactory condition, free of debris, dirt, dust, and other contaminants.

3.03 FIELD QUALITY CONTROL

A. After installation inspect installed components for damage and faulty work, including the following, but not limited to:

1. Electrical component supporting devices.

2. Electrical equipment components.

3. Raceways

4. Concrete bases.

B. Correct all items identified as a result of inspections and observations during construction in a timely manner.

C. Correct all items identified in the Owner’s final inspection lists prior to energization and final acceptance of the Work.

3.04 ADJUSTING

A. Coordinate the requirements of all sections of Division 26.

B. Voltage Check

1. At job completion, check voltage at several points of utilization for power equipment installed under this work with installed loads energized to achieve maximum system load.

2. Adjust transformers taps for acceptable voltage level at the main service switchboard to ±2% of nominal systems voltage under maximum load. If proper voltage cannot be obtained, inform the Owner's Representative and the serving utility company.

3. Measure and verify the maximum voltage drop on feeders does not exceed 2% and maximum voltage drop on branch circuits does not exceed 3%. The total voltage drop at the final load source terminals, or outlets, shall not exceed 5%. Voltage drop shall be measured verified under maximum load conditions.

C. Phase Rotation Check

1. Measure Phase Rotation prior to feeder cutover.

2. Record phase rotation prior to de-energizing existing services and feeders.

3. Reconnect new feeders in same phase sequence.

4. Measure phase rotation of new services and feeders prior to energization. Correct phase connections as necessary to maintain same phase sequence to buildings.

3.05 POWER SYSTEM STUDIES

A. See Section 26 0573 – Electrical Power Systems Study for a complete list of what is required.

B. Work required by Section 26 0573 - Electrical Power Systems Study and support shall be included in the Contract bid price.

C. Provide study submittal for approval. Refer to Division 01 for additional requirements. Power system study shall be submitted and approved prior to any protective device testing.

D. Provide study submittal in PDF format. Provide three (3) paper copies on a minimum of 8.5-inches by 11-inches paper size, if required by Owner’s Representative,

E. Contractor shall be responsible to implement review comments for changes and corrections, including adjustments to coordination settings and graphs, shall be updated at no additional costs to Owner.

F. Contractor shall submit all requests for Owner and Utility information in writing. Contractor is responsible to request all information for the existing system from the Owner and Utility in a timely manner.

3.06 TESTING

A. The Power study as listed in section 26 0573 Electrical Power Systems Study is to be completed and approved prior to testing performed in section 26 0800 Electrical Testing Requirements.

B. See section 26 0800 Electrical Testing Requirements for all that is required by the testing contractor along with support by electrical contractor.

C. Work required by section 26 0800 Electrical Testing Requirements and support shall be include in the Contract bid price.

D. Provide test submittal for approval. Refer to Division 01 for additional requirements.

E. Provide test reports submittal in PDF format. Provide three (3) paper copies on a minimum of 8.5-inches by 11-inches paper size if required by Owner’s Representative.

F. Contractor shall be responsible to correct and implement all corrections and retesting of equipment and cable at no additional costs to Owner.

3.07 COMMISSIONING

A. Refer to Section 26 0800, Electrical Testing Requirements, for all testing to be completed and approved prior to commissioning listed in Section 26 0801, Commissioning of Electrical Systems.

B. See to Section 26 0801, Commissioning of Electrical Systems, for system commissioning requirements.

C. The Electrical Contractor is responsible to provide assistance to the Commissioning Agent throughout the entire commissioning process to ensure that all systems are operating in a manner consistent with the Design Intent. The work is not complete until the Commissioning Agent and the Owner's Representative have signed off on the commissioned systems.

D. The Contractor shall provide all labor and required tools requested by the Commissioning Agent to complete the system commissioning work. Provide and schedule equipment Factory Representative for this work when needed.

E. Work for Contractor noted in Section 26 0801, Commissioning of Electrical Systems, along with support shall be included in the Contract bid price.

F. Commissioning Agent shall be responsible to prepare and submit the final commissioning report.

3.08 TRAINING

A. Upon completion and energization of each system provide training program and instructions to the Owner's personnel for each system that is installed as part of the Work. Refer to individual specification sections for additional requirements.

B. All training shall be videotaped and delivered to Owner's Representative in DVD format unless otherwise noted.

C. Coordinate the training schedule with Owner's Representative.

D. Equipment Operation & Maintenance (O&M) manuals shall be provided at least 2 weeks prior to the scheduled personnel training.

E. Contractors bid shall include the total cost for trainer's site visits and include all shipping, travel, lodging, per diem and local transportation.

3.09 RECORD DRAWINGS AND CLOSEOUT DOCUMENTATION

A. Maintain up to date record set of electrical prints on a daily basis during the course of construction, including deferred submittal drawings. Use green to indicate deletions and red to indicate additions. Use same symbols and follow as much as possible the same drafting procedures used on Contract Drawings. The prints are subject to weekly review by the Owner's Representative to ascertain that they are current. The IOR shall review the as-built drawings prior to approval of Contract progress payments. In addition to the requirements specified in Division 01, final electronic AutoCAD files for Record Drawings shall indicate at least the following:

1. Changes to raceway systems, size and location, for both exterior and interior; changes to locations of control devices; busways; distribution, changes in wire sizes, circuit designations of branch circuitry; fuse and circuit breaker size and arrangements. Changes to control, schedules, and one line drawings and details.

2. Changes on equipment locations (exposed and concealed), dimensioned from prominent building lines.

3. Approved substitutions, Contract Modifications, and actual equipment and materials installed shall be shown on the plans. Reference to RFI responses and directives alone is not acceptable.

4. All field changes shown on field markup drawings.

5. Surveyed coordinates as-built info for all underground duct banks, pullbox, handhole and vault locations added in this project.

B. Prepare closeout record documents in accordance with the requirements of this section and Division 01 Section Closeout and Procedures and Project Record Documents.

C. Provide PDF files for review of record and deferred submittal drawings by the Owner's Representative, Engineer, and Architect. Contractor shall make revisions and corrections as noted to the Record Documents review.

D. After approval of record drawings, provide two full-size, hardcopy sets of As-Built Record Drawings and (2) CDs of identical electronic unlocked with all reference files in AutoCAD (.dwg) or Revit files with PDFs of As-Built drawing files and As-Built drawings of the deferred submittals. Confirm with Owner's Representative version of AutoCAD or Revit software. Each drawing sheet shall be a separate file with sheet name.

E. Provide special tools and/or spare parts as required by Division 26 specifications. Provide written proof of delivery submittal for approval.

F. Create a Project Closeout Document Reference Index for review.

G. Coordinate the requirements of all sections of Division 26 and the associated electrical drawings for the closeout requirements. Prepare electronic files in PDF format for the list of items below, but not limited to. Follow file format described in submittals, above. Arrange all electronic Product Data Sheets on Record Document CDs by component type, as listed on the approved Project Closeout Document Reference Index. Document Reference Index shall be grouped into the Closeout Document Folder under the division identified in the Project Checklist.

1. All approved submittals for all equipment and deferred submittal equipment, items and products installed in the Project compiled as one.

2. Equipment and deferred submittal equipment System Block Diagrams, Point-to-Point Wiring Diagrams, and Terminal Identification.

3. Equipment Installation manual, maintenance manual, parts lists, operation manual, programing manuals, as-built data sheets, and manufacturers test reports.

    a. The O&M manual shall include the following information for equipment as minimum:

        1) Manufacturers' names and addresses.

        2) Product catalogs, exploded views and brochures, complete with technical and performance data for all equipment, marked to indicate actual items furnished and intended use and incorporating all amendments made.

        3) As-built wiring diagrams, including single-line and three-line wiring diagrams.

        4) As-built programming and sequence of operations for programmable equipment.

        5) Provide 3 hard bound copies when required by the Owner.

        6) Provide PDF copies in the closeout documentation.

4. Provide all documentation required from the manufacturer to honor the equipment and material warranty.

5. Provide manufacturer's written warranty.

6. Include a copy of all project RFI logs with dates and the listings of issues and resolutions.
7. Include all Submittal logs with dates and final approval documentation.
8. Panel schedules.
9. Fuse data and locations.
10. GPS survey data in Microsoft Excel.
11. Include all final Testing Reports.
12. Include all full and complete copy of the approved Power Systems Study including arc flash hazard labeling.
13. Provide a letter signed by the Contractor that states that the completed electrical installation of electrical equipment, raceway, cables, is warranted for a period of 1 year from the Owner's accepted of Notice of Completion.
14. Provide a list of all special tools and spare parts that have been delivered to the Owner with the Owner's Representative signature.

H. After review of closeout documents by the Owner's Representative, Engineer, and Architect, Contractor shall make additions, revisions, and corrections as noted to these documents and provide updated sets. Each PDF shall have a separate PDF file for its own component and not one PDF for all items.

END OF SECTION

SECTION 26 0501 – MINOR ELECTRICAL DEMOLITION

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Electrical demolition.

PART 2 - PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. Materials and equipment for patching and extending work: As specified in individual sections.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that abandoned wiring and equipment serve only abandoned facilities.

B. Report discrepancies to Engineer before disturbing existing installation.

C. Beginning of demolition means Contractor accepts existing conditions.

3.02 PREPARATION

A. Disconnect electrical systems in walls, floors, and ceilings to be removed.

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, 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. Minimize outage duration.

1. Obtain permission from Owner at least 4 weeks before partially or completely disabling system.

3.03 DEMOLITION AND EXTENSION OF EXISTING ELECTRICAL WORK

A. Remove, relocate, and extend existing installations to accommodate new construction.

B. Remove abandoned wiring to source of supply.

C. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes. Cut conduit flush with walls and floors, and patch surfaces.

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

E. Disconnect and remove abandoned panelboards and distribution equipment.

F. Repair adjacent construction and finishes damaged during demolition and extension work.

G. Maintain access to existing electrical installations that remain active. Modify installation or provide access panel as appropriate.

H. Provide cover plates to cover holes in trenches when equipment is removed.

3.04 CLEANING AND REPAIR

A. Comply with provisions of Section 26 0500.

B. Clean and repair existing materials and equipment that remain or that are to be reused.

END OF SECTION

SECTION 26 0519 – LOW-VOLTAGE ELECTRIC POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Single conductor building wire.

B. Underground feeder and branch-circuit cable.

C. Wiring connectors.

D. Electrical tape.

E. Heat shrink tubing.

F. Wire pulling lubricant.

G. Cable ties.

1.02 RELATED REQUIREMENTS

A. Section 07 8400 - Firestopping.

B. Section 26 0501 - Minor Electrical Demolition.

C. Section 26 0526 - Grounding and Bonding for Electrical Systems.

D. Section 26 0553 - Identification for Electrical Systems.

1.03 REFERENCE STANDARDS

A. ASTM B3 - Standard Specification for Soft or Annealed Copper Wire; 2013.

B. ASTM B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft; 2011.

C. ASTM B33 - Standard Specification for Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes; 2010 (Reapproved 2014).

D. ASTM B787/B787M - Standard Specification for 19 Wire Combination Unilay-Stranded Copper Conductors for Subsequent Insulation; 2004 (Reapproved 2014).

E. ASTM D3005 - Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape; 2010.

F. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.

G. NECA 121 - Standard for Installing Nonmetallic-Sheathed Cable (Type NM-B) and Underground Feeder and Branch-Circuit Cable (Type UF); 2007.

H. NEMA WC 70 - Nonshielded Power Cable 2000 V or Less for the Distribution of Electrical Energy; 2009.

I. CEC - California Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements, as based on NFPA 70.

J. UL 44 - Thermoset-Insulated Wires and Cables; Current Edition, Including All Revisions.

K. UL 83 - Thermoplastic-Insulated Wires and Cables; Current Edition, Including All Revisions.

L. UL 486A-486B - Wire Connectors; Current Edition, Including All Revisions.

M. UL 486C - Splicing Wire Connectors; Current Edition, Including All Revisions.

N. UL 486D - Sealed Wire Connector Systems; Current Edition, Including All Revisions.

O. UL 493 - Thermoplastic-Insulated Underground Feeder and Branch-Circuit Cables; Current Edition, Including All Revisions.

P. UL 510 - Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape; Current Edition, Including All Revisions.

1.04 ADMINISTRATIVE REQUIREMENTS

A. Coordination

1. Coordinate sizes of raceways, boxes, and equipment enclosures installed under other sections with the actual conductors to be installed, including adjustments for conductor sizes increased for voltage drop and allowable space for wire bends and terminations.

2. Coordinate with electrical equipment installed under other sections to provide terminations suitable for use with the conductors to be installed.

3. Notify Engineer and Owner of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

1.05 SUBMITTALS

A. Comply with Section 26 0500 for additional submittal requirements and procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for conductors and cables, including detailed information on materials, construction, ratings, listings, and available sizes, configurations, and stranding.

C. Project Record Documents: Record actual installed circuiting arrangements. Record actual routing for underground circuits.

1.06 QUALITY ASSURANCE

A. Conform to requirements of CEC.

PART 2 - PRODUCTS

2.01 CONDUCTOR AND CABLE APPLICATIONS

A. Do not use conductors and cables for applications other than as permitted by CEC and product listing.

B. Provide single conductor building wire installed in suitable raceway unless otherwise indicated, permitted, or required.

2.02 CONDUCTOR AND CABLE GENERAL REQUIREMENTS

A. Provide products that comply with requirements of CEC.

B. Provide products listed, classified, and labeled as suitable for the purpose intended.

C. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, etc. as required for a complete operating system.

D. Comply with NEMA WC 70.

E. Thermoplastic-Insulated Conductors and Cables: Listed and labeled as complying with UL 83.

F. Thermoset-Insulated Conductors and Cables: Listed and labeled as complying with UL 44.

G. Conductor Material

1. Copper Conductors: Soft drawn annealed, 98 percent conductivity, uncoated copper conductors complying with ASTM B3, ASTM B8, or ASTM B787/B 787M unless otherwise indicated.

2. Tinned Copper Conductors: Comply with ASTM B33.

H. Conductor Color Coding

1. Color code conductors as indicated unless otherwise required by the authority having jurisdiction. Maintain consistent color coding throughout project.

2. Color Coding Method: Integrally colored insulation.

3. Color Code:

a. 480Y/277 V, 3 Phase, 4 Wire System:

1) Phase A: Brown.

2) Phase B: Orange.

3) Phase C: Yellow.

4) Neutral/Grounded: Gray.

b. 208Y/120 V, 3 Phase, 4 Wire System:

1) Phase A: Black.

2) Phase B: Red.

3) Phase C: Blue.

4) Neutral/Grounded: White.

c. 240/120 V, 1 Phase, 3 Wire System:

1) Phase A: Black.

2) Phase B: Red.

3) Neutral/Grounded: White.

d. DC, 2 Wire Systems

1) Positive: Red

2) Negative: Black

e. Equipment Ground, All Systems: Green.

2.03 SINGLE CONDUCTOR BUILDING WIRE

A. Description: Single conductor insulated wire.

B. Conductor Stranding

1. Feeders and Branch Circuits:

a. Size 10 AWG and Smaller: Solid or Stranded Refer to Drawings for specific applications.

b. Size 8 AWG and Larger: Stranded.

C. Insulation Voltage Rating: 600 V.

D. Insulation

1. Copper Building Wire: Type THHN/THWN or THHN/THWN-2, except as indicated below.

2.04 UNDERGROUND FEEDER AND BRANCH-CIRCUIT CABLE

A. Description: CEC, Type UF multiple-conductor cable listed and labeled as complying with UL 493, Type UF-B.

B. Provide equipment grounding conductor unless otherwise indicated.

C. Conductor Stranding

1. Size 10 AWG and Smaller: Solid.

2. Size 8 AWG and Larger: Stranded.

D. Insulation Voltage Rating: 600 V.

2.05 WIRING CONNECTORS

A. Description: Wiring connectors appropriate for the application, suitable for use with the conductors to be connected, and listed as complying with UL 486A-486B or UL 486C as applicable.

1. Indoor, Size 10 AWG and Smaller:

a. Listed twist-on wire connectors, suitable for size and quantity of conductors to be spliced.

b. Acceptable Manufacturers: 3M, Ideal Industries, or approved equal.

2. Outdoor: Size 10 AWG and Smaller:

a. Silicone filled sealable waterproof connectors, acceptable for wet locations.

b. Acceptable Manufacturers: 3M, King Innovation, Ideal Industries, or approved equal.

3. Size 8 AWG or Larger:

a. Use insulated tap block connector with mechanical lugs to join conductors

b. Acceptable Manufacturers: Tork/NSI or approved equal.

4. Terminate conductors on padmount transformer secondary spade terminals with compression connectors.

a. Acceptable Manufacturers: Ideal Industries, Thomas and Betts, or approved equal.

2.06 WIRING ACCESSORIES

A. Electrical Tape

1. Vinyl Color Coding Electrical Tape: Integrally colored to match color code indicated; listed as complying with UL 510; minimum thickness of 7 mil (0.18 mm); resistant to abrasion, corrosion, and sunlight; suitable for continuous temperature environment up to 221 degrees F (105 degrees C).

2. Vinyl Insulating Electrical Tape: Complying with ASTM D3005 and listed as complying with UL 510; minimum thickness of 7 mil (0.18 mm); resistant to abrasion, corrosion, and sunlight; conformable for application down to 0 degrees F

(-18 degrees C) and suitable for continuous temperature environment up to 221 degrees F (105 degrees C).

3. Electrical Filler Tape: Rubber-based insulating moldable putty, minimum thickness of 125 mil (3.2 mm); suitable for continuous temperature environment up to 176 degrees F (80 degrees C).

B. Heat Shrink Tubing: Heavy-wall, split-resistant, with factory-applied adhesive; rated 600 V; suitable for direct burial applications; listed as complying with UL 486D.

C. Wire Pulling Lubricant: Listed; suitable for use with the conductors or cables to be installed and suitable for use at the installation temperature.

D. Cable Ties: Material and tensile strength rating suitable for application.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that interior of building has been protected from weather.

B. Verify that work likely to damage wire and cable has been completed.

C. Verify that raceways, boxes, and equipment enclosures are installed and are properly sized to accommodate conductors and cables in accordance with CEC.

D. Verify that field measurements are as shown on the drawings.

E. Verify that conditions are satisfactory for installation prior to starting work.

3.02 PREPARATION

A. Clean raceways thoroughly to remove foreign materials before installing conductors and cables.

3.03 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Install conductors and cable in a neat and workmanlike manner in accordance with NECA 1.

C. Install underground feeder and branch-circuit cable (Type UF-B) in accordance with NECA 121.

D. Installation in Raceway:

1. Tape ends of conductors and cables to prevent infiltration of moisture and other contaminants.

2. Pull all conductors and cables together into raceway at same time.

3. Do not damage conductors and cables or exceed manufacturer's recommended maximum pulling tension and sidewall pressure.

4. Use suitable wire pulling lubricant where necessary, except when lubricant is not recommended by the manufacturer.

E. Paralleled Conductors: Install conductors of the same length and type. Terminate all conductors in the same manner.

F. Secure and support conductors and cables in accordance with CEC using suitable supports and methods approved by the authority having jurisdiction. Provide independent support from building structure. Do not provide support from raceways, piping, ductwork, or other systems.

G. Terminate cables using suitable fittings.

H. Install conductors with a minimum of 12 inches (300 mm) of slack at each outlet.

I. Neatly train and bundle conductors inside boxes, wireways, panelboards and other equipment enclosures.

J. Group or otherwise identify neutral/grounded conductors with associated ungrounded conductors inside enclosures in accordance with CEC.

K. Make wiring connections using specified wiring connectors.

1. Make splices and taps only in accessible boxes. Do not pull splices into raceways or make splices in conduit bodies or wiring gutters.

2. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors.

3. Do not remove conductor strands to facilitate insertion into connector.

4. Clean contact surfaces on conductors and connectors to suitable remove corrosion, oxides, and other contaminates. Do not use wire brush on plated connector surfaces.

L. Insulate splices and taps that are made with uninsulated connectors using methods suitable for the application, with insulation and mechanical strength at least equivalent to unspliced conductors.

M. Insulate ends of spare conductors using vinyl insulating electrical tape.

N. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 8400.

O. Unless specifically indicated to be excluded, provide final connections to all equipment and devices, including those furnished by others, as required for a complete operating system.

END OF SECTION

SECTION 26 0523 – CONTROL-VOLTAGE ELECTRICAL POWER CABLES

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Furnishing and installing required remote control and signal cabling.

B. Products

C. Implementation requirements

1.02 RELATED WORK

A. Applicable provisions of Division 01 govern work under this Section.

B. Section 26 0500 – Common Work Results for Electrical

C. Section 26 0537 - Boxes.

D. Section 26 0553 – Identification for Electrical Systems.

1.03 REFERENCES

A. CEC – California Electric Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements, as based on NFPA 70.

1.04 SUBMITTALS

A. Comply with Section 26 0500 for additional submittal requirements and procedures.

B. Product Data: Provide for each type and size of cable showing electrical characteristics and outer dimension, cable section layout drawing etc.

C. Splice materials and pulling lubricant.

1.05 PROJECT CONDITIONS

A. Verify that field measurements are as shown on Drawings.

B. Conductor sizes are based on copper.

C. Wire and cable routing shown on Drawings is approximate unless dimensioned. Route wire and cable as required to meet Project Conditions.

D. Where wire and cable routing is not shown, and destination only is indicated, determine exact routing and lengths required.

PART 2 - PRODUCTS

2.01 GENERAL

A. All wire shall be new, delivered to the site in unbroken cartons and shall be less than one year old out of manufacturer's stock.

B. All conductors shall be copper.

C. Insulation shall have a 600 volt rating.

D. All conductors must be suitable for the application intended. Conductors #12 and smaller may be solid or stranded with the following requirements or exceptions:

E. All conductors terminated with crimp type devices must be stranded.

1. Stranded conductors may only be terminated with UL OR ETL Listed type terminations or methods: e.g. stranded conductors may not be wrapped around a terminal screw but must be terminated with a crimp type device or must be terminated in an approved back wired method.

2.02 REMOTE CONTROL AND SIGNAL CABLE

A. Refer to requirements for cable to be used on fire alarm systems.

B. Refer to requirements for cable to be used on communication systems.

C. All other systems cabling shall meet the requirements of NEC Article 725 and the following:

1. Control Cable for Class 1 Remote Control and Signal Circuits: 600 volt insulation, individual conductors twisted together, shielded, and covered with an overall PVC jacket. Cable shall be Listed, temperature rated, and general purpose, riser or plenum rated for the application as required in the National Electrical Code.

2. Control Cable for Class 2 or Class 3 Remote Control and Signal Circuits shall be Listed, temperature rated, and general purpose, riser or plenum rated for the application as required in the National Electrical Code.

2.03 WIRING CONNECTORS

A. Split Bolt Connectors: Not acceptable.

B. Spring Wire Connectors: Solderless spring type pressure connector with insulating covers for copper wire splices and taps. Use for conductor sizes 12 AWG and smaller.

C. All wire connectors used in underground or exterior pull boxes shall be gel filled twist connectors or a connector designed for damp and wet locations.

PART 3 - EXECUTION

3.01 GENERAL WIRING METHODS

A. Low voltage control and signal cables shall be installed in conduit.

B. Do not use wire smaller than 14 AWG for control wiring greater than 60 volts, or 18 AWG for voltages less than 60 volts, all sizes subject to NEC 725 requirements.

C. Splice only in junction boxes.

D. Identify wire per section 26 0553.

E. Neatly train and lace wiring inside boxes, and equipment.

3.02 WIRING INSTALLATION IN RACEWAYS

A. Pull all conductors into a raceway at the same time. Use Listed wire pulling lubricant for pulling conditions when necessary.

B. Install wire in raceway after interior of building has been physically protected from the weather and all mechanical work likely to injure conductors has been completed.

3.03 WIRING CONNECTIONS AND TERMINATIONS

A. Splice only in accessible junction boxes (except splices to low voltage occupancy sensor power packs and terminations to temperature control devices).

B. All splices shall be so made that they have an electrical resistance not in excess of two feet (600 mm) of the conductor.

C. Use solderless spring type pressure connectors with insulating covers for wire splices and taps, 12 AWG and smaller.

D. Thoroughly clean wires before installing lugs and connectors.

E. At all splices and terminations, leave tails long enough to cut splice out and completely re-splice.

3.04 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed under provisions of Section 26 0800.

END OF SECTION

SECTION 26 0526 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Grounding and bonding requirements.

B. Conductors for grounding and bonding.

C. Connectors for grounding and bonding.

D. Ground bars.

E. Ground rod electrodes.

F. Ground access wells.

G. Telecommunications/signaling systems grounding.

1.02 RELATED REQUIREMENTS

A. Section 26 0519 - Low-Voltage Electrical Power Conductors and Cables.

B. Section 26 0553 - Identification for Electrical Systems.

C. Section 26 0800 – Electrical Testing Requirements.

1.03 REFERENCE STANDARDS

A. IEEE 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.

B. IEEE Standard 80 - Guide for Safety in AC Substation Grounding.

C. NECA 1 - Standard for Good Workmanship in Electrical Construction.

D. NEMA GR 1 - Grounding Rod Electrodes and Grounding Rod Electrode Couplings.

E. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems.

F. CEC – California Electric Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements, as based on NFPA 70.

G. NFPA 780 - Standard for the Installation of Lightning Protection Systems.

H. UL 467 - Grounding and Bonding Equipment; Current Edition, Including All Revisions.

I. IEEE Standard 141 - Recommended Practice for Electrical Power Distribution for Industrial Plants.

J. IEEE Standard 142 - Recommended Practice for Grounding of Industrial and Commercial Power Systems.

1.04 SUBMITTALS

A. Comply with Section 26 0500 for additional submittal requirements and procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for grounding and bonding system components, listing all physical and electrical characteristics and ratings. Indicate NRTL listing and labeling compliance to listed standards. Clearly mark on each data sheet the specific item(s) being submitted and the proposed application.

C. Shop Drawings

1. Indicate proposed arrangement for signal reference grids. Include locations of items to be bonded and methods of connection.

D. Manufacturer's installation Instructions.

E. Project Record Documents: Record actual locations of grounding electrode system components and connections. The location of each ground rod, ground rod assembly, and other grounding electrodes shall be identified and record of ground resistance tests.

F. Measured resistance values shall be submitted for review.

1.05 ADMINISTRATIVE REQUIREMENTS

A. Coordination

1. Verify exact locations of underground metal water service pipe entrances to building.

2. Coordinate the work with other trades to provide steel reinforcement complying with specified requirements for concrete-encased electrode.

3. Notify Owner’s Representative of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

B. Sequencing

1. Do not install ground rod electrodes until final backfill and compaction is complete.

1.06 QUALITY ASSURANCE

A. Conform to requirements of CEC.

B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum seven years documented experience.

C. Product is listed and classified by Underwriters Laboratories Inc. or approved nationally recognized testing laboratory as suitable for the purpose specified and acceptable to authorities having jurisdiction.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 - PRODUCTS

2.01 GROUNDING AND BONDING REQUIREMENTS

A. Existing Work: Where existing grounding and bonding system components are indicated to be reused, they may be reused only where they are free from corrosion, integrity and continuity are verified, and where acceptable to the authority having jurisdiction.

B. Do not use products for applications other than as permitted by CEC and product listing.

C. Unless specifically indicated to be excluded, provide all required components, conductors, connectors, conduit, boxes, fittings, supports, accessories, etc. as necessary for a complete grounding and bonding system.

D. Where conductor size is not indicated, size to comply with CEC but not less than applicable minimum size requirements specified. Where Project Documents call for a larger size than mandated by CEC, the Project Documents shall prevail.

E. Provide and install copper ground bar minimum 1/4 by 4 by 14 inches in all electrical rooms.

F. Ground conductors shall have green insulation. Where continuous color-coded conductors are not commercially available, provide a minimum 2-inch green color tape band in direction of cable path, non-aging, plastic tape in accordance with CEC. Color band to be within 2 inches of the cable connector or termination.

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

H. Grounding System Resistance

1. Achieve specified grounding system resistance under normally dry conditions unless otherwise approved by Owner's Representative. Precipitation within the previous 48 hours does not constitute normally dry conditions.

2. Grounding Electrode System: Not greater than 5 ohms to ground, when tested according to IEEE 81 using "fall-of-potential" method.

3. Between Grounding Electrode System and Major Electrical Equipment Frames, System Neutral, and Derived Neutral Points: Not greater than 0.5 ohms, when tested using "point-to-point" methods.

I. Grounding Electrode System

1. Provide connection to required and supplemental grounding electrodes indicated to form grounding electrode system.

   a. Provide continuous grounding electrode conductors without splice or joint, except where indicated on Drawings.

   b. Install grounding electrode conductors in raceway where exposed to physical damage. Bond grounding electrode conductor to metallic raceways at each end with bonding jumper.

2. Metal Underground Water Pipe(s)

   a. Provide connection to underground metal domestic and fire protection (where present) water service pipe(s) that are in direct contact with earth for at least 10 feet at an accessible location not more than 5 feet from the point of entrance to the building.

   b. Provide bonding jumper(s) around insulating joints/pipes as required to make pipe electrically continuous.

   c. Provide bonding jumper around water meter of sufficient length to permit removal of meter without disconnecting jumper.

3. Concrete-Encased Electrode

   a. Provide connection to concrete-encased electrode consisting of not less than 20 feet of bare copper conductor not smaller than 4/0 AWG embedded within concrete foundation or footing that is in direct contact with earth in accordance with CEC.

4. Ground Ring

   a. Where indicated on drawings provide a ground ring encircling the building or structure consisting of bare copper conductor not less than 4/0 AWG in direct contact with earth, installed at a depth of not less than 30 inches.

   b. Where location is not indicated, locate ground ring conductor at least 24 inches outside building perimeter foundation.

   c. Provide connection from ground ring conductor to the building ground rod electrodes.

5. Ground Rod Electrode(s)
    a. Provide single electrode unless otherwise indicated or required.
    b. Space electrodes not less than 10 feet from each other and any other ground electrode.
    c. Where location is not indicated, locate electrode(s) at least 5 feet outside building perimeter foundation as near as possible to electrical service entrance; where possible, locate in softscape (uncovered) area.
    d. If ground rod resistance is over 25 ohms install another ground rod. Install additional rods if project requires a lower ground resistance below 25 ohms.
    e. Provide ground enhancement material around electrode where indicated.
    f. Provide ground access well for each electrode.
6. Provide additional ground electrode(s) as required to achieve specified grounding electrode system resistance.
7. Ground Bar: Provide ground bar, separate from service equipment enclosure, for common connection point of grounding electrode system bonding jumpers as permitted in CEC. Connect grounding electrode conductor provided for service-supplied system grounding to this ground bar.
    a. Ground Bar Size: 1/4 by 4 by 14 inches unless otherwise indicated or required.
    b. Where ground bar location is not indicated, locate in accessible location as near as possible to service disconnect enclosure.
    c. Ground Bar Mounting Height: 18 inches above finished floor unless otherwise indicated.
    d. Ground Bar Mounting Wall Standoff: 3 inches unless otherwise indicated.

J. Service-Supplied System Grounding:
1. For each service disconnect, provide grounding electrode conductor to connect neutral (grounded) service conductor to grounding electrode system. Unless otherwise indicated, make connection at neutral (grounded) bus in service disconnect enclosure.
2. For each service disconnect, provide main bonding jumper to connect neutral (grounded) bus to equipment ground bus where not factory-installed. Do not make any other connections between neutral (grounded) conductors and ground on load side of service disconnect.

K. Grounding for Separate Building or Structure Supplied by Feeder(s) or Branch Circuits
1. Provide grounding electrode system for each separate building or structure.
2. Provide equipment grounding conductor routed with supply conductors.
3. For each disconnecting means, provide grounding electrode conductor to connect equipment ground bus to grounding electrode system.
4. Do not make any connections and remove any factory-installed jumpers between neutral (grounded) conductors and ground.

L. Separately Derived System Grounding

1. Separately derived systems include, but are not limited to:
   a. Transformers (except autotransformers such as buck-boost transformers).
   b. Uninterruptible power supplies (UPS), when configured as separately derived systems.
   c. Generators, when neutral is switched in the transfer switch.
2. Connect the grounding bonding of the separately derived system to the electrical room ground bar.
3. Provide bonding jumper from nearest metal building frame to electrical room ground bar.
4. Provide bonding jumper from grounding electrode to electrical room ground bar.
5. Provide bonding jumper from nearest water piping in the area served by the derived system to electrical room ground bar.
6. Outdoor Source: Where the source of the separately derived system is located outside the building or structure supplied, provide connection to grounding electrode at source in accordance with CEC.
7. Provide system bonding jumper to connect system grounded conductor to equipment ground bus. Make connection at same location as grounding electrode conductor connection. Do not make any other connections between neutral (grounded) conductors and ground on load side of separately derived system disconnect.
8. Where the source and first disconnecting means are in separate enclosures, provide supply-side bonding jumper between source and first disconnecting means.

M. Bonding and Equipment Grounding

1. Provide bonding for equipment grounding conductors, equipment ground busses, metallic equipment enclosures, metallic raceways and boxes, device grounding terminals, and other normally non-current-carrying conductive materials enclosing electrical conductors/equipment or likely to become energized as indicated and in accordance with CEC.
2. Provide insulated equipment grounding conductor in each feeder and branch circuit raceway. Do not use raceways as sole equipment grounding conductor.
3. Where circuit conductor sizes are increased for voltage drop, increase size of equipment grounding conductor proportionally in accordance with CEC.
4. Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
5. Terminate branch circuit equipment grounding conductors on solidly bonded equipment ground bus only. Do not terminate on neutral (grounded) or isolated/insulated ground bus.
6. Provide bonding jumper across expansion or expansion/deflection fittings provided to accommodate conduit movement.
7. Provide bonding for interior metal piping systems in accordance with CEC. This includes, but is not limited to:
   a. Metal water piping where not already effectively bonded to metal underground water pipe used as grounding electrode.
   b. Metal gas piping.

c. Metal process piping.

8. Provide bonding for interior metal air ducts.

9. Provide bonding for metal building frame.

10. Provide bonding for metal siding not effectively bonded through attachment to metal building frame.

11. Provide bonding and equipment grounding for pools and fountains and associated equipment in accordance with CEC.

12. Provide redundant grounding and bonding for patient care areas of health care facilities in accordance with CEC and NFPA 99.

N. Communications Systems Grounding and Bonding

1. Provide intersystem bonding termination at service equipment or metering equipment enclosure and at disconnecting means for any additional buildings or structures in accordance with CEC.

2. Provide bonding jumper in raceway from intersystem bonding termination to each communications room or backboard and provide ground bar for termination.

a. Bonding Jumper Size: 4/0.

b. Raceway Size: 3/4-inch trade size unless otherwise indicated or required.

c. Ground Bar Size: 1/4 by 4 by 12 inches unless otherwise indicated or required.

d. Ground Bar Mounting Height: 18 inches above finished floor unless otherwise indicated.

e. Ground Bar Mounting Wall Standoff: 3 inches unless otherwise indicated.

2.02 GROUNDING AND BONDING COMPONENTS

A. General Requirements

1. Provide products listed, classified, and labeled as suitable for the purpose intended.

2. Provide products listed and labeled as complying with UL 467 where applicable.

3. Green THWN insulated copper wire where commercially available.

B. Conductors for Grounding and Bonding, in Addition to other Requirements of this spec:

1. Use insulated copper conductors unless otherwise indicated.

a. Exceptions:

1) Use 4/0 bare copper conductors where installed underground in direct contact with earth.

2) Use bare copper conductors where directly encased in concrete (not in raceway).

2. Factory Pre-fabricated Bonding Jumpers: Furnished with factory-installed ferrules; size braided cables to provide equivalent gage of specified conductors.

C. Connectors for Grounding and Bonding

1. Description: Connectors appropriate for the application and suitable for the conductors and items to be connected; listed and labeled as complying with UL 467.

2. Unless otherwise indicated, use exothermic welded connections for underground, concealed and other inaccessible connections.
    a. Exceptions
        1) Use mechanical connectors for connections to electrodes at ground access wells.
3. Unless otherwise indicated, use 2-hole lug compression connectors, or exothermic welded connections for accessible connections.
    a. Exceptions
        1) Use exothermic welded connections for connections to metal building frame if permitted to do so on structural drawings. Use steel tap or hole that was factory provided otherwise use structural grounding clamp without drilling into the steel.
        2) Ground connections inside 1200 amp or less rated equipment may also use 1-hole mechanical or 1-hole lug compression connectors.
        3) For water pipes, use mechanical clamp of OZ/Gedney G-200B series or equal.
        4) For making water pipes of continuous grounding use mechanical clamp of OZ/Gedney BJ series or equal
4. Manufacturers - Mechanical and Compression Connectors
    a. Advanced Lightning Technology (ALT).
    b. Burndy LLC.
    c. Harger Lightning & Grounding.
    d. Thomas & Betts Corporation.
    e. OZ/Gedney.
5. Manufacturers - Exothermic Welded Connections
    a. Burndy LLC.
    b. Cadweld, a brand of Erico International Corporation.
    c. ThermOweld, a brand of Continental Industries, Inc.

D. Ground Bars
1. Description: Copper rectangular ground bars with mounting brackets and insulators. Mounted on walls in locations shown, on insulating standoffs, 18" above finished floor unless otherwise noted.
2. Size: 14” iwide by 4" high by 1/4" thick unless otherwise indicated or required.
3. Ground Bar Mounting Wall Standoff: 3 inches unless otherwise indicated.
4. Provide UL approved two-hole lugs for connecting grounding system cables. Attach lugs to bus with bolts and washers. Torque all connections.
5. Holes for Connections: As indicated or as required for connections to be made. Provide 6 spare lug spaces unless otherwise noted.
6. Manufacturers for lugs:
    a. Burndy.
    b. Thomas & Betts.

c. Or Equal

E. Ground Rod Electrodes

1. Comply with NEMA GR 1.
2. Material: Copper-bonded (copper-clad) steel with heavy uniform copper coating.
3. Size: 3/4-inch diameter by 10 feet length, unless otherwise indicated.
4. Where rod lengths of greater than 10 feet are indicated or otherwise required, sectionalized ground rods may be used.
5. Manufacturers:
   a. Advanced Lightning Technology (ALT).
   b. Erico International Corporation.
   c. Galvan Industries, Inc.
   d. Harger Lightning & Grounding.
   e. Blackburn.

F. Ground Access Wells

1. Description: Pre-cast concrete open bottom round or rectangular well with access cover for testing and inspection; suitable for the expected load at the installed location.
2. Size: As required to provide adequate access for testing and inspection, but not less than minimum size requirements specified.
   a. Round Wells: Not less than 8 inches in diameter.
   b. Rectangular Wells: Not less than 12 by 12 inches.
3. Depth: As required, but not less than 10 inches.
4. Cover: Factory-identified by permanent means with word "GROUND".
5. Manufacturers:
   a. Brooks Products
   b. Jensen Precast.
   c. Armorcast.
   d. Or Equal

G. Oxide Inhibiting Compound.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that work likely to damage grounding and bonding system components has been completed.

B. Verify that field measurements are as shown on the drawings.

C. Verify that conditions are satisfactory for installation prior to starting work.

D. Verify that final backfill and compaction has been completed before driving rod electrodes.

3.02 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Install grounding and bonding system components in a neat and workmanlike manner in accordance with NECA 1 and CEC.

C. Ground Rod Electrodes: Unless otherwise indicated, install ground rod electrodes vertically. Where encountered rock prohibits vertical installation, install at 45-degree angle or bury horizontally in trench at least 30 inches (750 mm) deep in accordance with CEC.

1. Outdoor Installations: Unless otherwise indicated, install with top of rod 12 inches below finished grade.

2. Indoor Installations: Unless otherwise indicated, install with 4 inches of top of rod exposed.

D. Make grounding and bonding connections using specified connectors.

1. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors. Do not remove conductor strands to facilitate insertion into connector.

2. Remove nonconductive paint, enamel, or similar coating at threads, contact points, and contact surfaces.

3. Exothermic Welds: Make connections using molds and weld material suitable for the items to be connected in accordance with manufacturer's recommendations.

4. Mechanical Connectors: Secure connections according to manufacturer's recommended torque settings.

5. Compression Connectors: Secure connections using manufacturer's recommended tools and dies.

E. Identify grounding and bonding system components in accordance with Section 26 0553 Identification for Electrical Systems.

3.03 FIELD QUALITY CONTROL

A. Test in accordance with Section 26 0800 Electrical Testing Requirements

B. Perform ground electrode resistance tests under normally dry conditions. Precipitation within the previous 48 hours does not constitute normally dry conditions.

C. Investigate and correct deficiencies where measured ground resistances do not comply with specified requirements.

D. Submit detailed reports indicating inspection and testing results and corrective actions taken.

END OF SECTION

SECTION 26 0529 – HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Support and attachment components for equipment, conduit, cable, boxes, and other electrical work.

1.02 RELATED REQUIREMENTS

A. Section 26 0534 - Conduit.

B. Section 26 0537 - Boxes.

1.03 REFERENCE STANDARDS

A. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2015.

B. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware; 2009.

C. ASTM B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel; 2013.

D. MFMA-4 - Metal Framing Standards Publication; 2004.

E. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.

F. CEC - California Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements, as based on NFPA 70.

1.04 ADMINISTRATIVE REQUIREMENTS

A. Coordination

1. Coordinate sizes and arrangement of supports and bases with the actual equipment and components to be installed.

2. Coordinate the work with other trades to provide additional framing and materials required for installation.

3. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.

4. Coordinate the arrangement of supports with ductwork, piping, equipment and other potential conflicts installed under other sections or by others.

5. Notify Engineer of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

1.05 SUBMITTALS

A. Comply with Section 26 0500 for additional submittal requirements and procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for metal channel (strut) framing systems, non-metallic cable racking systems, non-penetrating rooftop supports, and post-installed concrete and masonry anchors.

1.06 QUALITY ASSURANCE

A. Comply with CEC.

B. Comply with CBC.

PART 2 - PRODUCTS

2.01 SUPPORT AND ATTACHMENT COMPONENTS

A. General Requirements

1. Provide all required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for the complete installation of electrical work.

2. Provide products listed, classified, and labeled as suitable for the purpose intended, where applicable.

3. Do not use products for applications other than as permitted by CEC and product listing.

4. Steel Components: Use corrosion resistant materials suitable for the environment where installed.

a. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.

b. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.

B. Conduit and Cable Supports: Straps, clamps, etc. suitable for the conduit or cable to be supported.

1. Conduit Straps: One-hole or two-hole type; steel or malleable iron.

2. Conduit Clamps: Bolted type unless otherwise indicated.

C. Outlet Box Supports: Hangers, brackets, etc. suitable for the boxes to be supported.

D. Metal Channel (Strut) Framing Systems: Factory-fabricated continuous-slot metal channel (strut) and associated fittings, accessories, and hardware required for field-assembly of supports.

1. Comply with MFMA-4.

2. All strut framing systems installed outdoors shall be hot-dipped galvanized steel. All fasteners shall be galvanized steel suitable for the hot dipped galvanized steel materials.

E. Hanger Rods: Threaded zinc-plated steel unless otherwise indicated.

F. Rack Supports in Manholes

1. Install nonmetallic cable racking system with stanchion and arms.

2. Cable rack shall be constructed of nonmetallic UL Listed Glass Reinforced Polymer.

G. Anchors and Fasteners:

1. Unless otherwise indicated and where not otherwise restricted, use the anchor and fastener types indicated for the specified applications.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that field measurements are as shown on the drawings.

B. Verify that mounting surfaces are ready to receive support and attachment components.

C. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Install support and attachment components in a neat and workmanlike manner in accordance with NECA 1.

C. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.

D. Unless specifically indicated or approved by Engineer, do not provide support from suspended ceiling support system or ceiling grid.

E. Unless specifically indicated or approved by Engineer, do not provide support from roof deck.

F. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.

G. Equipment Support and Attachment

1. Use metal fabricated supports or supports assembled from metal channel (strut) to support equipment as required.

2. Use metal channel (strut) secured to studs to support equipment surface-mounted on hollow stud walls when wall strength is not sufficient to resist pull-out.

3. Use metal channel (strut) to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.

4. Use nonmetallic UL Listed glass reinforced polymer stanchions and racking arms for cable racking within manholes.

5. Securely fasten floor-mounted equipment. Do not install equipment such that it relies on its own weight for support.

H. Secure fasteners according to manufacturer's recommended torque settings.

I. Remove temporary supports.

3.03 FIELD QUALITY CONTROL

A. Inspect support and attachment components for damage and defects.

B. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.

C. Correct deficiencies and replace damaged or defective support and attachment components.

END OF SECTION

SECTION 26 0534 - CONDUIT

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Galvanized steel rigid metal conduit (RMC).

B. Intermediate metal conduit (IMC).

C. Flexible Metal Conduit (FMC).

D. Liquidtight flexible metal conduit (LFMC).

E. Electrical metallic tubing (EMT)

F. Rigid polyvinyl chloride (PVC) conduit.

G. Liquidtight flexible nonmetallic conduit (LFNC).

H. PVC-coated galvanized steel rigid metal conduit (P-RMC).

I. Extra Heavy wall Fiberglass conduit (RTRC XHW).

J. Conduit fittings.

K. Accessories.

1.02 RELATED REQUIREMENTS

A. Section 07 8400 - Firestopping.

B. Section 26 0500 – Common Work Results for Electrical.

C. Section 26 0526 - Grounding and Bonding for Electrical Systems.

D. Section 26 0529 - Hangers and Supports for Electrical Systems.

E. Section 26 0537 – Boxes.

F. Section 26 0553 – Identification for Electrical Systems.

1.03 REFERENCE STANDARDS

A. ANSI C80.1 - American National Standard for Electrical Rigid Steel Conduit (ERSC).

B. ANSI C80.3 - American National Standard for Steel Electrical Metallic Tubing (EMT).

C. ANSI C80.6 - American National Standard for Electrical Intermediate Metal Conduit (EIMC).

D. NECA 1 - Standard for Good Workmanship in Electrical Construction; National Electrical Contractors Association.

E. NECA 101 - Standard for Installing Steel Conduits (Rigid, IMC, EMT); National Electrical Contractors Association.

F. NECA 111 - Standard for Installing Nonmetallic Raceways (RNC, ENT, LFNC); National Electrical Contractors Association.

G. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable; National Electrical Manufacturers Association; 2012 (ANSI/NEMA FB 1).

H. NEMA RN 1 – Polyvinyl-Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.

I. NEMA TC 2 - Electrical Polyvinyl Chloride (PVC) Conduit; National Electrical Manufacturers Association; 2013.

J. NEMA TC 3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing; National Electrical Manufacturers Association; 2015.

K. CEC – California Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements, as based on NFPA 70.

L. UL 2 – Flexible Metal Conduit; Current Edition, Including All Revisions.

M. UL 6 - Electrical Rigid Metal Conduit-Steel; Current Edition, Including All Revisions.

N. UL 360 – Liquid-Tight Flexible Steel Conduit; Current Edition, Including All Revisions.

O. UL 514B - Conduit, Tubing, and Cable Fittings; Current Edition, Including All Revisions.

P. UL 651 - Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings; Current Edition, Including All Revisions.

Q. UL 797 – Electrical Metallic Tubing-Steel; Current Edition, Including All Revisions.

R. UL 1242 - Electrical Intermediate Metal Conduit-Steel; Current Edition, Including All Revisions.

S. UL 1660 - Liquid-Tight Flexible Nonmetallic Conduit; Current Edition, Including All Revisions.

T. UL 1684 - Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.

U. UL 1684A –Supplemental Requirements for Extra Heavy Wall Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.

1.04 SUBMITTALS

A. Comply with Section 26 0500 for additional submittal requirements and procedures.

B. Product Data: Provide for each type and size of conduit, liquid tight flexible, conduit bodies, fittings, showing characteristics and dimensions.

C. Shop drawings of any fire rated assembly and roof penetrations: provide proposed locations of penetrations and methods for sealing.

D. Cable pulling tension calculations:

1. Submit cable pulling tension calculations as indicated on the drawings.

2. Submit cable pulling tension calculations for all cables rated above 600 volts.

E. Structural Engineers stamped and approved drawings for conduits not attached to building walls, not using C-clamps to building I beams and/or trapeze as noted this specification.

1.05 ADMINISTRATIVE REQUIREMENTS

A. Coordination

1. Coordinate minimum sizes of conduits with the actual conductors to be installed, including adjustments for conductor sizes increased for voltage drop, and as required by code.

2. Coordinate the arrangement of conduits with structural members, ductwork, piping, equipment and other potential conflicts installed under other sections or by others.

3. Verify exact conduit termination locations required for boxes, enclosures, and equipment that is installed for this project or is existing and to be interconnected for this project.

4. Coordinate the work with other trades to provide roof penetrations that preserve the integrity of the roofing system and do not void the roof warranty.

5. Notify Engineer of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

B. Sequencing

1. Do not begin installation of conductors and cables until installation of conduit is complete between outlet, junction and splicing points, and cable pulling tension calculations are approved.

1.06 QUALITY ASSURANCE

A. Conform to requirements of CEC.

B. Product is listed and classified by Underwriters Laboratories Inc. or approved nationally recognized testing laboratory as suitable for the purpose specified and acceptable to authorities having jurisdiction.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store conduit and fittings in accordance with manufacturer's instructions.

B. Protect conduit from corrosion and entrance of debris by storing above grade. Provide appropriate covering.

C. Inspect for damage and replace as needed.

D. Protect conduit that is not sunlight and ultra-violet resistant from sunlight.

PART 2 - PRODUCTS

2.01 CONDUIT APPLICATIONS

A. Conduit and associated fittings shall only be used for applications as permitted by CEC and product listing.

B. The minimum size of conduit shall be ¾ inch unless otherwise specified.

C. Unless otherwise indicated and where not otherwise restricted, use the conduit types indicated for the specified applications. Where more than one listed application applies, comply with the most restrictive requirements. Where conduit type for a particular application is not specified, use galvanized steel rigid metal conduit.

D. Underground:

1. Under Slab on Grade (within structure slabs only where approved by Structural Engineer): Use rigid PVC conduit.

2. Exterior, Direct-Buried: Use rigid PVC conduit.

3. Exterior, Embedded within Concrete: Use rigid PVC conduit.

4. Transition to galvanized steel rigid metal conduit where emerging from underground.

E. Embedded Within Concrete Walls:

1. Use galvanized steel rigid metal conduit (RMC), intermediate metal conduit (IMC), PVC-coated galvanized steel rigid metal (P-RMC), or rigid PVC conduit.

2. Where rigid polyvinyl (PVC) conduit is provided, transition to galvanized steel rigid metal conduit where emerging from concrete.

F. Concealed Within Masonry: Use galvanized steel rigid metal conduit (RMC), intermediate metal conduit (IMC), PVC-coated galvanized steel rigid metal (P-RMC), or electrical metallic tubing (EMT).

G. Concealed Within Hollow Stud Walls: Use galvanized steel rigid metal conduit (RMC), intermediate metal conduit (IMC), or electrical metallic tubing (EMT).

H. Concealed Above Accessible Ceilings: Use galvanized steel rigid metal conduit (RMC), intermediate metal conduit (IMC), or electrical metallic tubing (EMT).

I. Exposed, Interior, Not Subject to Physical Damage:

1. Use galvanized steel rigid metal conduit (RMC) or intermediate metal conduit (IMC). or electrical metallic tubing (EMT).

2. Locations Not subject to Physical Damage shall include electrical rooms, control rooms, data / telephone rooms, and offices, and protected locations in Processing plant rooms, industrial process, and utilization equipment where conduits are 9 feet above finished grade.

J. Exposed, Interior, Subject to Physical Damage:

1. Use galvanized steel rigid metal conduit (RMC) or intermediate metal conduit (IMC).

2. Locations subject to Physical Damage areas shall include, but not limited to processing plant rooms, industrial process, and utilization equipment. Conduits for these rooms, 0 to 9 feet above finished grade, or where exposed to damage due to operations and maintenance activity, are considered to be the subject to physical damage.

K. Exposed, Exterior, outdoor areas: Use galvanized steel rigid metal conduit (RMC), intermediate metal conduit (IMC), or PVC-coated galvanized steel rigid metal (P-RMC).

L. Exposed, Exterior, in continuous wet and/or corrosive areas such as Cooling Towers:

1. Use Extra Heavy Wall Fiberglass conduit or rigid PVC schedule 80 conduit and non-metallic fittings and boxes.

2. Locations subject to continuous damp/wet and/or corrosive areas shall extend to 40 feet of surrounding area.

M. Concealed, Exterior, Not Embedded in Concrete or in Contact with Earth: Use galvanized steel rigid metal conduit (RMC), intermediate metal conduit (IMC), or PVC-coated galvanized steel rigid metal (P-RMC).

N. Connections to Luminaries above Accessible Ceilings: Use flexible metal conduit (FMC).

O. Connections to Vibrating Equipment:

1. Dry and outdoor locations: Use liquidtight flexible metallic conduit (LFMC).

2. Continues damp/wet or Corrosive Locations: Use liquidtight flexible nonmetallic conduit (LFNC).

3. Maximum Length of flexible connection: 6 feet (1.8 m) unless otherwise indicated.

4. Minimum Length of flexible connection:

a. Conduits of 1 ¼ inches or less: 14 inches.

b. Conduits of 2 ½ to 2 inches: 18 inches.

c. Conduits of 4 to 3 inches: 22 inches

5. Vibrating equipment includes but not limited to:

a. Transformers

b. Motors

c. Pressure, flow, etc. sensors attached to plumbing or HVAC equipment

2.02 CONDUIT APPLICATIONS

A. Existing Work: Where existing conduits are indicated to be reused, they may be reused only where they comply with specified requirements, are free from damage and corrosion, and integrity and interior shape is verified by pulling a mandrel through them.

B. Provide all conduit, fittings, supports, and accessories required for a complete raceway system.

C. Provide products listed, classified, and labeled as suitable for the purpose intended.

D. Exceptions to the minimum conduit size of ¾ inch is ½ inch for flex connections to process sensors and lighting fixtures or as noted on drawings.

E. Where conduit size is not indicated, size to comply with CEC but not less than applicable minimum size requirements specified.

2.03 GALVANIZED STEEL RIGID METAL CONDUIT (RMC)

A. Description: CEC, Type RMC galvanized steel rigid metal conduit complying with ANSI C80.1 and listed and labeled as complying with UL 6.

B. Fittings

1. Non-Hazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.

2. Material: Use steel or malleable iron.

3. Connectors and Couplings: Use threaded type fittings only. Threadless set screw and compression (gland) type fittings are not permitted.

2.04 INTERMEDIATE METAL CONDUIT (IMC)

A. Description: CEC, Type IMC galvanized steel intermediate metal conduit complying with ANSI C80.6 and listed and labeled as complying with UL 1242.

B. Fittings

1. Non-Hazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.

2. Material: Use steel or malleable iron.

3. Connectors and Couplings: Use threaded type fittings only. Threadless set screw and compression (gland) type fittings are not permitted.

2.05 PVC-COATED GALVANIZED STEEL RIGID METAL CONDUIT (P-RMC)

A. Description: CEC, Type RMC galvanized steel rigid metal conduit with external polyvinyl chloride (PVC) coating complying with NEMA RN 1 and listed and labeled as complying with UL 6.

B. Exterior Coating: Polyvinyl chloride (PVC), nominal thickness of 40 mil.

C. Interior Coating: Urethane, minimum thickness of 2 mil.

D. PVC-Coated Fittings:

1. Manufacture: Same as manufacture of PVC-coated conduit to be installed.

2. Material: Use steel or malleable iron.

3. Exterior Coating: Polyvinyl chloride (PVC), nominal thickness of 40 mil.

4. Interior Coating: Urethane, minimum thickness of 2 mil.

E. PVC-Coated Supports: Furnish with exterior coating of polyvinyl chloride (PVC), minimum thickness of 15 mil.

2.06 FLEXIBLE METAL CONDUIT (FMC)

A. Description: CEC, Type FMC standard wall steel flexible metal conduit listed and labeled as complying with UL 1, and listed for use in classified firestop systems to be used.

B. Fittings:

1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B,

2. Material: Use steel or malleable iron.

2.07 LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC)

A. Description: CEC, Type LFMC polyvinyl chloride (PVC) jacketed steel flexible metal conduit listed and labeled as complying with UL 360.

B. Fittings:

1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.

2. Material: Use steel or malleable iron.

2.08 ELECTRICAL METALLIC TUBING (EMT)

A. Description: CEC, Type EMT steel electrical metallic tubing complying with ANSI C80.3 and listed and labeled as complying with UL 797.

B. Fittings:

1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.

2. Material: Use steel or malleable iron.

3. Connectors and Couplings: Use compression (gland).

a. Do not use indenter type or set-screw connectors or couplings.

2.09 RIGID POLYVINYL CHLORIDE (PVC) CONDUIT

A. Description: CEC, Type PVC rigid polyvinyl chloride conduit complying with NEMA TC 2 and listed and labeled as complying with UL 651; Schedule 40 unless otherwise indicated, Schedule 80 where subject to physical damage; rated for use with conductors rated 90 degrees C.

B. Fittings

1. Manufacturer: Same as manufacturer of conduit to be connected.

2. Description: Fittings complying with NEMA TC 3 and listed and labeled as complying with UL 651; material to match conduit.

C. Paint PVC conduits and fittings exposed to sun light. Paint to be rated for outside usage and color shall be approved by the engineer before application.

2.10 LIQUIDTIGHT FLEXIBLE NONMETALLIC CONDUIT (LFNC)

A. Description: CEC, Type LFNC liquidtight flexible nonmetallic conduit listed and labeled as complying with UL 1660.

B. Fittings

1. Manufacturer: Same as manufacturer of conduit to be connected.
2. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B; suitable for the type of conduit to be connected.

2.11 FIBERGLASS CONDUIT

A. Description: CEC, Type "XW" Extra Heavy Wall Epoxy Fiberglass conduit (RTRC XHW), XW UL 1684A listed and labeled as for use as heavy wall reinforced conduit. Rated for use with conductors rated 90 degrees C and UV restraint.

1. Conduit and fittings shall be manufactured in accordance with the following specifications:
   a. UL-1684-UL-1684A, UL Guide DZKT
   b. Physical Properties:
      1) Glass Content, 68% ± 3%; API 15LR
      2) Specific Gravity; ASTM D792
      3) Barcol Hardness; ASTM D2583
      4) Water Absorption; ASTM D570
      5) UV Resistance; CSA C22.2 #221.3/UL-1684
2. All RTRC XHW Conduits and Associated Fittings shall meet the following Specifications:

Size (in.)	Wall (in.)	Weight (lbs./ft.)	Failure Load (ASTM D2412) (lbs./ft.)	Impact (ASTM D2444) (lbs./ft.)	Moment of Inertia (in.)
2	.250	1.49	12,000	120	1.132
3	.250	2.16	11,000	160	3.390
4	.250	2.82	10,000	200	7.562
5	.250	3.48	8,000	240	14.238
6	.250	4.14	7,000	280	24.007

3. Extra Heavy Wall Epoxy Fiberglass Conduit and Fittings Type RTRC XHW shall manufactured and supplied by FRE Composites Inc., or approved equal.

B. Fittings

1. Manufacturer: Same as manufacturer of conduit to be connected.
2. Description: Fittings Extra Heavy Wall Epoxy Fiberglass, XW UL 1684A listed and labeled. Material to match conduit and made of same process as the conduit.
3. Connection: Straight socket with Fiberglass epoxy adhesive approved by the manufacture. Threaded joints not allowed.

2.12 ACCESSORIES

A. Corrosion Protection Tape: PVC-based, minimum thickness of 20 mil.

B. Conduit Joint Compound: Corrosion-resistant, electrically conductive; suitable for use with the conduit to be installed.

C. Solvent Cement for PVC Conduit and Fittings: As recommended by manufacturer of conduit and fittings to be installed.

D. Use pull tape of Polyaramid Kevlar in all underground PVC conduits for pulling in cables. Pulling with pull rope or other similar items is not allowed. Pull tape with footage markers and minimum strength 1250 pound-force. Minimum strength will be selected based on contractor's cable pulling calculations.

1. Tape to be minimum ¼ inch size for conduit sizes ¾ to 1 inch.
2. Tape to be minimum 3/8 inch size for conduit sizes 1 ¼ to 1 ½ inches.
3. Tape to be minimum ½ inch size for conduit sizes 2 to 2 ½ inches.
4. Tape to be minimum 5/8 inch size for conduit sizes 3 to 4 inches.
5. Tape to be minimum ¾ inch size for conduit sizes 5 to 6 inches.

E. Provide continuous-fiber polyline/nylon cord in spare conduits with average breaking strength of not less than 200 pound-force.

F. Use compressible rubber modular sealing products (i.e. Link Seal) for all core drilled conduit penetrations through concrete or masonry to provide a watertight seal for all under grade locations.

G. Use expandable mechanical conduit duct plug seals for spare underground conduits in manholes, pullboxes, and below grade conduit entries into equipment and boxes. Plug to be of high impact plastic components with durable elastic gaskets with pull rope tie device to allow the securing pull rope on back side of seal. Not required if both ends of the conduit are terminated inside a fully enclosed building and at the end terminating inside an enclosure.

H. Expandable polyurethane foam products (i.e. Semco PR-821 by PRC-DeSoto) with density of 7 to 8 pounds per cubic foot or duct sealing compound to seal insides of underground conduits with cables entering manholes, pullboxes, and equipment. Seal against intrusion of water, gases, or critters. Check drawings to insure which type, polyurethane or sealing compound is noted as acceptable. Not required if both ends of the conduit are terminated inside a fully enclosed building.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that field dimensions and measurements are as shown on drawings.

B. Verify scale and dimensions when provided.

C. Verify routing and termination locations of conduit prior to rough-in.

D. Verify that mounting surfaces are ready to receive conduits.

3.02 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Install conduit in a neat and workmanlike manner in accordance with NECA 1.

C. Install galvanized steel rigid metal conduit (RMC) in accordance with NECA 101.

D. Install intermediate metal conduit (IMC) in accordance with NECA 101.

E. Install PVC-coated galvanized steel rigid metal conduit (P-RMC) using only tools approved by the manufacture.

F. Install rigid polyvinyl chloride (PVC) conduit in accordance with NECA 111.

G. Install liquidtight flexible nonmetallic conduit (LFNC) in accordance with NECA 111.

H. Use suitable caps to protect installed conduits against entrance of dirt and moister. Install caps on end of all stubbed out underground conduits.

I. Conduit Routing

1. Unless dimensioned, conduit routing indicated is diagrammatic.
2. When conduit destination is indicated and routing is not shown, determine exact routing required.
3. Unless otherwise approved, do not route conduits exposed:
   a. Across floors.
   b. Across roofs.
   c. Across top of parapet walls.
   d. across building exterior surfaces.
4. Conduits installed underground or embedded in concrete may be routed in the shortest possible manner unless otherwise indicated. Route all other conduits parallel or perpendicular to building structure and surfaces, following surface contours where practical.
5. Arrange conduit to maintain adequate headroom, clearances, and access.
6. Combining conduit runs of conduit homeruns for any different systems from those shown on the drawings is not acceptable.
7. It shall be unacceptable to combine circuits, conduits, cables, pull boxes, or junction boxes of extra low voltage systems and low voltage systems. No combining of communications systems with power systems will be permitted, unless the combination is necessary for termination within an equipment assembly.
8. Arrange conduit to provide no more than the equivalent of three 90 degree bends between pull points.
9. Arrange conduit to provide no more than 150 feet between pull points unless otherwise shown for underground duct banks.
10. Route conduits above water and drain piping inside of buildings where possible.
11. Arrange conduit to prevent moisture traps. Provide drain fittings at low points and at sealing fittings where moisture may collect.
12. Maintain minimum clearance of 6 inches between conduits and piping for other systems.
13. Maintain minimum clearance of 12 inches between conduits and hot surfaces exceeding 104 degrees F.
14. Group parallel conduits in the same area together on a common rack.
15. Use conduit hubs to fasten conduit to sheet metal boxes in damp and wet locations.

J. Conduit Support

1. Secure and support conduits in accordance with CEC and Section 26 0529 using suitable supports and methods approved by the authority having jurisdiction.
2. Provide independent supports that are attached to the building structure. Do not provide support from piping, ductwork, ceiling grid, or other systems.
3. Use conduit strap to support single surface-mounted conduit.
4. Use metal channel (strut) with accessory conduit clamps to support multiple parallel surface-mounted conduits.
5. Use conduit clamp to support single conduit from beam clamp.

6. Use of wire for support of conduits is not permitted. Remove temporary supports.
7. The use of trapeze hangers assembled from threaded rods and metal channel (strut) with accessory conduit clamps to support multiple parallel suspended conduits require the submittal of structural drawings stamped and approved.
8. Provide structural drawings and details stamped and approved for all conduits that are not supported from walls or not supported from building I beams using beam C-clamps.
9. Use non-penetrating rooftop supports to support conduits routed across rooftops (only where approved).
10. Non-metal conduit couplings and expansion joints shall be located no closer than 12-inches from support hangers.

K. Connections and Terminations

1. Use approved zinc-rich paint or conduit joint compound on field-cut threads of galvanized steel conduits prior to making connections.
2. Where two threaded conduits must be joined and neither can be rotated, use three-piece couplings or split couplings. Do not use running threads.
3. Use suitable adapters where required to transition from one type of conduit to another.
4. Provide drip loops for liquidtight flexible conduit connections to prevent drainage of liquid into connectors.
5. Terminate threaded conduits in boxes and enclosures using threaded hubs or double lock nuts for dry locations and raintight hubs for wet locations.
6. Where spare conduits stub up thru floors and not terminated in a box or enclosure, provide threaded couplings equipped with threaded plugs set flush with finished floor, unless otherwise noted.
7. Provide insulating bushings or insulated throats at all conduit terminations to protect conductors.
8. Secure joints and connections to provide maximum mechanical strength and electrical continuity.
9. Provide bell end bushings for conduit entries into underground manholes, pullboxes, and terminating inside equipment from underground.

L. Penetrations

1. Do not penetrate or otherwise notch or cut structural members, including footings and grade beams, without approval of Structural Engineer.
2. Make penetrations perpendicular to surfaces unless otherwise indicated.
3. Provide sleeves for penetrations as indicated or as required to facilitate installation. Set sleeves flush with exposed surfaces unless otherwise indicated or required.
4. Make penetrations through floors water-tight with non-hardening sealant even though concealed within wall or furred space.
5. Make penetrations through any damp-proofed/water-proofed surfaces damp-proof/waterproof by appropriate means to maintain integrity of system penetrated.
6. Seal around penetration with acoustical material to maintain the integrity of acoustical rating where occurs.
7. Conceal bends for conduit risers emerging above ground.

8. Seal interior of conduits entering the building or equipment from underground at first accessible point to prevent entry of moisture and gases.

9. Seal interior of underground conduits entering manholes and pull boxes to prevent entry of moisture, gases, and critters.

10. Provide modular sealing where conduits penetrate exterior wall below grade.

11. Where conduits penetrate waterproof membrane, seal as required to maintain integrity of membrane.

12. Make penetrations for roof-mounted equipment within associated equipment openings and curbs where possible to minimize roofing system penetrations. Where penetrations are necessary, seal as indicated or as required to preserve integrity of roofing system and maintain roof warranty. Include proposed locations of penetrations and methods for sealing with submittals.

13. Pack space between conduit, sleeve in rated walls with non-combustible materials. Install fire marshal approved firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 8400.

M. Concrete Encasement Where Required:

1. Secure conduits to conduit racks and supports to prevent floating or movement during pouring of concrete.

2. Minimum concrete of 3 inches on all sides unless otherwise indicated.

3. Provide underground warning tape in accordance with Section 26 0553 along entire conduit length.

N. Conduit Movement Provisions:

1. Where conduits are subject to flexure from seismic earth movement, provide (expansion/contraction, angular misalignment, and parallel deflection) fittings and/or flexible conduit assembly consisting of a combination of approved fittings and conduit to prevent damage to enclosed conductors, conduits, or connected equipment. Approved assembly shall meet total movement requirements provided by the structural engineer or as indicated on the drawings. The locations include, but is not limited to:

   a. Where conduits cross structural joints intended for expansion, contraction, or deflection.

   b. Where conduits cross between free standing buildings or seismic gap.

   c. Where conduits are subject to seismic earth movement.

2. Where conduits are subject to thermal movement, provide (expansion/ contraction, angular misalignment, and parallel deflection) fittings and/or flexible conduit assembly consisting of a combination of approved fittings and conduit to prevent damage to enclosed conductors, conduits, or connected equipment. The locations include, but not limited to:

   a. Where conduits are outside and straight runs longer than 150 feet.

   b. Where shown or noted on the drawings.

   c. As required by the conduit manufacturer.

O. Condensation Prevention: Where conduits cross barriers between areas of potential substantial temperature differential, provide sealing fitting or approved sealing compound at an accessible point near the penetration to prevent condensation. This includes, but is not limited to:

1. Where conduits of a long run of 100 feet or more outside pass from outdoors into conditioned interior spaces. Sealing fitting also with drain.

2. Where conduits of a long run of 200 feet or more outside and then go down and pass into a building or underground. Sealing fitting also with drain.

3. Where conduits penetrate coolers or freezers.

P. Provide pull string in all empty conduits and in conduits where conductors are to be installed by others. Leave minimum slack of 18 inches at each end. Add tag at each end identifying opposite end location.

Q. Provide grounding and bonding in accordance with Section 26 0526.

R. Identify conduits in accordance with Section 26 0553.

3.03 FIELD QUALITY CONTROL

A. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by the manufacture. Replace components that exhibit signs of corrosion.

B. Where coating of PVC-coated galvanized steel rigid metal conduit (RMC) contains cuts or abrasions, repair in accordance with manufacturer's instructions.

C. Correct deficiencies and replace damaged or defective conduits.

3.04 CLEANING

A. Clean interior of conduits to remove moisture and foreign matter prior to conductor installation.

END OF SECTION

SECTION 26 0537 – BOXES

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Outlet and device boxes up to 100 cubic inches, including those used as junction and pull boxes.

B. Junction and pull boxes larger than 100 cubic inches not subject to vehicular traffic.

C. Boxes for hazardous (classified) locations.

D. Underground boxes/enclosures not subject to vehicular traffic.

1.02 RELATED REQUIREMENTS

A. Section 26 0526 - Grounding and Bonding for Electrical Systems.

B. Section 26 0529 - Hangers and Supports for Electrical Systems.

C. Section 26 0534 - Conduit

1. Conduit bodies and other fittings.

2. Additional requirements for locating boxes to limit conduit length and/or number of bends between pulling points.

D. Section 26 0553 - Identification for Electrical Systems.

1.03 REFERENCE STANDARDS

A. NECA 1 - Standard for Good Workmanship in Electrical Construction.

B. NECA 130 - Standard for Installing and Maintaining Wiring Devices.

C. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable.

D. NEMA OS 1 - Sheet Steel Outlet Boxes, Device Boxes, Covers, and Box Supports.

E. NEMA OS 2 - Nonmetallic Outlet Boxes, Device Boxes, Covers and Box Supports.

F. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

G. CEC – California Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements, as based on NFPA 70.

H. SCTE 77 - Specifications for Underground Enclosure Integrity

I. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations; Current Edition, Including All Revisions.

J. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations; Current Edition, Including All Revisions.

K. UL 508A - Industrial Control Panels; Current Edition, Including All Revisions.

L. UL 514A - Metallic Outlet Boxes; Current Edition, Including All Revisions.

M. UL 514C - Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers; Current Edition, Including All Revisions.

N. UL 1203 - Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations; Current Edition, Including All Revisions.

1.04 SUBMITTALS

A. Comply with Section 26 0500 for additional submittal requirements and procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for cabinets and enclosures, boxes for hazardous (classified) locations, floor boxes, and underground boxes/enclosures.

1. Underground Boxes/Enclosures: Include reports for load testing in accordance with SCTE 77 certified by a professional engineer or an independent testing agency upon request.

C. Project Record Documents: Record actual locations for outlet and device boxes, pull boxes, cabinets and enclosures, floor boxes, and underground boxes/enclosures.

1.05 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by CEC.

2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.

3. Coordinate minimum sizes of boxes with the actual installed arrangement of conductors, clamps, support fittings, and devices, calculated according to CEC.

4. Coordinate minimum sizes of pull boxes with the actual installed arrangement of connected conduits, calculated according to CEC.

5. Coordinate the work with other trades to provide wall space suitable for installation of flush-mounted boxes and concealed conduits where indicated.

6. Notify Owner’s Representative of any conflicts with, or deviations from, the contract documents. Obtain direction before proceeding with work.

1.06 QUALITY ASSURANCE

A. Conform to requirements of CEC.

B. Assure product is listed and classified by Underwriters Laboratories Inc. or approved nationally recognized testing laboratory as suitable for the purpose specified and acceptable to authorities having jurisdiction.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 - PRODUCTS

2.01 BOXES

A. General Requirements:

1. Do not use boxes and associated accessories for applications other than as permitted by CEC and product listing.

2. Provide all boxes, fittings, supports, and accessories required for a complete raceway system and to accommodate devices and equipment to be installed.

3. Provide products listed, classified, and labeled as suitable for the purpose intended.
4. Where box size is not indicated, size to comply with CEC but not less than applicable minimum size requirements specified.
5. Provide grounding terminals within boxes where equipment grounding conductors terminate.
6. Assure grounding system continuity as required by CEC and install all required bonding fittings and conductors.

B. Outlet and Device Boxes Up to 100 cubic inches, Including Those Used as Junction and Pull Boxes:

1. Use sheet-steel boxes for dry locations unless otherwise indicated or required.
2. Use cast iron boxes for damp or wet locations unless otherwise indicated or required; furnish with compatible weatherproof gasketed covers.
3. Use cast iron boxes where exposed galvanized steel rigid metal conduit or exposed intermediate metal conduit (IMC) is used.
4. Use nonmetallic boxes where exposed rigid PVC conduit is used.
5. Use suitable concrete type boxes where flush-mounted in concrete.
6. Use suitable masonry type boxes where flush-mounted in masonry walls.
7. Use raised covers suitable for the type of wall construction and device configuration where required.
8. Use shallow boxes where required by the type of wall construction.
9. Do not use "through-wall" boxes designed for access from both sides of wall.
10. Sheet-Steel Boxes: Comply with NEMA OS 1, and list and label as complying with UL 514A.
11. Cast Metal Boxes: Comply with NEMA FB 1, and list and label as complying with UL 514A ; furnish with threaded hubs.
12. Nonmetallic Boxes: Comply with NEMA OS 2, and list and label as complying with UL 514C.
13. Boxes for Supporting Luminaires and Ceiling Fans: Listed as suitable for the type and weight of load to be supported; furnished with fixture stud to accommodate mounting of luminaire where required.
14. Boxes for Ganged Devices: Use multigang boxes of single-piece construction. Do not use field-connected gangable boxes.
15. Minimum Box Size, Unless Otherwise Indicated:
    a. Wiring Devices: 4-inch square by 2-1/8 inch deep (100 by 38 mm) trade size.
    b. Ceiling Outlets: 4-inch octagonal or square by 2-1/8 inch deep (100 by 38 mm) trade size.
16. Wall Plates: Comply with Section 26 2726, Wiring Devices.
17. Manufacturers:
    a. Cooper Crouse-Hinds, a division of Eaton Corporation.
    b. Hubbell Incorporated; Bell Products.
    c. Hubbell Incorporated; RACO Products.

d. O-Z/Gedney, a brand of Emerson Industrial Automation.

e. Thomas & Betts Corporation.

C. Junction and Pull Boxes Larger Than 100 cubic inches (1,650cu cm) not subject to vehicular traffic:

1. Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E, or UL 508A.

2. NEMA 250 Environment Type, Unless Otherwise Indicated:

a. Indoor Clean, Dry Locations: Type 1, painted steel.

b. Outdoor Locations: Type 3R, galvanized steel, stainless steel, or fiberglass.

3. Covers:

a. Provide screw-cover or hinged-cover enclosures unless otherwise indicated.

b. Boxes 6 square feet and Larger: Provide sectionalized screw-cover or hinged-cover enclosures.

4. Finish for Painted Steel Enclosures: Manufacturer's standard grey unless otherwise indicated.

5. Manufacturers:

a. Cooper B-Line, a division of Eaton Corporation.

b. Hoffman, a brand of Pentair Technical Products.

c. Hubbell Incorporated; Wiegmann Products.

D. Boxes for Hazardous (Classified) Locations: Listed and labeled as complying with UL 1203 for the classification of the installed location.

1. Manufacturers:

a. Appleton, a brand of Emerson Industrial Automation.

b. Cooper Crouse-Hinds, a division of Eaton Corporation.

c. Hubbell Incorporated; Killark Products.

E. Underground Boxes/Enclosures:

1. Description: In-ground, open bottom boxes furnished with flush, non-skid covers with legend indicating type of service and stainless steel tamper resistant cover bolts.

2. Size: As indicated on drawings.

3. Depth: As indicated on drawings, but not less than 12 inches.

4. Provide logo on cover to indicate type of service.

5. Applications:

a. Sidewalks and Landscaped Areas with no Vehicular Traffic: Use polymer concrete enclosures, with minimum SCTE 77, Tier 8 load rating.

b. Do not use polymer concrete enclosures in areas subject to vehicular traffic.

6. Polymer Concrete Underground Boxes/Enclosures: Comply with SCTE 77.
   a. Manufacturers:
      1) Armorcast.
      2) Highline Products, a subsidiary of MacLean Power Systems.
      3) Hubbell Incorporated; Quazite Products.
      4) Oldcastle Precast, Inc.
      5) Crouse-Hinds.
   b. Combination fiberglass/polymer concrete boxes/enclosures are acceptable.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that field conditions and measurements are as shown on drawings.

B. Verify that mounting surfaces are ready to receive boxes.

C. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Perform work in a neat and workmanlike manner in accordance with NECA 1 and, where applicable, NECA 130, including mounting heights specified in those standards where mounting heights are not indicated.

C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and CEC.

D. Provide separate boxes for emergency power, low-voltage communication and normal power systems.

E. Unless otherwise indicated, provide separate boxes for extra low voltage and low voltage systems.

F. Flush-mount boxes in finished areas unless specifically indicated to be surface-mounted.

G. Unless otherwise indicated, boxes may be surface-mounted where exposed conduits are indicated or permitted.

H. Box Locations:
   1. Locate boxes to be accessible after all conduit and equipment are installed.
   2. Unless dimensioned, box locations indicated are approximate.
   3. Locate boxes as required for devices installed under other sections or by others.
   4. Locate boxes so that wall plates do not span different building finishes.
   5. Locate boxes so that wall plates do not cross masonry joints.
   6. Unless otherwise indicated, where multiple outlet boxes are installed at the same location at different mounting heights, install along a common vertical center line.
   7. Do not install flush-mounted boxes on opposite sides of walls back-to-back. Provide minimum 6 inches horizontal separation unless otherwise indicated.

8. Acoustic-Rated Walls: Do not install flush-mounted boxes on opposite sides of walls back-to-back; provide minimum 24 inches horizontal separation.

9. Fire Resistance Rated Walls: Install flush-mounted boxes such that the required fire resistance will not be reduced.

   a. Do not install flush-mounted boxes on opposite sides of walls back-to-back; provide minimum 24 inches separation where wall is constructed with individual non-communicating stud cavities or protect both boxes with listed putty pads.

   b. Do not install flush-mounted boxes with area larger than 16 square inches or such that the total aggregate area of openings exceeds 100 square inches for any 100 square feet of wall area.

10. Locate junction and pull boxes as indicated, as required to facilitate installation of conductors, and to limit conduit length and/or number of bends between pulling points in accordance with Section 26 0534, Conduit.

11. Locate junction and pull boxes in the following areas, unless otherwise indicated or approved by the Owner's Representative:

    a. Concealed above accessible suspended ceilings.

    b. Within joists in areas with no ceiling.

    c. Electrical rooms.

    d. Mechanical equipment rooms.

I. Box Supports:

1. Secure and support boxes in accordance with CEC and Section 26 0529, Hangers and Supports for Electrical Systems, using suitable supports and methods in accordance with structural engineer's details. Where no structural details are provided, the contractor shall provide and submit structural details for review and approval by the authority having jurisdiction.

2. Do not provide support from piping, ductwork, or other systems.

3. Installation Above Suspended Ceilings: Do not provide support from ceiling grid or ceiling support system.

4. Use far-side support to secure flush-mounted device boxes supported from single stud in hollow stud walls. Repair or replace supports for boxes that permit excessive movement.

J. Install boxes plumb and level.

K. Flush-Mounted Boxes:

1. Install boxes in noncombustible materials such as concrete, tile, gypsum, plaster, etc. so that front edge of box or associated raised cover is not set back from finished surface more than 1/4 inch (6mm) or does not project beyond finished surface.

2. Install boxes in combustible materials such as wood so that front edge of box or associated raised cover is flush with finished surface.

3. Repair rough openings around boxes in noncombustible materials such as concrete, tile, gypsum, plaster, etc. so that there are no gaps or open spaces greater than 1/8 inch (3mm) at the edge of the box.

L. Install boxes as required to preserve insulation integrity.

M. Underground Boxes/Enclosures:

1. Install enclosure on gravel base, minimum 6 inches deep.
2. Flush-mount enclosures located in concrete or paved areas.
3. Mount enclosures located in landscaped areas with top at 1 inch above finished grade.
4. Install additional bracing inside enclosures in accordance with manufacturer's instructions to minimize box sidewall deflections during backfilling. Backfill with cover bolted in place.

N. Install permanent barrier between ganged wiring devices when voltage between adjacent devices exceeds 300 V.

O. Close unused box openings.

P. Install blank wall plates on junction boxes and on outlet boxes with no devices or equipment installed or designated for future use.

Q. Provide grounding and bonding in accordance with Section 26 0526, Grounding and bonding for Electrical Systems.

R. Identify boxes in accordance with Section 26 0553, Identification for Electrical Systems.

3.03 CLEANING

A. Clean interior of boxes to remove dirt, debris, plaster and other foreign material prior to installation of conductors.

3.04 PROTECTION

A. Immediately after installation, protect boxes from entry of moisture and foreign material until ready for installation of conductors.

END OF SECTION

SECTION 26 0548 – VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. Engineering for all bracing, anchorage and seismic restraints.

B. Vibration isolation for all rotating equipment, inertia bases, and equipment support frames.

C. Vibration isolation for electrical transformers.

D. Seismic restraints for all vibration isolated and non-vibration isolated equipment, conduit.

E. Supervision and inspection of installed vibration isolation hardware.

F. The contractor is responsible for selecting, engineering, and incorporating all bracing, anchorage and seismic restraints. Such restraints must not reduce the vibration isolation capabilities of the system.

1.02 QUALITY ASSURANCE

A. Design Criteria

1. Vibration Isolation: Provide isolation to avoid excessive noise or vibration in the building due to the operation of electrical equipment, or due to interconnected conduit.

2. Anchorage and Bracing: Anchor, support and brace all conduits to resist seismic forces in accordance with requirements for anchorage bracing as specified.

B. Requirements of Regulatory Agencies

1. CBC – California Building Code, California Code of Regulations, Title 24, Part 2, Part 8, Part 10.

1.03 DESIGN RESPONSIBILITY

A. Vibration isolation manufacturer shall:

1. Determine vibration isolation sizes and locations.

2. Provide piping and equipment isolation system as scheduled or specified.

3. Guarantee specified isolation system deflection.

4. Provide installation instructions and drawings.

1.04 SUBMITTALS

A. Comply with 26 0500 for additional submittal requirements and procedures including preparation and transmittals. The submittal shall contain the following information:

1. Catalog cuts and data sheets on specific vibration isolators to be utilized.

2. A table showing the mark of equipment, conduits, etc., to be isolated, the equipment location, the isolator type and model number selected for each piece of equipment, isolator loading and deflection including isolator free height and deflected height, and reference to specific drawing showing frame construction where applicable. For steel spring isolators include solid height and diameter of spring coil.

3. Drawings showing equipment frame construction. Written approval of the frame design to be used from the manufacturer.

4. Seismic restraint requirements including:

   a. Specific details for restraints including anchor bolts for mounting, snubbers, cable size, and the maximum loading at each location.

   b. Method of attachment to conduits, electrical equipment, and structure.

   c. Seismic restraint calculations for all restraints performed and signed by a structural engineer licensed in the State of California.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Manufacturers

1. Vibration isolation

   a. Mason Industries

   b. M.L. Sausse & Co. (Vibrex)

   c. California Dynamics Corporation

2. Supports

   a. B-Line

   b. Superstrut

   c. Unistrut

B. General Requirements

1. All frames, vibration isolation devices and seismic restraints, shall be designed and furnished by a single manufacturer, or supplier, who will be responsible for adequate coordination of all phases of this work.

C. Vibration Isolation

1. General Requirements

   a. All isolators shall operate in the linear portion of their load versus deflection curve. Load versus deflection curves must be linear over a deflection range 50% above the design deflection.

   b. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection.

   c. The ratio of lateral to vertical stiffness shall not be less than 0.5 or greater than 1.0.

   d. The vertical static deflection for each support point, based upon the load per isolator and isolator stiffness, shall not differ by more than + or - 10%.

   e. Isolation above the resonant frequency shall follow the theoretical prediction based upon an undamped single degree of freedom system.

   f. Isolators shall be selected by the supplier, even if sizing is shown. Size vibration isolators on single piece of equipment for equal static deflections based on actual static and dynamic weight distribution per point of support furnished by equipment manufacturer. Dynamic loads include those due to: wind, fluid flow, thrust and rotations inertial. Select each isolator

independently for the load distribution on the equipment base, duct or pipe support.

g. In determining weight of equipment, include concrete inertia bases, grout filled pump bases, etc.

h. All static deflections are nominal. Actual installed deflections are to be +15 percent of the specified value.

i. Where static deflections are not specified, provide minimum 2-inch deflection for rotating and reciprocating equipment.

j. Use as few isolators on each equipment as practical. For example, 4 isolators on small equipment and inertia bases.

k. Vibration isolators shall have either known height without a load or other markings so that after adjustment, when fully loaded, the deflection can be verified.

l. Incorporate a resilient neoprene element of 1/4-inch minimum thickness on spring hangers to prevent solid contact between the spring and isolator housing.

m. Install thrust restraints on fans over 3 inches wg static pressure with the same deflection as isolators supporting the fan.

n. All spring isolators laterally stable with leveling bolts. Spring isolators minimum additional "travel" to full compression of half the rated deflection. The ratio of lateral to vertical stiffness shall be 0.9 minimum and 1.5 maximum.

o. Provide all floor-mounted spring isolators with mounting base plates that provide for bolting to the floor and incorporate 1/2-inch thick neoprene bearing pads.

p. Provide EPDM or equal elastomeric elements in place of neoprene on all vibration isolators installed outdoors.

q. Provide neoprene material with anti-ozone and anti-oxidant additives.

r. Cp value as required by Title 24, Part 2, Table 2-23J.

s. Supply all miscellaneous steel to make support compatible with equipment.

t. Confirm seismic calculations and compatibility with particular equipment to be installed. Submit seismic calculations.

u. Mount motors on rigid base common with equipment or supported from equipment frame.

v. Snubbers must not limit vibration isolation capability during normal operation. Where steel limit stops are used, provide 3/4-inch thick neoprene to prevent metal-to-metal impact.

w. Vibration isolation manufacturer representative to supervise and inspect all installed isolation hardware and generate punchlist for the Owner's Representative along with corrective measures required. Submit inspection report.

2. Isolator types: Type of mounting and supporting base and minimum static deflection, as scheduled and required. Mason model numbers used.

   a. Base Mounts

      1) Type NP: Neoprene pad. Waffle, ribbed, or other forms. Typically 3/4-inch thick. Durometers of 40 to 50. Static deflections from 1/8" inch. Provide steel load distribution plates. Size of pad to be specified by isolator supplier based on load per point. Provide grommetted bolt when anchoring. Mason "Super" W and WM, ML Sausse, or equal.

      2) Type NM: Neoprene mounts. Molded one-piece assemblies with skid resistant base plates and mounting holes. Double deflection type with static deflection range from 0.3 to 0.5 inch. Coat metal surfaces with neoprene to prevent corrosion. Provide friction pad. Mason ND, ML Sausse, or equal.

      3) Type SM: Spring mounts. Single or multiple bare steel springs, base plates with neoprene pad. Height saving mounting brackets where applicable, height adjustment bolts. Static deflection range from 1.0 to 5.0 inches nominal. Mason SLFH, ML Sausse, or equal.

      4) Type USM: Unhoused spring mounts. Single or multiple bare steel springs, baseplates with neoprene pad. Height saving mounting brackets where applicable, height adjustment bolts. Static deflection range from 1.0 to 5.0 inches nominal. Mason SLR with C-spring, ML Sausse, or equal.

      5) Type SML: Spring mounts, drop and rise limiting. Same as Type USM multiple spring with assembly fabricated to prevent rise or drop of greater than 1/4-inch when overloaded or when load removed. Withstand 0.5G acceleration in all directions. Mason, SLR, ML Sausse, or equal.

      6) Type SSM: Seismic spring mounts. Single spring, leveling device, maximum 1/4-inch travel. Spring diameters no less than 0.8 of compressed height of spring at rated load. Minimum additional travel to solid equal to 50 percent of rated deflection. Spring inspection ports. Static deflection range from 1.0 to 5.0 inches nominal. Withstand 1.0G acceleration in all directions. Mason SSLFH, ML Sausse, or equal.

      7) Type RSC: Roof spring curb. Roof-mounted spring curbs with continuous perimeter structural steel curb supporting laterally stable coil springs sitting on 1/4-inch neoprene pads. Springs vertically and laterally restrained using neoprene isolated bolts. Provide leveling bolts and cadmium-plated or galvanized hardware. Mason RSC, ML Sausse, or equal.

   b. Hangers

      1) Type NH: Neoprene hangers. Molded neoprene units in a steel hanger frame. Double deflection types with static deflection range from 0.3- to 0.5-inch. Designed to preclude contact of hanger rods with frame (30 degrees misalignment). Insert neoprene bushing where rod passes through housing. Mason HD, ML Sausse, or equal.

2) Type SH: Hanger containing spring in series with deflected neoprene element, load transfer. Same as Type NH with yoke assembly and indicator for load transfer seat spring in neoprene cup with washer to distribute load evenly to cup and to prevent spring-to-casing contact. Mason PC 30N, ML Sausse, or equal.

c. Seismic Snubbers

1) Type SS: All-directional seismic snubber. Mason Z-1225, ML Sausse, or equal.

d. Resilient Attachments

1) Type RA-1: 3/4-inch nominal thickness resilient pipe sleeve between pipe and clamp or hanger.

e. Operating temperature at or below 80 degrees F, except in plenums: Armstrong Armaflex, Manville Aerotube or approved equal.

f. Operating temperature above 80 degrees F or in plenums: preformed glass fiber pipe insulation not exceeding 6 pcf.

1) Type RA-2: Manufactured insulated hanger for uninsulated pipe: Superstrut P/A-716 Cush-A-Clamp, Unistrut, B-line or approved equal.

2) Type RA-3: Manufacturer resilient attachment for water pipes 1 inch and less diameter: Technical Specialties Acousto-Plumb System (orange and blue) or equal.

g. Other Supports

1) Type A: Pipe anchors, vertical or horizontal. Resilient anchor points in piping to preclude direct contact of piping with structure, yet provide a neutral point for expansion/contraction or piping. Mason ADA, ML Sausse, or equal.

2) Type T: Trapeze. Supporting sling of steel member with mount or hangers at each end. Used to distribute load or to conserve space.

3) Type S: Stanchion support. A supporting arm or system for equipment or piping between the isolator and load.

4) Type "cable" seismic restraints shall be constructed of 7 by 19 strand galvanized aircraft cable. Cable assembly shall come compete with 2 "U" bolt clamps per end. Allowed loads shall contain a safety factor of three when worse case loading applied to 1 cable. Cable shall be installed with 1/4-inch slack to prevent the transmission of vibration to the structure.

h. Bases

1) Type SF: Structural steel integral frame of wide flange (W) or junior beam (M) members. Rigid fabrication to preclude deflections or frame distortion under dynamic load. Motor mounts, base plate mounts, stanchion support for piping or as shown on Drawings for equipment, pumps, fans, etc. Brackets to prevent drop of frame more than 3/8-inch. Thickness minimum 8 percent longest dimension. Mason WFSL, ML Sausse, or equal.

2) Type B: Brackets to equipment. Height saving brackets attached directly to equipment where rigidity of same does not require

supplemental frame. Drop protection as for Mason Type SF, ML Sausse, or equal.

3) Type IB: Inertia base frame. Welded steel frame with rebar reinforcement and height saving brackets. Provision for air decoupling holes on large units. Unit delivered ready for assembly. Pour of concrete by General Contractor. Preset equipment mount attachment bolts or other hold down methods for equipment involved. Space between bottom of base and floor to be at least 2 inches. Minimum weight equal to one to two times weight of equipment or as noted. Thickness minimum 8 percent largest dimension. Mason KSL, ML Saussg, or equal.

D. Conduit Seismic Supports

1. Provide products with current OSHPD certification number or provide calculations demonstrating compliance with regulatory requirements. Only known complying systems are "Superstrut Seismic Restraint System", pre-approval No. OPA-0003, and "B-Line Seismic Restraint System", pre-approval No. OPA-0114 and "Tomarco - ISAT Seismic Restraint System", pre-approval No. OPA-0485

2. Cp value as required by UBC Chapter 23, Table 23-P.

E. Expansion Bolts: As specified on structural drawings

PART 3 - EXECUTION

3.01 INSTALLATION

A. General

1. Install vibration isolation equipment in full accordance with the manufacturer's instructions.

2. Suspend the vibration isolators supporting conduits and equipment from structural members.

3. Provide a minimum of 1-inch clearance between the building structure and vibration isolated supports, conduits, and equipment.

4. Provide 2 inches minimum clearance between the top of the housekeeping pad or floor and the underside of concrete inertial pads and/or steel equipment support frames.

5. Fasten all vibration isolators to the structure, not to floor diaphragms or lightweight components. Use bolts where holes are provided in the mounting flanges; otherwise, adhere using structural adhesive. Where mounting flanges are steel, use neoprene grommets and washers under anchor bolts.

6. Do not use vibration isolation components to straighten or connect misaligned sections of conduits.

7. Align spring isolation hanger rods to clear the hanger box under all operating conditions.

8. Any bracing or supports for electrical conduits and equipment shall not bridge or reduce the effectiveness of vibration isolators.

9. Level vibration isolated equipment under rated design operating conditions while maintaining the isolation criteria. Isolators shall be plumb and aligned to preclude misalignment or undesired contact during operation.

B. Conduits

1. Support and brace all conduits as required in CBC Chapter 23, Table 23-P.
2. Use trapezes for vertical support to horizontal piping only. Brace trapeze with an OSHPD pre-approved bracing system, or provide calculations demonstrating compliance with regulatory requirements.
3. No electrical conduit, fixture, ceiling suspension wires or other elements of the building construction shall be attached to or abutted against HVAC duct and piping systems.
4. Install flexible connections at all connections to vibration isolated equipment, rotating, reciprocating and other vibrating equipment, whether isolated or not.

END OF SECTION

SECTION 26 0553 – IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Electrical identification requirements.

B. Identification nameplates and labels.

C. Wire and cable markers.

D. Voltage markers.

E. Underground warning tape.

F. Warning signs and labels.

1.02 RELATED REQUIREMENTS

A. Section 26 0519 – Low-Voltage Electrical Power Conductors and Cable.

B. Section 26 0534 – Conduit.

C. Section 26 0537 – Boxes.

1.03 REFERENCE STANDARDS

A. ANSI Z535.2 - American National Standard for Environmental and Facility Safety Signs.

B. ANSI Z535.4 - American National Standard for Product Safety Signs and Labels.

C. CEC – California Electrical Code; Most Recent Addition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements, as based on NFPA 70.

D. NFPA 70E – Standard for Electrical Safety in the Workplace.

E. UL 969 - Marking and Labeling Systems; Current Edition, Including All Revisions.

1.04 SUBMITTALS

A. Comply with Section 26 0500 for additional submittal requirements and procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for each product.

C. Shop Drawings: Provide nameplate and label schedule in Microsoft Excel that includes all information, including proposed designations, materials, legends, and formats for each label or nameplate required to be installed for power and communications equipment and cables The Microsoft Excel spreadsheet shall be submitted and approved prior to fabrication and installation.

1.05 QUALITY ASSURANCE

A. Conform to requirements of CEC, UL, and OSHA requirements for equipment labeling and hazard warning identification.

B. Labels and nameplates shall be the colors designated in this spec unless otherwise noted.

1.06 FIELD CONDITIONS

A. Do not install adhesive products when ambient temperature is lower than recommended by manufacturer.

B. Do not install identification products until final surface finishes and painting are completed.

C. Nameplates and labels shall be installed so they are readily visible and legible.

PART 2 - PRODUCTS

2.01 IDENTIFICATION REQUIREMENTS

A. Nameplates and labels shall confirm to the drawings and Owner's electrical equipment and cable numbering schemes.

B. Identification for Equipment:

1. Use identification nameplate to identify each piece of electrical distribution and control equipment and associated sections, compartments, and components.

a. Switchgear, Switchboards, Motor Control Centers, and Power Distribution Panelboards:

1) Use identification nameplate to identify the name of the power equipment.

2) Identify power source and circuit number. Where applicable include location when not within sight of equipment.

3) Use identification nameplate to identify main and tie devices.

4) Use identification nameplate to identify load(s) served for each feeder and branch device. Identify spares. Do not identify spaces.

b. Lighting and Appliance Panelboards:

1) Use identification nameplate to identify the name of the panelboard.

2) Identify power source and circuit number. Where applicable include location when not within sight of equipment.

3) Identify main overcurrent protective device.

4) Use typewritten circuit directory to identify load(s) served for panelboards with a door. Identify spares and spaces using pencil.

5) For panelboards without a door, use identification nameplate to identify load(s) served for each branch device and spares. Do not identify spaces.

c. Enclosed Switches, Enclosed Circuit Breakers, and Motor Controllers

1) Use identification nameplate to identify the name of the switch, breaker, or controller.

2) Identify power source and circuit number. Include location when not within sight of equipment.

3) Use identification nameplate to identify load(s) served including location when not within sight of equipment.

d. Transformers:

1) Use identification nameplate to identify the name of the transformer.

2) Identify power source and circuit number. Include location when not within sight of equipment.

3) Use identification nameplate to identify load(s) served including location when not within sight of equipment.

e. Transfer Switches:

1) Use identification nameplate to identify the name of the transfer switch.

2) Identify power source and circuit number for both normal power source and standby power source. Include location when not within sight of equipment.

3) Identify load(s) served. Include location when not within sight of equipment.

f. Electric Meters:

1) Identify load(s) metered.

2. Service Equipment:

a. Use identification nameplate to identify each service disconnecting means.

b. For buildings or structures supplied by more than one service, or any combination of branch circuits, feeders, and services, use identification nameplate or means of identification acceptable to authority having jurisdiction at each service disconnecting means to identify all other services, feeders, and branch circuits supplying that building or structure. Verify format and descriptions with authority having jurisdiction.

c. Provide available short circuit duty label with data from short circuit study per CEC 110.24.

3. Use identification nameplate to identify disconnect location for equipment with remote disconnecting means.

4. Use handwritten text using indelible marker on inside of door at each fused switch to identify required NEMA fuse class and size.

5. Use handwritten text and indelible marker to label inside door of switchboards, MCC's, and other equipment with phase sequence measured after energization.

6. Use floor marking tape, to identify required equipment working clearances, yellow 1-½ inch wide outlining the working space.

7. Arc Flash Hazard Warning Labels: Comply with Section 26 0573, Electrical Power System Study. If section 26 0573 is not in the project documents obtain Arc Flash Warning Labels from the Owners Representative or Engineer for all new power equipment and install per this spec.

8. Use warning signs to identify electrical hazards for entrances to all buildings, vaults, rooms, or enclosures containing exposed live parts or exposed conductors operating at over 600V nominal with the word message "DANGER; HIGH VOLTAGE; KEEP OUT".

9. Use warning labels to identify electrical hazards for equipment, compartments, and enclosures containing exposed live parts or exposed conductors operating at over 600V nominal with the word message "DANGER; HIGH VOLTAGE; KEEP OUT".

10. Use warning identification nameplates to identify electrical hazards for equipment where multiple power sources are present with the word message "DANGER; Hazardous voltage; Multiple power sources may be present; Disconnect all electric power including remote disconnects before servicing" or approved equivalent.

C. Identification for Conductors and Cables:

1. Color Coding for Power Conductors 600V and Less: Comply with Section 26 0519, Low-Voltage Electrical Power Conductors Cables.

2. Use wire and cable markers to identify circuit number and source panel number or other designation indicating control and instrumentation conductors and cables at the following locations:

a. At each source and load connection. Branch circuit number is not required in the source panel.

b. Within boxes with splices.

3. Use wire and cable markers to identify connected grounding electrode system components for grounding electrode conductors.

4. Use underground warning tape to identify direct buried cables.

D. Identification for Raceways:

1. Use voltage warning label to identify accessible conduits and raceways with voltages over 600 volts at maximum intervals of 20 feet.

2. Purchase pre-colored raceway for special systems and as required by the Codes. Field apply paint to all conduit and boxes that are not pre-colored or the correct color.

a. Color Code:

1) Fire Alarm System: Red

3. Use handwritten text using indelible marker, or plastic marker tags to identify spare conduits at each end. Identify purpose and termination location.

4. Use underground warning tape to identify underground raceways.

E. Identification for Boxes:

1. Use warning labels to identify electrical hazards for boxes containing exposed live parts or exposed conductors operating at over 600 V nominal with the message reading as follows: "DANGER; HIGH VOLTAGE; KEEP OUT".

2. Purchase pre-colored raceway for special systems and as required by the Codes. Field apply paint to all conduit and boxes that are not pre-colored or the correct color.

a. Color Code:

1) Fire Alarm System: Red

F. Identification for Devices:

1. Use identification label or engraved wall plate to identify serving branch circuit and source panel for all receptacles. Provide identification on inside surface of wall plate for all receptacles in general public areas or in areas as directed by Owner Representative.

2. Use identification label or engraved wall plate to identify load controlled for wall-mounted control devices controlling loads that are not visible from the control location and for multiple wall-mounted control devices installed at one location.

3. Use identification label to identify fire alarm system devices.

G. Identification for Manholes:

1. Manhole Covers shall be provided with the following identification cast into the cover:

   a. “HIGH VOLTAGE” for manholes containing conductors operating at a voltage greater than 600V.

   b. “ELECTRIC” for manholes containing only power/lighting conductors operating at 600V or less.

   c. “COMMUNICATION” for manholes containing copper and/or fiber communication cables.

2. Bead-weld manhole identifier (HMH, EMH, CMH, along with ID number per plans) into manhole cover.

H. Identification for underground Pullboxes

1. Concrete pullbox covers shall be provided with the following identification engraved into the cover:

   a. “ELECTRIC” for pullboxes containing only power/lighting conductors operating at 600V or less.

   b. “GROUND” for pullboxes containing a ground rod or ground conductors only.

   c. “COMMUNICATION” for pullboxes containing copper and/or fiber communication cables.

2. Metal pullbox covers shall have the following information welded onto the cover:

   a. “ELECTRIC” for pullboxes containing only power/lighting conductors operating at 600V or less.

   b. “COMMUNICATION” for pullboxes containing copper and/or fiber communication cables.

   c. Bead-weld pullbox identifier (EPB, CPB, along with ID number per plans) into pullbox cover.

2.02 IDENTIFICATION NAMEPLATES AND LABELS

A. Identification Nameplates

1. Materials:

   a. Indoor Locations: Use engraved laminated plastic nameplates.

   b. Outdoor Locations: Use engraved laminated plastic or stainless steel nameplates. Nameplates shall be suitable for exterior use.

2. Plastic Nameplates: Two-layer or three-layer laminated acrylic or electrically non-conductive phenolic with beveled edges; minimum thickness of 1/16 inch (1.6 mm); engraved text.

3. Stainless Steel Nameplates: Minimum thickness of 1/32 inch (0.8 mm); engraved or laser-etched text.

4. Mounting Holes for Mechanical Fasteners: Two (2), centered on sides for sizes up to 1 inch (25 mm) high; Four (4), located at corners for larger sizes.

B. Identification Labels

1. Materials: Use adhesive laminated plastic labels, UV and water resistant.

2. Laminated labels are acceptable for branch circuit device identification.

C. Format for Equipment Identification:
   1. Minimum Size: 1 inch by 2.5 inches.
   2. Legend:
      a. System designation where applicable:
         1) Emergency Power System: Identify with text "EMERGENCY".
         2) Fire Alarm System: Identify with text "FIRE ALARM".
      b. Equipment designation or other approved description.
   3. Text: All capitalized unless otherwise indicated.
   4. Minimum Text Height:
      a. System Designation: 1/8 inch.
      b. Equipment Designation: 1/8 inch.
      c. Exception: Provide minimum text height of 1 inch for equipment located more than 10 feet above floor or working platform.
   5. Color:
      a. Normal Power System: White text on black background.
      b. Emergency Power System: White text on red background.
      c. Fire Alarm System: White text on red background.

D. Format for Caution and Warning Messages:
   1. Text: All capitalized unless otherwise indicated.
   2. Minimum Text Height: 3/8 inch.
   3. Color: Black text on yellow background unless otherwise indicated.

E. Format for Receptacle Identification:
   1. Legend: Power source and circuit number or other designation indicated.
   2. Text: All capitalized unless otherwise indicated.
   3. Minimum Text Height: 3/16 inch.
   4. Color: Black text on clear background.

F. Format for Control Device Identification:
   1. Minimum Size: 3/8 inch by 1.5 inches.
   2. Legend: Load controlled or other designation indicated.
   3. Text: All capitalized unless otherwise indicated.
   4. Minimum Text Height: 3/16 inch.
   5. Color: Black text on clear background.

G. Format for Fire Alarm Device Identification:
   1. Minimum Size: 3/8 inch by 1.5 inches.
   2. Legend: Designation indicated and device zone or address.
   3. Text: All capitalized unless otherwise indicated.
   4. Minimum Text Height: 3/16 inch.
   5. Color: Red text on white background.

2.03 WIRE AND CABLE MARKERS

A. A Manufacturers:

1. Brady Corporation
2. Thomas & Betts

B. Markers for Conductors and Cables: Use wrap-around self-adhesive vinyl cloth, wrap-around self-adhesive vinyl self-laminating, heat-shrink sleeve, plastic sleeve, plastic clip-on, or vinyl split sleeve type markers suitable for the conductor or cable to be identified.

C. Markers for Conductor and Cable Bundles: Use plastic marker tags secured by nylon cable ties.

D. Legend: Power source and circuit number or other designation indicated.

E. Text: Use factory pre-printed or machine-printed text, all capitalized unless otherwise indicated.

F. Minimum Text Height: 1/8 inch.

G. Color: Black text on white background unless otherwise indicated.

2.04 UNDERGROUND WARNING TAPE

A. Materials: Use foil-back detectable type polyethylene tape suitable for direct burial, unless otherwise indicated.

B. Foil-backed Detectable Type Tape: 6 inches wide, with minimum thickness of 5 mil.

C. Legend: Type of service, continuously repeated over full length of tape.

D. Color:

1. Tape for Buried Power Lines: Black text on yellow background.
2. Tape for Buried Communication, Alarm, and Signal Lines: Black text on orange background.

2.05 FLOOR MARKING TAPE

A. Manufacturers:

1. 3M
2. Brady
3. Thomas & Betts.

B. Floor Marking Tape for Equipment Working Clearance Identification: Self-adhesive vinyl or polyester tape with over laminate, 1 1/2 inches wide, yellow.

2.06 WARNING SIGNS AND LABELS

A. Comply with ANSI Z535.2 or ANSI Z535.4 as applicable.

B. Warning Signs:

1. Materials:
   a. Use factory pre-printed rigid plastic signs.
2. Rigid Signs: Provide four mounting holes at corners for mechanical fasteners.
3. Minimum Size: 7 by 10 inches unless otherwise indicated.

C. Warning Labels:

1. Materials: Use factory pre-printed or machine-printed self-adhesive polyester or self-adhesive vinyl labels; UV, chemical, water, heat, and abrasion resistant; produced using materials recognized to UL 969.

2. Machine-Printed Labels: Use thermal transfer process printing machines and accessories recommended by label manufacturer.

3. Minimum Size: 2 by 4 inches unless otherwise indicated.

PART 3 - EXECUTION

3.01 PREPARATION

A. Clean surface to receive adhesive products according to manufacturer's instructions.

3.02 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Install identification products to be plainly visible for examination, adjustment, servicing, and maintenance. Unless otherwise indicated, locate products as follows:

1. Surface-Mounted Equipment: Enclosure front.

2. Flush-Mounted Equipment: Inside of equipment door.

3. Free-Standing Equipment: Enclosure front; also label enclosure rear for equipment with rear access.

4. Elevated Equipment: Legible from the floor or working platform.

5. Branch Devices: On device cover plate or adjacent to device.

6. Interior Components: Legible from the point of access.

7. Conductors and Cables: Legible from the point of access.

C. Install nameplates and identification products centered, level, and parallel with lines of item being identified.

D. Secure nameplates and identification plates to surfaces of enclosures using silicone adhesive or stainless steel screws or rivets. The use of double sided tape is unacceptable.

E. Install Identification Labels and markers to achieve maximum adhesion, with no bubbles or wrinkles and edges properly sealed.

F. Install underground warning tape above buried lines with one tape per trench at 12 inches above the buried line.

G. Secure rigid signs to doors using silicone adhesive or stainless steel screws or rivets. The use of double sided tape is unacceptable.

H. Secure rigid signs to gates using stainless steel clamps and stainless steel screws.

I. Mark all handwritten text, where permitted, to be neat and legible.

3.03 FIELD QUALITY CONTROL

A. Replace self-adhesive labels and markers that exhibit bubbles, wrinkles, curling or other signs of improper adhesion.

B. Replace any nameplates or labels that do not match the Owner's identification scheme, or project documents.

END OF SECTION

SECTION 26 0800 – ELECTRICAL TESTING REQUIREMENTS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Provide the services of an Owner Approved recognized independent testing firm to perform testing work, including but not limited to:

1. Overcurrent protective devices.
2. Grounding.
3. Medium Voltage Cables.
4. Low-Voltage 600-Volt Maximum Cables.
5. Switchboards.
6. Power distribution panelboards.
7. Lighting and appliance panelboards.
8. Small Power Centers.
9. Dry-Type Transformers.
10. Liquid-Filled Transformers.
11. Enclosed Switches.
12. Motor starters.
13. Electrical Power Metering.

1.02 RELATED REQUIREMENTS

A. Test procedures specified in this Section are in addition to that specified in other Sections of Division 26.

1. 26 0513 Medium-Voltage Cables
2. 26 0519 Low-Voltage Electrical Power Conductors and Cables
3. 26 1116 Secondary Unit Substations
4. 26 1216 Dry-Type, Medium-Voltage Transformers
5. 26 1219 Pad-Mounted, Liquid-Filled, Medium-Voltage Transformers
6. 26 2413 Switchboards
7. 26 2416 Panelboards
8. 26 2200 Low Voltage Transformers
9. 26 2713 Electrical Power Metering
10. 26 2818 Enclosed Switches
11. 26 2817 Enclosed Circuit Breakers
12. 26 2419 Motor-Control Centers

1.03 REFERENCE

A. Perform inspections and tests in accordance with the following codes and standards:

1. National Electrical Manufacturers Association - NEMA.

2. American Society for Testing and Materials - ASTM.
3. Institute of Electrical and Electronic Engineers - IEEE.
4. NETA STD ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems; International Electrical Testing Association.
5. American National Standards Institute -ANSI.
6. State and local codes and ordinances.
7. Insulated Cable Engineers Association - ICEA.
8. Occupational Safety and Health Administration - OSHA.
9. ANSI/NFPA 70: National Electrical Code.
10. ANSI/NFPA 70B: Electrical Equipment Maintenance.
11. NFPA 70E: Electrical Safety Requirements for Employee Workplaces

B. Division 26 specification sections and drawings are interrelated. Use Division 26, in its entirety, and accompanying electrical drawings for interpreting inspection and testing requirements.

C. Use manufacturer's instruction manuals applicable to each particular apparatus for special inspection and testing requirements.

1.04 SUBMITTALS

A. Comply with Section 26 0500 for additional submittal requirements and procedures.

B. Provide the following certified test report information, including but not limited to:

1. Summary of job.
2. Description of equipment tested.
3. Description of test procedure.
4. List of test equipment and calibration date.
5. Test results, except for the thermographic survey which will be handled as a separate submittal.
6. Conclusions and recommendations.
7. Appendix, including all field test reports.

C. Provide report certification by a licensed electrical engineer.

D. Secure report and test documents together using index in PDF format. Also provide index tabs in 3 ring binder if required by Owner.

E. Provide a copy of test date sheets after completion of any test prior to leaving the site. Report may be typed or printed. List the equipment tested, describe any deficiencies found and recommended corrections. Leave report copies with the Inspector of Record (I0R) and General Contractor.

F. One week before issuing the notice of project work completion, perform thermographic survey testing. The thermographic survey report will be a separate submittal. Thermographic survey shall be completed with the electrical system under "fully loaded" conditions.

G. Provide the following certified thermographic survey test report information, including but not limited to:

1. Summary of job.

2. Description of equipment tested.
3. Description of test procedure.
4. List of test equipment and calibration date.
5. Test results.
6. Discrepancies.
7. Temperature difference between the area of concern and the reference area.
8. Probable cause of temperature difference.
9. Areas inspected. Identify inaccessible and/or unobservable areas and/or equipment.
10. Identify load conditions at time of inspection.
11. Provide photographs and/or thermograms of the deficient area.
12. Conclusions and recommendations
13. Appendix, including all thermographic field test reports.

H. Secure the thermographic survey test report and test thermographic documents together using index in PDF format. Also provide index tabs in 3 ring binder if required by Owner.

I. Thermographic survey test report may be typed or printed. List the equipment tested, describe any deficiencies found and recommended corrections. Leave report copies with the Inspector of Record (10R) and General Contractor.

1.05 TESTING AGENCY QUALIFICATIONS

A. Company that is a financially independent testing organization which can function as an unbiased testing authority, professionally independent of the contractor, manufacturers, suppliers and installers of equipment or systems evaluated by the testing firm.

B. Meets or has the qualifications for membership of the International Electrical Testing Association, specializing in the testing of equipment or apparatus specified in this Section with minimum 5 years' experience.

C. See list of pre-approved testing firms in section 2.01.

D. Substitutions comply with Section 26 0500 for additional requirements and procedures. Submit the following for Owner review and approval.

1. Company Name and primary contact.
2. Company overview.
3. Qualifications.
4. Test technician qualifications.
5. Project summary of five projects completed in the last two (2) years with a similar scope of work.

1.06 DIVISION OF RESPONSIBILITY

A. Routine work performed by the Contractor prior to and in addition to tests performed by the testing firm:

1. Cleaning of equipment and apparatus.
2. Insulation-resistance and continuity test.
3. Rotation test.

4. Equipment bolt torquing.
5. Inspect for physical damage.
6. Proper equipment connection and operation.
7. Coordinate exact motor overload requirements.

B. The Contractor has the option to assign all or any portion of above listed routine work to the testing firm at his own expense.

C. The Contractor shall provide suitable and stable source of electrical power to each test site as required by the testing firm.

D. The Contractor shall notify the Inspector of Record (IOR) and the testing firm when equipment becomes available for acceptance tests. Work shall be coordinated to expedite project scheduling.

E. The testing firm shall notify the Owners Representative prior to commencement of any testing.

F. Report any system, material, or workmanship which is found defective on the basis of acceptance tests to the Owners Representative in writing.

G. The testing firm shall maintain a written record of all tests and, upon completion of project, assembles and certifies final test report.

H. Safety and Precautions:

1. Safety practices include, but are not limited to, the following requirements:
   a. Occupation Safety and Health Act.
   b. Accident Prevention Manual for Industrial Operations, National Safety Council.
   c. Applicable state and local safety operating procedures.
   d. Owner’s safety practices.
   e. National Fire Protection Association - NFPA 70E.
   f. American National Standards for Personnel Protection.
2. Testing performed with apparatus de-energized. Exceptions, including Thermographic survey, must be thoroughly reviewed to identify safety hazards and devise adequate safeguards.
3. The testing firm shall provide a designated safety representative on the project to supervise the testing operations with respect to safety.

PART 2 - PRODUCTS

2.01 TESTING FIRMS

A. Electrical Reliability Services / Vertiv

B. Power Systems Testing

C. Power Systems Services

D. Hampton Tedder Technical Services

E. Applied Engineering Concepts

2.02 TEST EQUIPMENT

A. The testing agency shall provide all required test equipment.

B. Care and Precautions:

1. Contractor is responsible for any damage to equipment or material due to improper test procedures or test apparatus handling. Replace or restore to original condition any damaged equipment or material.

2. Provide and use safety devices such as rubber gloves and blankets, protective screen, barriers and danger signs to adequately protect and warn all personnel in the vicinity of the tests.

3. Use test equipment that is calibrated and certified traceable to the National Institute of Standards and Technology. Certification date: Certification must be current and no more than 1 year duration.

PART 3 - EXECUTION

3.01 APPLICATION

A. General

1. Provide all necessary materials, supplies, tools, equipment, labor, and services required to perform all tests as specified in this Section.

2. Contractor is responsible to correct all deficiencies revealed by tests. Replace at contractors cost, all materials and equipment supplied by the contractor that are found faulty.

3. The testing intent is to assure that all electrical equipment, both contractor and Owner supplied, is operational within industry and manufacturers tolerances and is installed in accordance with design specifications.

4. The test and inspections determine the suitability for energization.

5. Use the International Electrical Testing Association (NETA) guidelines for testing procedures and acceptance test values of results.

6. Complete all test prior to commissioning and final acceptance.

7. Protective device settings shall be applied based on the owner approved coordination study. Testing of the protective devices shall not be performed prior to receiving the approved protective device settings.

B. Summary

1. Testing listed below is to assure proper installation, setting, connections, and functioning in accordance with the Drawings, Specifications, and the manufacturer's recommendations. It is the intent that field testing be extensive, and complete as specified, to provide positive assurance of totally correct installation and operation of equipment.

2. When conducting tests, comply with the following:

a. Notify the Owner and Inspector of Record at least 2 weeks prior to commencement of any testing.

b. Conduct all tests in the presence of the Owners Representative and Inspector of Record except when advised that his presence will not be necessary.

c. Include all tests and inspections recommended by the equipment manufacturer whether required by these Specifications or not, unless specifically waived by the owner.

d. Maintain a written record of all tests showing date, personnel making test, equipment or material tested, tests performed, manufacturer and serial number of testing equipment and results.

3. Tests include, but are not limited to, the following:

a. Circuit Breakers: Function within trip curves tolerances.

b. Grounding system: Ground resistance (impedance), ground integrity.

c. Ground Fault System: Neutral free of improper grounds.

d. Feeder Cables: Exhibit correct phase continuity and free of shorts and grounds.

e. Switchboard, and Power Distribution Panelboard Assemblies, Lighting and appliance panelboards, Small Power Centers, and Enclosed Circuit Breakers: Installed for sturdy and secure parts, free of short circuits and grounds, cabling secure to breakers, and accessories are in place.

f. Dry Transformers: Are connected properly, free of shipping parts, and shipping bolts lessen to allow vibration.

g. Liquid Filled Transformers: Are connected properly and sealed from general public access.

h. Enclosed Switches: Connected properly and function of door cannot open with switch closed with bypass for this function.

i. Motor starters: Controls function and overloads installed or settings for proper protection of motor.

4. See technical requirements section below for detailed test requirements.

3.02 TECHNICAL REQUIREMENTS

A. Circuit Breakers

1. Circuit Breakers, Air, Insulated-Case/Molded-Case for all breakers in new switchboards, new MCCs, new power distribution panelboards, and any breaker that are new or replacing existing shown on the one lines. Including breakers that are shown on one line for main or feeder breakers of lighting and appliance panelboards, i.e. breaker symbol with size is shown for the main or one of the feeder breaker then these particular breakers will be tested. Exceptions as noted on one line diagram.

2. Visual and Mechanical Inspection

a. Compare equipment nameplate data with drawings and specifications.

b. Inspect physical and mechanical condition.

c. Inspect anchorage and alignment.

d. Verify the unit is clean.

e. Operate the circuit breaker to insure smooth operation.

f. Inspect bolted electrical connections for high resistance using one or more of the following methods:

1) Use of a low-resistance ohmmeter in accordance with section A3 below Electrical Tests.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

g. Inspect operating mechanism, contacts, and arc chutes in unsealed units.

h. Perform adjustments for final protective device settings in accordance with the coordination study.

3. Electrical Tests

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable, in accordance with section A2 above Visual and Mechanical Inspection.

b. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to- ground with the circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.1.

c. Perform a contact/pole-resistance test.

d. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential shall be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration shall be one minute. For units with solid-state components, follow manufacturer's recommendation.

e. Determine long-time pickup and delay by primary current injection.

f. Determine short-time pickup and delay by primary current injection.

g. Determine ground-fault pickup and time delay by primary current injection.

h. Determine instantaneous pickup by primary current injection.

i. Test functions of the trip unit by means of secondary injection.

j. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data.

k. Verify correct operation of auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, anti-pump function, and trip unit battery condition. Reset all trip logs and indicators.

l. Verify operation of charging mechanism.

4. Test Values

a. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

b. Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

c. Final setting shall comply with approved coordination study. Complete test reports shall include final approved settings.

d. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data. If the manufacturer's published data is not available, investigate values that

deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.

e. Insulation-resistance values shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations should be investigated.

f. Insulation-resistance values of control wiring shall not be less than two megohms.

g. Long-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors. If manufacturer's curves are not available, trip times shall not exceed the value shown in NETA ATS Table 100.7.

h. Short-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.

i. Ground fault pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.

j. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances. In the absence of manufacturer's published data, refer to NETA ATS Table 100.8.

k. Pickup values and trip characteristics shall be within manufacturer's published tolerances.

l. Minimum pickup voltage of the shunt trip and close coils shall conform to the manufacturer's published data. In the absence of the manufacturer's published data, refer to NETA ATS Table 100.20.

m. Breaker open, close, trip, trip-free, anti-pump, and auxiliary features shall function as designed.

n. The charging mechanism shall operate in accordance with manufacturer's published data.

B. Grounding Systems

1. Inspect physical and mechanical conditions.

2. Verify ground system is in compliance with the drawings, specifications, and CEC.

3. Verify that ground system installation is completed before performing testing work.

4. Use "3 probe - fall of potential" method or alternative test in accordance with ANSI/IEEE 80 on the main grounding electrode or system ground rods. All other ground tests may be measured to system ground by use of ground reference method or point-to-point between the main grounding system and all major electrical equipment frames, system neutral, an/or derived neutral points.

5. Tests include measurement of ground resistance at the following equipment and structures:

a. All switchboards.

b. All Power distribution panelboards.

c. All power transformer frames and neutral grounds.

d. Other miscellaneous grounds selected at random in a manner to be representative of the entire installation.

e. Ground system ground rods, including those in manholes.

f. Isolated instrumentation system.

6. The main ground electrode system resistance to ground to be no greater than 5 ohms.

7. Main system grounds showing more than 5 ohms resistance to earth shall be identified and reviewed by the owner's representative.

8. Investigate point-to-point resistance values which exceed 0.5 ohms.

9. Test main service entrance neutral systems to be free of grounding by temporarily removing the neutral to grounding bar and measuring to ground. Investigate resistance values less than 100 ohms.

10. Test any new derived neutral systems to be free of grounding by temporarily removing the neutral to grounding bar and measuring to ground. Investigate resistance values less than 100 ohms.

C. Cables, Low-Voltage, 600-Volt Maximum

1. Test all cables shown on the one line drawings to assure proper installation and connections in accordance with the Drawings, Specifications, and the manufacturer's recommendations.

2. Visual and Mechanical Inspection

a. Compare cable data with drawings and specifications.

b. Inspect exposed sections of cable for physical damage and correct connection in accordance with the single-line diagram.

c. Inspect bolted electrical connections for high resistance using one or more of the following methods:

1) Use of low-resistance ohmmeter in accordance with section C3 below Electrical tests.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

d. Inspect compression-applied connectors for correct cable match and indentation.

e. Inspect for correct identification and arrangements.

f. Inspect cable jacket insulation and condition.

3. Electrical Tests

a. Perform resistance measurements through bolted connections with low-resistance ohmmeter, if applicable, in accordance section C2 above Visual and Mechanical.

b. Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. Applied potential shall be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration shall be one minute.

c. Perform continuity tests to insure correct cable connection.

d. Verify uniform resistance of parallel conductors.

4. Test Values

a. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

b. Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

c. Insulation-resistance values shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations or less than 50 megohmes shall be investigated.

d. Microhm or millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer's data is not available, investigate any values which deviate from similar connections by more than 50 percent of the lowest value.

D. Cables, Medium and High-Voltage

1. Test all cables shown on the one line drawings to assure proper installation and connections in accordance with the Drawings, Specifications, and the manufacturer's recommendations.

2. Visual and Mechanical Inspection

a. Compare cable data with drawings and specifications.

b. Inspect exposed sections of cable for physical damage and correct connection in accordance with the single-line diagram.

c. Inspect bolted electrical connections for high resistance using one or more of the following methods:

1) Use of low-resistance ohmmeter in accordance with section D3 below Electrical tests.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

d. Inspect compression-applied connectors for correct cable match and indentation.

e. Inspect shield grounding, cable supports, and terminations.

f. Verify that visible cable bends meet or exceed ICEA and manufacturer's minimum published bending radius.

g. If cables are terminated through window-type current transformers, inspect to verify that neutral and ground conductors are correctly placed and that shields are correctly terminated for operation of protective devices.

h. Inspect for correct identification and arrangements.

i. Inspect cable jacket insulation and condition.

3. Electrical Tests

a. Perform resistance measurements through bolted connections with low-resistance ohmmeter, if applicable, in accordance section D2 above Visual and Mechanical.

b. Perform an insulation-resistance test individually on each conductor with all other conductors and shields grounded. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.1

c. Perform a shield-continuity test on each power cable.

d. In accordance with ICEA, IEC, IEEE and other power cable consensus standards, testing can be performed by means of direct current, power frequency alternating current, or very low frequency alternating current. These sources may be used to perform insulation-withstand tests, and baseline diagnostic tests such as partial discharge analysis, and power factor or dissipation factor. The selection shall be made after an evaluation of the available test methods and a review of the installed cable system. Some of the available test methods are listed below.

1) Dielectric Withstand

a) Direct current (dc) dielectric withstand voltage

b) Very low frequency (VLF) dielectric withstand voltage

c) Power frequency (50/60 Hz) dielectric withstand voltage

2) Baseline Diagnostic Tests

a) Power factor/ dissipation factor (tan delta)

b) Power frequency (50/60 Hz)

c) Very low frequency (VLF)

3) DC insulation resistance

4) Partial discharge

a) Online (50/60 Hz)

b) Off line

(1) Power Frequency (50/60 Hz)

(2) Very low frequency (VLF)

e. Perform continuity tests to insure correct cable connection.

f. Verify uniform resistance of parallel conductors.

4. Test Values

a. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

b. Bolt-torque levels shall be in accordance with manufacturer’s published data. In the absence of manufacturer’s published data, use NETA ATS Table 100.12.

c. The minimum bend radius to which insulated cables may be bent for permanent training shall be in accordance with NETA ATS Table 100.22.

d. Insulation-resistance values shall be in accordance with manufacturer’s published data. In the absence of manufacturer’s published data, use NETA ATS Table 100.1. Values of insulation resistance less than this table or manufacturer’s recommendations or less than 50 megohmes shall be investigated.

e. Shielding shall exhibit continuity. Investigate resistance values in excess of ten ohms per 1000 feet of cable.

f. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the test, the test specimen is considered to have passed the test.

g. Based on the test methodology chosen, refer to applicable standards or manufacturer's literature for acceptable values.

h. Microhm or millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer's data is not available, investigate any values which deviate from similar connections by more than 50 percent of the lowest value.

E. Switchboards, Power Distribution Panelboard Assemblies, Lighting and appliance panelboards, Small Power Centers, and Enclosed Circuit Breakers:

1. Visual and Mechanical Inspection

a. Compare equipment nameplate data with drawings and specifications.

b. Inspect physical and mechanical condition.

c. Inspect anchorage, alignment, grounding, and required area clearances.

d. Verify the unit is clean and all shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.

e. Verify that fuse and circuit breaker sizes and types correspond to drawings and coordination study as well as to the circuit breaker's address for microprocessor-communication packages.

f. Verify that wiring connections are tight and that wiring is secure to prevent damage during routine operation of any moving parts.

g. Inspect bolted electrical connections for high resistance using one or more of the following methods:

1) Use of a low-resistance ohmmeter in accordance with section E2 below Electrical Tests.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

h. Verify operation and sequencing of any breaker electrical and mechanical interlocking systems. Attempt to close a locked open device and attempt to open a locked closed device and again after exchange of sequencing breakers.

i. Inspect insulators for evidence of physical damage or contaminated surfaces.

j. On switchboards with more than one section verify section barriers are installed.

k. Exercise all active components.

l. Verify that filters are in place and/or vents are clear.

2. Electrical Tests

a. Perform resistance measurements through bolted electrical connections with a low-resistance ohmmeter, if applicable, in accordance section E1 above Visual and Mechanical Inspection.

b. Perform insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground, for one minute in accordance with NETA ATS Table 100.1. For units with solid-state components or control devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.

c. Perform ground-resistance tests from switchboard/panel to ground system.

d. Perform phasing checks on double-ended or dual-source switchgear to insure correct bus phasing from each source.

e. Verify operation of switchboard space heaters and thermostat control per each section for equipped switchboards.

3. Test Values – Visual and Mechanical

a. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

b. Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

4. Test Values – Electrical

a. Bolt-torque levels should be in accordance with NETA Table 100.12 unless otherwise specified by manufacturer.

b. Microhm or millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

c. Insulation-resistance values of bus insulation shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations should be investigated.

d. Results of ground-resistance tests shall be in accordance with grounding testing section of this spec.

5. Perform visual and mechanical inspection and testing of instrument current and potential transformers and metering devices in accordance Electrical Power Metering Section 26 2713.

F. Dry Transformers – Low Voltage

1. Visual and Mechanical Inspection

a. Compare equipment nameplate data with drawings and specifications.

b. Inspect physical and mechanical condition.

c. Inspect anchorage, alignment, and grounding.

d. Verify that resilient mounts are free and that any shipping brackets have been removed.

e. Verify the unit is clean.

f. Verify that neutral is grounded unless otherwise noted on one line drawing. Grounding of neutral cable size is acceptable per CEC.

g. Inspect bolted electrical connections for high resistance using one of the following methods:

1) Use of low-resistance ohmmeter in accordance with Section F2 below Electrical Tests.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

h. Verify that as-lift tap connections are as specified.

2. Electrical Tests

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable, in accordance with Section F1 above Visual and Mechanical Inspection.

b. Perform insulation-resistance tests winding to winding and each winding to ground. Apply voltage in accordance with manufacturer's published data or in the absence of manufacturer's published data, use NETA ATS Table 100.5. Calculate polarization index.

c. Perform turns ratio tests at all tap positions.

d. Verify correct secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.

3. Test Values

a. Compare bolted connection resistances to values of similar connections.

b. Bolt-torque levels should be in accordance with NETA ATS Table 100.12 unless otherwise specified by manufacturer.

c. Microhm or millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer's data is not available, investigate any values which deviate from similar connections by more than 50 percent of the lowest value.

d. Minimum insulation-resistance values of transformer insulation shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.5. Values of insulation resistance less than this table or manufacturer's recommendations should be investigated.

e. The polarization index shall be greater than 1.0 and shall be recorded for future reference. The polarization index shall not be less than 1.0.

f. Turns-ratio test results should not deviate more than one-half percent from either the adjacent coils or the calculated ratio.

g. Phase-to-phase and phase-to-neutral secondary voltages shall be in agreement with nameplate data.

G. Dry Transformers – Medium Voltage

1. Visual and Mechanical Inspection

a. Compare equipment nameplate data with drawings and specifications.

b. Inspect physical and mechanical condition.

c. Inspect anchorage, alignment, and grounding.

d. Verify that resilient mounts are free and that any shipping brackets have been removed.

e. Verify the unit is clean.

f. Verify that neutral is grounded unless otherwise noted on one line drawing. Grounding of neutral cable size is acceptable per CEC.

g. Verify that control and alarm settings on temperature indicators are as specified.

h. Verify that cooling fans operate and that fan motors have correct overcurrent protection.

i. Inspect bolted electrical connections for high resistance using one of the following methods:

1) Use of low-resistance ohmmeter in accordance with Section G2 below Electrical Tests.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

j. Perform specific inspections and mechanical tests as recommended by the manufacturer.

k. Verify that as-lift tap connections are as specified.

l. Verify the presence of surge arresters.

2. Electrical Tests

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable, in accordance with Section G1 above Visual and Mechanical Inspection.

b. Perform insulation-resistance tests winding to winding and each winding to ground. Apply voltage in accordance with manufacturer's published data or in the absence of manufacturer's published data, use NETA ATS Table 100.5. Calculate polarization index.

c. Perform power-factor or dissipation-factor test in accordance with the test equipment manufacturer's published data.

d. Perform a power-factor or dissipation-factor tip-up test on windings greater than 2.5 kV.

e. Perform turns ratio tests at all tap positions.

f. Perform an excitation-current test on each phase.

g. Measure the resistance of each winding at each tap connection.

h. Measure core insulation-resistance at 500 volts dc if the core is insulated and the core ground strap is removable.

i. Verify correct secondary voltage phase to phase and phase to neutral after energization and prior to loading.

j. Test surge arresters in accordance NETA STD ATS Section 7.19.

3. Test Values

a. Compare bolted connection resistances to values of similar connections.

b. Bolt-torque levels should be in accordance with NETA ATS Table 100.12 unless otherwise specified by manufacturer.

c. Microhm or millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer's data is not available, investigate any values which deviate from similar connections by more than 50 percent of the lowest value.

d. Minimum insulation-resistance values of transformer insulation shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.5.. .Values of insulation resistance less than this table or manufacturer's recommendations should be investigated.

e. The dielectric absorption ratio or polarization index shall be greater than 1.0 and shall be recorded for future reference. The polarization index shall not be less than 1.0.

f. Turns-ratio test results should not deviate more than one-half percent from either the adjacent coils or the calculated ratio.

g. Record the CH and CL in the power-factor or dissipation-factor test and expect the CHL power factor values for ventilated dry-type transformers:

4. Power transformers: 2.0 percent or less.

5. Distribution transformers: 5.0 percent or less.

a. Power-factor or dissipation-factor tip-up exceeding 1.0 percent should be investigated.

b. Temperature corrected winding-resistance test results should compare within one percent of previously obtained results.

c. Typical excitation current test data pattern for three-legged core transformer is two similar current readings and one lower current reading.

d. Core insulation-resistance values should be comparable to factory obtained results but not less than 1.0 megohm at 500 volts dc.

e. Phase-to-phase and phase-to-neutral secondary voltages shall be in agreement with nameplate data.

f. Control and alarm settings on temperature indicators shall operate within manufacturer's recommendations for specified settings.

g. Cooling fans shall operate.

H. Liquid Filled Transformers – Medium Voltage

1. Visual and Mechanical Inspection

a. Compare equipment nameplate data with drawings and specifications.

b. Inspect physical and mechanical condition.

c. Inspect anchorage, alignment, and grounding.

d. Verify removal of any shipping bracing after placement.

e. Verify the bushings are clean.

f. Verify that alarm, control, and trip settings on temperature and level indicators are as specified.

g. Verify operation of alarm, control, and trip circuits from temperature and level indicators, pressure relief device, gas accumulator, and fault pressure relay, if applicable.

h. Verify that cooling fans and pumps operate correctly and have appropriate overcurrent protection.

i. Inspect bolted electrical connections for high resistance using one or more of the following methods:

1) Use of a low-resistance ohmmeter in accordance with Section H2 below Electrical Tests.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

j. Verify correct liquid level in tanks and bushings.

k. Verify that positive pressure is maintained on gas-blanketed transformers.

l. Perform inspections and mechanical tests as recommended by the manufacturer.

m. Verify presence of transformer surge arresters.

n. Verify de-energized tap-changer position is left as specified.

2. Electrical Tests

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter if applicable, in accordance with Section H1 above Visual and Mechanical Inspection

b. Perform insulation-resistance tests, winding-to-winding and each winding-to-ground. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.5. Calculate polarization index.

c. Perform turns-ratio tests at all tap positions.

d. Perform insulation power-factor or dissipation-factor tests on all windings in accordance with test equipment manufacturer's published data.

e. Perform power-factor or dissipation-factor tests on each bushing equipped with a power-factor/ capacitance tap. In the absence of a power-factor/ capacitance tap, perform hot-collar tests. These tests shall be in accordance with the test equipment manufacturer's published data.

f. Perform excitation-current tests in accordance with test equipment manufacturer's published data.

g. Measure the resistance of each high-voltage winding in each de-energized tap-changer position. Measure the resistance of each low-voltage winding in each de-energized tap-changer position, if applicable.

h. Remove a sample of insulating liquid in accordance with ASTM D 923. Sample shall be tested in accordance ASTM D 6871 for the following.

1) Dielectric breakdown voltage: ASTM D 877 and/or ASTM D 1816.

2) Acid neutralization number: ANSI/ASTM D 974.

3) Specific gravity: ANSI/ASTM D 1298.

4) Interfacial tension: ANSI/ASTM D 971 or ANSI/ASTM D 2285.

5) Color: ANSI/ASTM D 1500.

6) Visual Condition: ASTM D 1524.

i. Remove a sample of insulating liquid in accordance with ASTM D 3613 and perform dissolved-gas analysis (DGA) in accordance with ANSI/IEEE C57.104 or ASTM D3612 and IEEE C57.155 Guide for Interpretation of Gases Generated in Natural Ester and Synthetic Ester-Immersed Transformers.

j. Test transformer neutral grounding impedance device, if present.

k. Verify operation of cubicle or air terminal compartment space heaters.

3. Test Values – Visual and Mechanical

a. Alarm, control, and trip circuits from temperature and level indicators as well as pressure relief device and fault pressure relay shall operate within manufacturer's recommendations for their specified settings.

b. Cooling fans and pumps shall operate.

c. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

d. Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

e. Liquid levels in the transformer tanks and bushings shall be within indicated tolerances.

f. Positive pressure shall be indicated on pressure gauge for gas-blanketed transformers.

4. Test Values – Electrical

a. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

b. Minimum insulation-resistance values of transformer insulation shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.5. Values of insulation resistance less than this table or manufacturer's recommendations should be investigated. The polarization index shall not be less than 1.0.

c. Turns-ratio test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio.

d. Typical excitation-current test data pattern for a three-legged core transformer is two similar current readings and one lower current reading.

e. Temperature corrected winding-resistance values shall compare within one percent of previously obtained results.

f. 1Insulating liquid values shall be in accordance with NETA ATS Table 100.4.

g. Evaluate results of dissolved-gas analysis in accordance with ANSI/IEEE Standard C57.104.

h. Heaters shall be operational.

I. Enclosed Switches – Low Voltage

1. Visual and Mechanical Inspection

a. Compare equipment nameplate data with drawings and specifications.

b. Inspect physical and mechanical condition.

c. Inspect anchorage, alignment, grounding, and required clearances.

d. Verify the unit is clean.

e. Verify correct blade alignment, blade penetration, travel stops, and mechanical operation.

f. Verify that fuse sizes and types are in accordance with drawings, short-circuit studies, and approved coordination study.

g. Verify that each fuse has adequate mechanical support and contact integrity.

h. Inspect bolted electrical connections for high resistance using one of the following methods.

1) Use of low-resistance ohmmeter in accordance with Section I2 below Electrical Tests.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

i. Verify operation and sequencing of door interlocking system.

j. Verify correct phase barrier installation.

k. Verify correct operation of all indicating devices.

2. Electrical Test

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable, in accordance with Section I1 above Visual and Mechanical Inspection.

b. Measure contact-resistance across each switchblade and fuseholder.

c. Measure fuse resistance.

3. Test Values

a. Compare bolted connection resistances to values of similar connections.

b. Bolt-torque levels should be in accordance with NETA ATS Table 100.12 unless otherwise specified by the manufacturer.

c. Microhm or millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data. Investigate any values which deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.

d. Investigate fuse-resistance values that deviate from each other by more than 15 percent.

J. Enclosed Switches – Medium Voltage

1. Visual and Mechanical Inspection

a. Compare equipment nameplate data with drawings and specifications.

b. Inspect physical and mechanical condition.

c. Inspect anchorage, alignment, grounding, and required clearances.

d. Verify the unit is clean.

e. Verify correct blade alignment, blade penetration, travel stops, arc interrupter operation, and mechanical operation.

f. Verify that fuse sizes and types are in accordance with drawings, short-circuit studies, and approved coordination study.

g. Verify that expulsion-limiting devices are in place on all holders having expulsion-type elements.

h. Verify that each fuseholder has adequate mechanical support and contact integrity.

i. Inspect bolted electrical connections for high resistance using one of the following methods.

1) Use of low-resistance ohmmeter in accordance with Section J2 below Electrical Tests.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

j. Verify operation and sequencing of interlocking systems.

k. Verify correct phase barrier installation.

l. Verify correct operation of all indicating and control devices.

m. Lubrication requirements

1) Verify appropriate lubrication on moving current-carrying parts.

2) Verify appropriate lubrication on moving and sliding surfaces.

2. Electrical Test

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable, in accordance with Section J1 above Visual and Mechanical Inspection.

b. Measure contact-resistance across each switchblade and fuseholder.

c. Perform insulation-resistance tests on each pole, phase-to-phase and phase-to-ground with switch closed and across each open pole for one minute. Test voltage shall be in accordance with manufacturer's published data or in the absence of manufacturer's published data use NETA ATS Table 100.1.

d. Perform an overpotential test on each pole with switch closed. Test each pole-to-ground with all other poles grounded. Test voltage shall be in accordance with manufacturer's published data or NETA ATS Table 100.2.

e. Measure fuse resistance.

f. Verify cubicle space heater operation and control of thermostat.

3. Test Values

a. Compare bolted connection resistances to values of similar connections.

b. Bolt-torque levels should be in accordance with NETA ATS Table 100.12 unless otherwise specified by the manufacturer.

c. Microhm or millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data. Investigate any values which deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.

d. Insulation resistance values should be in accordance with manufacturer's published data or in the absence of manufacturer's published data NETA ATS Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations or Table 100.1 should be investigated.

e. The insulation shall withstand the overpotential test voltage applied.

f. Investigate fuse-resistance values that deviate from each other by more than 15 percent.

g. Heaters shall be operational.

K. Motor Starters

1. Visual and Mechanical Inspection

a. Compare equipment nameplate data with drawings and specifications.

b. Inspect physical and mechanical condition.

c. Inspect anchorage, alignment, and grounding.

d. Verify the unit is clean.

e. Verify contactors.

1) Verify mechanical operation.

2) Inspect contact gap, wipe, alignment, and pressure are in accordance with manufacturer's published data.

f. Motor-Running Protection.

1) Verify overload element rating and or setting is correct for its application and report sizes along with motor nameplate data.

2) If motor-running protection is provided by fuses, verify correct fuse rating.

g. Inspect bolted electrical connections for high resistance using one of the following methods:

1) Use of low-resistance ohmmeter in accordance with Section K2 below Electrical Tests.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

2. Electrical Test

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable, in accordance with Section K1 above Visual and Mechanical Inspection.

b. Perform operational tests by initiating control devices.

3. Test Values

a. Compare bolted connection resistance to values of similar connections.

b. Bolt-torque levels should be in accordance with NETA ATS Table 100.12 unless otherwise specified by manufacturer.

c. Microhm or millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer's data is not available, investigate any values which deviate from similar connections by more than 50 percent of the lowest value.

L. Electrical Power Metering

1. New Electrical Power Meters installed for this project shall be, but not limited to, check and tested per this specification.

2. Visual and Mechanical Inspection

a. Compare equipment nameplate data with drawings and specifications.

b. Inspect meters and cases for physical damage.

c. Clean front panel and remove shipping restraint material.

d. Verify tightness of electrical connections.

e. Record model number, serial number, firmware revision, software revision, and rated control voltage.

f. Verify and record meter current and voltage transformer ratios and that they correspond to drawings.

g. Verify operation of display and indicating devices.

h. Record passwords.

i. Verify unit is grounded in accordance with manufacturer's instructions.

j. Verify unit is connected in accordance with manufacturer's instructions and project drawings.

k. Verify control power to the meter is protected by an accessible disconnect fuse switch with CC fuses.

l. Verify sensing voltage to the meter is protected by 3 single phase accessible disconnect fuse switches with CC fuses for 3 phase or with 1 single accessible disconnect CC fuse for single phase monitoring.

m. Record all CC fuse amp ratings.

n. Verify that all current sensing to the meter is provide thru a shorting terminal blocks.

o. Set all required parameters including instrument transformer ratios, system type and voltage, frequency, power demand methods/intervals, and communications requirements along with IP address.

p. Provide support for establishing meter communications to owner power monitoring system. Meter shall communicate with owner utility monitoring system.

3. Electrical Tests

a. Apply voltage or current as appropriate to each analog input and verify correct measurement and indication. This should include phase checking as wattage readings that should not be in reverse and not less then what is expected. All phase should add to wattage total and not be negative readings for some phases.

b. Confirm correct operation and setting of each auxiliary input/output feature including mechanical relay, digital, and analog.

c. After during initial system energization, confirm measurements and indications are consistent with loads present. Confirm readings using a secondary portable meter.

4. Test Values

a. Nameplate data shall be per drawings and specifications.

b. Tightness of electrical connections shall assure a low resistance connection.

c. Display and indicating devices shall operate per manufacturer's published data.

d. Measurement and indication of applied values of voltage and current shall be within manufacturer's published tolerances for accuracy.

e. All auxiliary input/output features shall operate per settings and manufacturer's published data.

f. Measurements and indications shall be consistent with energized system loads.

g. Wattage readings should not be in reverse and not less then what is expected. All phases should add to wattage total and not be negative readings for some phases.

3.03 THERMOGRAPHIC TECHNICAL REQUIREMENTS

A. After all acceptance tests are completed and approved, system is energized with load, at one or two weeks before notice of project work completion, perform thermographic survey testing for all new electrical system components installed for this project, and including all existing electrical system components that are interconnected of the following with as much system load energized as possible:

1. Cables, Low-Voltage, 600-Volt Maximum.
2. Cables, Medium and High-Voltage.
3. Switchboards, Power Distribution Panelboard Assemblies, Lighting and appliance panelboards, Small Power Centers, and Enclosed Circuit Breakers.
4. Dry Transformers – Low Voltage.
5. Dry Transformers – Medium Voltage.
6. Pad-Mounted, Liquid-Filled, Medium - Voltage Transformers.
7. Enclosed Switches – Low Voltage.
8. Enclosed Switches – Medium Voltage.
9. Motor Starters.

B. Survey shall include all current-carrying devices.

C. Visual and Mechanical Inspection

1. Perform thermographic survey when load is applied to the system.
2. Remove all necessary covers prior to thermographic inspection. Use appropriate caution, safety devices, and personal protective equipment.

D. Test Parameters

1. Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1° C at 30° C.
2. Equipment shall detect emitted radiation and convert detected radiation to visual signal.

E. Test Results

1. Suggested actions based on temperature rise can be found in NETA ATS Table 100.18.

3.04 RETESTING RETESTING

A. Retest any equipment which does not pass initial tests after correction is made, or where subsequent testing is required for acceptance as directed by the Owner’s Representative.

3.05 REPLACEMENT OF DEFECTIVE MATERIAL OR EQUIPMENT

A. Repair or replace any material or equipment found defective or cannot pass the tests specified in this Section at no additional cost to the Owner.

B. Complete correction of defective material or equipment and retesting within the Contract period.

C. If the equipment or material cannot pass the second test, remove the defective equipment and replace it with equivalent equipment that meets the requirements of the Specifications. Such replacement shall be at no cost to the Owner.

D. Remove defective equipment or material from the site no later than 15 days from the date of notification by the Owner or Owner's Representative.

3.06 FIELD ADJUSTMENTS TECHNICAL REQUIREMENTS

A. Testing firm is responsible to apply final setting and adjustments on protective devices in accordance with values from the approved coordination study. Submit complete test reports that include final approved settings.

END OF SECTION

SECTION 26 2416 – PANELBOARDS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Power distribution panelboards.

B. Lighting and appliance panelboards.

C. Overcurrent protective devices for panelboards.

1.02 RELATED REQUIREMENTS

A. Section 26 0526 - Grounding and Bonding for Electrical Systems.

B. Section 26 0529 - Hangers and Supports for Electrical Systems.

C. Section 26 0548 – Vibration and Seismic Controls for Electrical Systems.

D. Section 26 0553 – Identification for Electrical System.

E. Section 26 0800 – Electrical Testing Requirements

1.03 REFERENCE STANDARDS

A. FS W-C-375 – Circuit Breakers, Molded Case; Branch Circuit and Service; Federal Specification; Revision E.

B. NECA 1 - Standard for Good Workmanship in Electrical Construction; National Electrical Contractors Association.

C. NECA 407 - Standard for Installing and Maintaining Panelboards; National Electrical Contractors Association.

D. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

E. NEMA PB 1 - Panelboards; National Electrical Manufacturers Association.

F. NEMA PB 1.1 - General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less; National Electrical Manufacturers Association; 2013 (ANSI/NEMA PB 1.1).

G. CEC – California Electric Code; Most Recent Addition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements, as based on NFPA 70.

H. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations; Current Edition, Including All Revisions.

I. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations; Current Edition, Including All Revisions.

J. UL 67 - Panelboards; Current Edition, Including All Revisions.

K. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures; Current Edition, Including All Revisions.

L. UL 869A – Reference Standard for Service Equipment; Current Edition, Including All Revisions.

M. NETA STD ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems; International Electrical Testing Association.

1.04 SUBMITTALS

A. Comply with 26 0500 for additional submittal requirements and procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for panelboards, enclosures, overcurrent protective devices, and other installed components and accessories, include outline and dimensions, voltage, main bus ampacity, integrated short circuit ampere rating, circuit breaker and fusible switch arrangement and sizes.

C. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

D. Project Record Documents: Record actual locations of panelboards and record actual circuiting arrangements. Provide a PDF file with all panelboard schedules and branch circuit identification.

E. Maintenance Data: Include information on replacement parts; and recommended maintenance procedures and intervals.

1.05 QUALITY ASSURANCE

A. Conform to requirements of CEC.

B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum ten years documented experience.

C. Product is listed and classified by Underwriters Laboratories Inc. or approved nationally recognized testing laboratory as suitable for the purpose specified and acceptable to authorities having jurisdiction.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store panelboards in accordance with manufacturer’s instructions and NECA 407.

B. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

C. Handle carefully in accordance with manufacture’s written instructions to avoid damage to enclosed switch internal components, enclosure, and finish.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Schneider Electric; Square D Products

B. Eaton Corporation

C. General Electric

2.02 ALL PANELBOARDS - GENERAL REQUIREMENTS

A. Provide products listed, classified, and labeled as suitable for the purpose intended.

B. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:

1. Altitude: Less than 6,600 feet (2,000 m).

2. Ambient Temperature:

a. Panelboards Containing Circuit Breakers: Between 23 degrees F (-5 degrees C) and 104 degrees F (40 degrees C).

C. Short Circuit Current Rating:

1. Provide panelboards and breakers with listed short circuit current rating as noted on single-line, or panel schedules included in the project documents. Short circuit interrupting rating and bracing shall exceed the final calculated available fault current at the installed location as indicated on the drawings and the Owner's approved coordination study or the Contractor required provided power system study, as applicable to the project scope of work.

2. Series rated breakers are not acceptable unless agreed to in writing with the Engineer of Record and Owner's Representative.

D. Panelboards Used for Service Entrance: Listed and labeled as suitable for use as service entrance equipment according to UL 869A.

E. Mains: Configure for top or bottom termination of incoming feed as indicated or as required for the installation.

F. Branch Overcurrent Protective Devices: Replaceable without disturbing adjacent devices.

G. Bussing: Sized in accordance with UL 67 temperature rise requirements.

1. Provide fully rated neutral bus unless otherwise indicated, with a suitable terminal lug for connecting all installed and future feeder or branch circuit requiring a neutral connection.

2. Provide solidly bonded equipment ground bus in each panelboard, with a suitable terminal lug for all installed and future feeder and branch circuit equipment grounding conductors.

H. Conductor Terminations: Suitable for use with the conductors to be installed.

I. Enclosures: Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E.

1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:

a. Indoor Clean, Dry Locations: Type 1

b. Outdoor Locations: Type 3R

2. Boxes: Galvanized steel unless otherwise indicated.

a. Provide wiring gutters sized to accommodate the conductors to be installed.

3. Fronts

a. Fronts for Surface-Mounted Enclosures: Same dimensions as boxes.

b. Fronts for Flush-Mounted Enclosures: Overlap boxes on all sides to conceal rough opening.

4. Lockable Doors: All locks keyed alike unless otherwise indicated.

J. Future Provisions: Prepare all unused spaces for future installation of devices including bussing, connectors, mounting hardware and all other required provisions.

2.03 POWER DISTRIBUTION PANELBOARDS

A. Description: Panelboards complying with NEMA PB 1, power and feeder distribution type, circuit breaker type, and listed and labeled as complying with UL 67; ratings, configurations and features as indicated on the drawings.

B. Conductor Terminations

1. Main and Neutral Lug Material: Copper, suitable for terminating copper conductors only.

2. Main and Neutral Lug Type: Mechanical.

C. Bussing

1. Phase and Neutral Bus Material: Copper.

2. Ground Bus Material: Copper.

D. Circuit Breakers

1. Provide bolt-on type.

2. Breakers with pad locking provisions.

3. Molded case breakers for amp frames of 150 or less.

4. Electronic Trip Circuit Breakers molded case with electronic sensing, timing and tripping circuits for adjustable current settings; UL listed. All frames from 225A to 1200A shall use field installed rating plugs (70A to 1200A) to establish or change the ampere rating and shall be suitable for reverse feed. Digital microprocessor trip system shall be applicable for 60Hz systems and shall accurately sense sinusoidal and non-sinusoidal current waveforms (fundamental through the thirteenth harmonic order on a 60Hz base) by continuously sampling each phase throughout life cycle. Breakers shall function normally at up to 95% relative humidity, non-condensing

5. Electronic Trip Circuit Breakers molded case style breakers with solid state, microprocessor-based, true rms sensing as identified on single-line diagrams as LSI or LSIG or larger than 1200A frame. Breakers as molded case style with electronic sensing, timing and tripping circuits for adjustable current settings; UL listed. All frames from 100A to 4000A shall use field installed rating plugs (15A to 4000A) to establish or change the ampere rating and shall be suitable for reverse feed. Digital microprocessor trip system shall be applicable for 60Hz systems and shall accurately sense sinusoidal and non-sinusoidal current waveforms (fundamental through the thirteenth harmonic order on a 60Hz base) by continuously sampling each phase throughout life cycle. Breakers shall function normally at up to 95% relative humidity, non-condensing

a. Provide the following field-adjustable trip response settings:

1) Instantaneous trip.

2) Adjustable short time trip.

3) Short time delay setting of I^2T in and out.

4) Long time trip.

5) Long time delay setting.

6) LSIG trip unit shall include ground fault pickup

7) LSIG trip unit shall have time delay setting of I^2T in and out

8) Breakers shall be 100% rated as indicated on the single lines diagrams

9) Provide neutral sensor for ground fault trip if load has neutral conductor.

E. Enclosures

1. Provide surface-mounted enclosures unless otherwise indicated.
2. Provide an overall door when indicated.
3. Provide flush mounted where indicated with door style dead front with key lock

2.04 LIGHTING AND APPLIANCE PANELBOARDS

A. Description: Panelboards complying with NEMA PB 1, lighting and appliance branch circuit type, circuit breaker type, and listed and labeled as complying with UL 67; ratings, configurations and features as indicated on the drawings.

B. Conductor Terminations

1. Main and Neutral Lug Material: Copper, suitable for terminating copper conductors only.
2. Main and Neutral Lug Type: Mechanical.

C. Bussing

1. Phase Bus Connections: Arranged for sequential phasing of overcurrent protective devices.
2. Phase and Neutral Bus Material: Copper.
3. Ground Bus Material: Copper.

D. Circuit Breakers: Thermal magnetic bolt-on type unless otherwise indicated.

1. Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers listed and labeled as complying with UL 489, and complying with FS W-C-375 where applicable; ratings, configurations, and features as indicated on the drawings.
2. Lug Material: Copper, suitable for terminating copper conductors only.
3. Thermal Magnetic Circuit Breakers: For each pole, furnish thermal inverse time tripping element for overload protection and magnetic instantaneous tripping element for short circuit protection.
4. Multi-Pole Circuit Breakers: Furnish with common trip for all poles.
5. Provide Ground Fault circuit breakers where indicated.
6. Provide Arc Fault circuit breakers where indicated.

E. Enclosures

1. Provide surface-mounted or flush-mounted enclosures as indicated.
2. Fronts: Provide door-in-door trim with hinged cover for access to load terminals and wiring gutters, and separated lockable hinged door with concealed hinges for access to overcurrent protective device handles without exposing live parts.

3. Provide clear plastic circuit directory holder mounted on inside of door.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Install panelboards securely, in a neat and workmanlike manner in accordance with NECA 1 (general workmanship), NECA 407 (panelboards), and NEMA PB 1.1.

C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and CEC.

D. Provide required supports in accordance with Section 26 0529 Hangers and Supports for Electrical Systems and seismic restraints and mounting per Section 26 0548 Vibration and Seismic Controls for Electrical Systems.

E. Install panelboards plumb.

F. Install flush-mounted panelboards so that trims fit completely flush to wall with no gaps and rough opening completely covered.

G. Mount panelboards such that the highest position of any operating handle for circuit breakers or switches does not exceed 79 inches above the floor or working platform.

H. Provide minimum of four spare conduits of which three are ¾ and one is 1 ½ inch trade size out of each flush-mounted panelboard with pull strings shall be terminated into the accessible space above ceiling.

I. Provide grounding and bonding in accordance with Section 26 0526 Grounding and Bonding for Electrical Systems.

J. Install all field-installed branch devices, components, and accessories.

K. Provide filler plates to cover unused spaces in panelboards.

L. Provide circuit breaker locking devices to prevent unauthorized personnel from de-energizing life safety and essential loads where indicated. All fire detection and alarm circuits shall be red and lockable.

M. Install all equipment and circuit identification in accordance with Section 26 0553 Identification for Electrical System.

N. Install a typed panel schedule in all panelboards. The panel schedule shall be based on final installed conditions, including circuit changes made during construction. A PDF for each panel schedule shall be included in the close-out documentation.

3.02 ADJUSTING

A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

B. Adjust alignment of panelboard covers and doors.

3.03 FIELD QUALITY CONTROL

A. Test in accordance with Section 26 0800 Testing Requirements.

B. Correct deficiencies and replace damaged or defective panelboards or associated components.

C. Adjust breakers with adjustable settings in accordance with Section 26 0800 Testing Requirements and the Owner's approved coordination study or the Contractor required provided power system study, as applicable to the project scope of work.

3.04 CLEANING FIELD QUALITY CONTROL

A. Clean dirt and debris from panelboard enclosures and components according to manufacturer's instructions.

B. Repair scratched or marred exterior surfaces to match original factory finish.

C. Provide all missing hardware required to secure panel covers.

END OF SECTION

SECTION 26 3353 – STATIC UNINTERRUPTIBLE POWER SUPPLY

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. This specification describes a three-phase continuous duty, on-line, double conversion, solid-state uninterruptible power system, hereafter referred to as the UPS. The UPS shall operate in conjunction with the existing building electrical system to provide power conditioning, back-up and distribution for critical electrical loads. The UPS shall consist of, as required by the project, the UPS module, batteries, or other DC storage systems, and accessory cabinet(s) for transformers, maintenance bypass, and distribution applications, and other features as described in this specification.

1.02 UPS SYSTEM DESCRIPTION

A. UPS System Components: The UPS system shall be configured as shown in the projects documents and shall include the main components and operational capability as listed in Part 1.02.

B. UPS module containing Rectifier(s), Inverter(s), Battery Charger(s), Static Bypass, and associated Control and Monitor Panel.

C. Battery string(s) in Line-and-Match Battery Cabinets.

D. Line-and-Match and/or sidecar-type accessory cabinets for transformer, maintenance bypass, parallel tie and distribution applications. Specific accessory availability depends on UPS model.

E. Non-matching wall mounted or floor standing maintenance bypass cabinets or multi-module parallel tie cabinets.

F. UPS Module Modes of Operation: The UPS Module shall operate as an on-line, fully automatic system in the following modes:

G. Normal: Utilizing commercial AC power, the critical load shall be continuously supplied by the Inverter. The Inverter shall power the load while regulating both voltage and frequency. The Rectifier shall derive power from the commercial AC source and shall supply DC power to the Inverter. Simultaneously, the Battery Charger shall charge the battery.

H. Battery: Upon failure of the commercial AC power, the critical load shall continue to be supplied by the Inverter, which shall obtain power from the batteries without any operator intervention. There shall be no interruption to the critical load upon failure or restoration of the commercial AC source. The 93PM UPS shall be capable of operating with 432V or 480VDC battery systems.

I. Recharge: Upon restoration of the AC source, the Charger shall recharge the batteries and simultaneously the Rectifier shall provide power to the Inverter. This shall be an automatic function and shall cause no interruption to the critical load.

J. Bypass: If the UPS module must be taken out of the Normal mode for overload, load fault, or internal failures, the static bypass switch shall automatically transfer the critical load to the commercial AC power. Return from Bypass mode to Normal mode of operation shall be automatic. No-break transfer to and from Bypass mode shall be capable of being initiated manually from the front panel.

K. Energy Saver: The UPS shall continuously monitor the voltage and frequency of the bypass source. When the source parameters are within acceptable limits, the UPS will utilize a minimal/optimal combination of its internal subsystems to ensure acceptable power is always delivered to the critical load, at a system efficiency of up to 99.1%. The Energy Saver System shall be enabled by the user, and shall be adjustable. It shall

incorporate a “High Alert Mode” to automatically (without user intervention) provide maximum power conditioning any time bypass source variation levels exceed preset, adjustable limits. When Energy Saver System is utilized, the UPS shall attenuate ANSI C62.41-type line transients to within IEC and ITIC limits. The Energy Saver System shall be able to distinguish between upstream (utility) faults and downstream (load) faults, and react appropriately to protect and support the critical load, without interruption.

1.03 REFERENCES

A. UL 1778 (Underwriters Laboratories) – Standard for Uninterruptible Power Supply Equipment. Product safety requirements for the United States, 4th Edition.

B. CSA/cUL C22.2 No 107.1(Canadian Standards Association) – Commercial and Industrial Power Supplies. Product safety requirements for Canada.

C. NEMA PE-1 – (National Electrical Manufacturers Association) – Uninterruptible Power Systems standard.

D. IEC 62040-2 C3

E. IEC 62040-3 (International Electrotechnical Commission) – Uninterruptible power systems (UPS) – Part 3: Method of specifying the performance and test requirements.

F. IEEE 587 (ANSI C62.41) Category A & B (International Electrical and Electronics Engineers) – Recommended practices on surge voltages in low voltage power circuits.

G. CISPR 22 and 24, FCC Rules and Regulations 47, Part 15, Class A (Federal Communications Commission) – Radio Frequency Devices.

H. MIL-HDBK-217E (Military Handbook) – Reliability prediction of electronics equipment

1.04 SUBMITTALS

A. Prepare and submit for approval all shop drawings and material data sheets as required by specification section 26 0500, Part 1.04. All submittals shall be approved by the EOR prior to release of order for manufacture.

B. The following information shall be submitted for review and approval prior to Contractor purchase of the UPS and all material required for the installation of the UPS:

1. Installation and Operation Manual: One copy of the installation and operation manual shall be furnished. It shall possess sufficient detail and clarity to enable the owner’s technicians or representatives to install and operate the UPS equipment and accessories. The manual shall include the following major items:

a. UPS description

b. UPS site planning and unpacking

c. UPS installation

d. Optional accessory installation

e. UPS theory of operation

f. Operating procedures

g. System events

h. UPS maintenance

i. Performance and technical specifications

j. Wiring requirements and recommendations

k. Physical features and requirements

l. Cabinet dimensions

2. Prepare the deferred submittal design documents, including details and calculations, for the structural support and anchorage of the UPS that are to be submitted to the Authority Having Jurisdiction (AHJ) for review and approval by the Contractor, and submit to the AHJ. AHJ approval is required prior to release of order by the Contractor to the manufacturer.

3. Provide programming and setting parameters for review with the Owner in order to establish UPS software programming requirements. This includes firmware, software for communications, alarms, graceful shutdown, voltage input, voltage output, and other operating, monitoring, alarm and control options. Contractor and factory are responsible to complete all programming as described above prior to installation of the UPS. Provide a DVD with the final version of the software programming for Owner's records. All costs for software and programming are to be included in the Contractor's bid.

4. Provide the warranty terms and conditions.

1.05 QUALIFICATIONS

A. The UPS manufacturer shall have a minimum of forty years' experience in the design, manufacture and testing of solid-state UPS systems. A list of installed UPS systems of the same type as the manufacturer proposes to furnish for this application shall be supplied upon request.

B. The UPS manufacturer shall have ISO 9001 certification for engineering/R&D, manufacturing facilities and service organization.

C. The UPS manufacturer shall maintain a staffed 7x24x365 call center for technical and emergency support.

D. Field Engineering Support: The UPS manufacturer shall directly employ a nationwide field service department staffed by factory-trained field service engineers dedicated to startup, maintenance, and repair of UPS equipment. The organization shall consist of local offices managed from a central location. Field engineers shall be deployed in key population areas to provide on-site emergency response within 24 hours. A map of the United States showing the location of all field service offices shall be submitted with the proposal. Third-party service or maintenance will not be accepted.

E. Spare Parts Support: Parts supplies shall be located in the field to provide 80% of all emergency needs. The factory shall serve as the central stocking facility where a dedicated supply of all parts shall be available within 24 hours.

F. Product Enhancement Program: The UPS manufacturer shall make available feature upgrade service offerings to all users as they are developed. These upgrades shall be available as optional field-installable kits.

G. Maintenance Contracts: A complete range of preventative and corrective maintenance contracts shall be provided and offered with the proposal. Under these contracts, the manufacturer shall maintain the user's equipment to the latest factory revisions.

1.06 ENVIRONMENTAL REQUIREMENTS

A. The UPS shall withstand any combination of the following external environmental conditions without operational degradation.

1. Operating Temperature: 5 degrees C to + 40 degrees C (41 degrees F to 104 degrees F) without de-rating (excluding batteries).

2. Storage Temperature: - 25 degrees C to + 55 degrees C (-13 degrees F to 131 degrees F). Prolonged storage above + 40 degrees C (104 degrees F) will cause rapid self-discharge and permanent damage to the battery.

3. Relative Humidity (operating and storage): 5-95% non-condensing.

4. Elevation:

   a. Operational: 5000 ft. (1500 m) maximum without de-rating.

   b. Transportation: Capable of air transport, up to 15,000m.

1.07 SAFETY

A. The UPS shall be certified by Underwriters Laboratories in accordance with UL 1778, 4th Edition.

B. The UPS shall be certified by the Canadian Standards Association in accordance with cUL./CSA C22.2 NO.107.1-M91.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Approved Manufacturers: Eaton Corporation, or equal, complying with the project requirements. Contact Ramtek Mission Critical Solutions, 1382 M Valencia Avenue, Tustin CA 92780, Michael Ohmer, 949-266-1414.

2.02 UPS MODULE STANDARD FEATURES

A. The UPS module shall consist of the following standard components, housed in a 50 kW, 100kW, 150kW, 200kW, or 400kW frame:

1. Quantity 1, 2, 3, 4, 5, 6, 7, or 8 identical 50kW UPM Universal Power Modules, each containing:

   a. Rectifier/Charger: The rectifier/charger shall convert incoming AC power to regulated DC output for supplying the inverter and for charging the battery. The rectifier/charger shall be a high-frequency PWM design, using Insulated Gate Bi-polar Transistors (IGBTs). The modular design of the UPS shall permit safe and fast removal and replacement of the rectifier/charger module. Mean time to repair (MTTR) for the module shall be no more than 30 minutes in order to return UPS to normal mode. The rectifier/charger module shall also provide the following:

   b. The rectifier shall be capable of drawing power from the utility with a power factor of 0.99 under nominal conditions.

   c. The rectifier shall feature protection circuitry that prevents the IGBTs from sourcing current in excess of their published ratings.

   d. Inverter: The inverter shall feature an IGBT pulse-width-modulation (PWM) design with high speed switching. The inverter shall also have the following features:

   e. The inverter shall be capable of providing the specified quality output power while operating from any DC source voltage (rectifier or battery) within the specified DC operating range.

   f. The modular design of the UPS shall permit safe and fast removal and replacement of the power module, while in maintenance bypass. Mean time to repair (MTTR) for the module shall be no more than 30 minutes in order to return UPS to normal mode.

   g. The inverter shall feature protection circuitry that prevents the IGBTs from sourcing current in excess of their published ratings.

B. Static Bypass: The bypass shall serve as an alternative source of power for the critical load when an abnormal condition prevents operation in normal mode. The bypass for 50-200kW frames shall consist of a fully rated, continuous duty, naturally commutated static

switch for high-speed transfers. The 400kW bypass system will consist of two 200kW static switches. The bypass shall feature the following transfer and operational characteristics.

1. Transfers to bypass (for stand alone, and parallel capacity systems) shall be automatically initiated for the following conditions:
   a. Output overload period expired.
   b. Critical bus voltage out of limits.
   c. Internal over temperature period expired.
   d. Total battery discharge.
   e. UPS failure.
2. Parallel Redundant UPS systems shall transfer to bypass on conditions (a), (b), and (d) above. Conditions (c) and (e) will result in the affected UPS isolating itself from the parallel bus, allowing the remaining UPS(s) to support the critical load.
3. Uninterrupted automatic re-transfer shall take place whenever the inverter(s) is capable of assuming the critical load.
4. Uninterrupted automatic re-transfers shall be inhibited for the following conditions:
   a. When transfer to bypass is activated manually or remotely.
   b. In the event of multiple transfers/re-transfer operations the control circuitry shall limit “cycling” to three (3) operations in any ten-minute period. The third transfer shall lock the critical load on the bypass source, for 60 minutes.
   c. UPS failure.
5. Uninterrupted manual transfers shall be initiated from the control panel. Uninterrupted manual transfers to bypass and from bypass shall be possible with the inverter logic. During manual transfers to bypass mode, the inverter must verify proper bypass operations before transferring the critical load to the bypass.
6. All transfers to bypass shall be inhibited for the following conditions:
   a. Bypass voltage out of limits (+10%, to -10% of nominal)
   b. Bypass frequency out of limits (+/- 4 Hz, adjustable, factory set)
   c. Bypass out of synchronization
   d. Bypass phase rotation / installation error
7. Static transfer time: No break, complete in less than 4ms.
8. The bypass shall be manually energized using the control panel or remotely through a building alarm input.

C. Monitoring and control components: The following components shall provide monitor and control capability:

1. Control panel: color LCD, touch sensitive, with LED status indicators.
2. Alarm and metering display.
3. Building alarm monitoring.
4. Communication ports: RS-232 and USB.

D. Battery management system: The UPS shall contain a battery management system which has the following features:

1. The battery management system shall provide battery time remaining while operating in normal mode and battery mode. Battery time available information shall be displayed real-time, even under changing load conditions. Upon commissioning, battery runtime information shall be available.

2. The battery management system shall automatically test the battery system to ensure that the battery is capable of providing greater that 80% of its rated capacity. Testing the batteries shall not jeopardize the operation of the critical load. Upon detection of the battery string(s) not capable of providing 80%, the UPS system will alarm that the battery needs attention/replacement. The battery test shall be able to detect the following:

a. Open battery string

b. Shorted battery string (current limit)

c. Battery capacity (runtime) less than 80% of “new” battery capacity

E. Wiring Terminals: The UPS 50 kW, 100kW, and 150kW frame modules shall contain mechanical compression terminals (adequately sized to accommodate 75 degree C wiring). The 200kW and 400kW frames shall utilize threaded busbar landings sized for 2-hole lugs, for securing user wiring to the following locations:

1. Rectifier/charger input connections (3-wire plus ground)

2. Bypass input connections, (for dual source configurations): 3-wire plus ground for 3-wire plus ground output configuration (480Vac)

3. DC link connections for battery cabinets (positive and negative plus ground).

4. AC output connections (3 wires plus ground)., 4 wire plus ground if distribution accessory cabinet with transformer is utilized.

2.03 UPS MODULE OPTIONS AND ACCESSORIES

A. The UPS system will include the following options and accessories based on the UPS kWac rating, project configuration including inputs and outputs, and as shown on the project single line diagram:

1. Integrated Maintenance Bypass, Distribution, Parallel Tie and Accessory Cabinet(s): Integrated Line-and-Match cabinet(s) shall be provided that include(s):

a. All hardware and interconnecting cable for connection to UPS module. Exception is the IAC-D distribution cabinet.

b. IAC-B (Bypass) Sidecar: Two, three, or four-breaker manual maintenance bypass switch in a sidecar configuration, to isolate UPS module from commercial AC input and critical load. The sidecar may be mounted on either side of the UPS module. Switch shall provide complete isolation of UPS for servicing. Switch shall be make-before-break, interlocked between UPS and bypass to prohibit improper operation. The bypass sidecar for the 400kW model may optionally include 480V distribution breakers, for supplying downstream distribution.

c. IAC-D (Distribution) cabinet (20-200kW models): This may be positioned on either side of the UPS module, and may include a K-1, or K-13 rated output isolation and step down transformer. Optionally, the transformer shall meet TP-1 specifications. An optional input step up transformer may be included as well.

1) The 50kW, 100kW, 150kW, and 200kW versions house up to qty two (2), 42 pole distribution panels with main disconnects for a total of 84 poles of distribution. Up to five (5) distribution circuit breakers may be substituted in lieu of distribution panels. The 200kW version may have one of its 42-pole panels provided with a 400A main breaker Additionally, a separate 225A sub feed breaker may be provisioned, regardless of the configuration of distribution panels.

d. Parallel Tie Sidecar (20-200kW models): This will include 2x Module Output Breakers (MOB) intended to allow a maximum of 2 UPS modules to be paralleled for capacity or redundancy. Optionally, a maintenance bypass circuit, including a Maintenance Isolation Switch (MIS) and a Maintenance Bypass Switch (MBS) can be included in this sidecar. The Parallel Tie sidecar may be provisioned with a single UPS for the intention of adding the second UPS at a later time.

e. IAC-T (Tie) cabinet (20-200kW models): This can include up to 4x Module Output Breakers (MOB) intended to allow a maximum of 4 UPS modules to be paralleled for capacity or redundancy. Optionally, a maintenance bypass circuit, including a Maintenance Isolation Switch (MIS) and a Maintenance Bypass Switch (MBS) can be included in this cabinet.

2. Network Adapter and UPS Power Monitoring Software: Optional PX Gateway card adapter shall provide a communications interface between the UPS module and the following network management systems.

a. SNMP v.1, v.3

b. Modbus TCP

c. BACnet/WS or /IP

d. IPv6

3. This capability shall allow the unit to be monitored remotely over an Ethernet network using a standard web browser.

4. UPS Power Monitoring Software: This system shall continuously monitor critical power elements associated with the UPS, using the communications port on each module and a customer furnished PC. The system shall automatically alarm if any problems arise and notify local or remote personnel of the alarm condition via email, page, or text message.

a. Relay Card: Serial dry contact card providing 4 isolated dry output contacts, 1 isolated input. The relays are programmable.

b. External Battery Cabinet: The battery cabinet shall feature valve regulated, high-rate discharge, lead-acid batteries which provide energy to the support the critical load during a momentary loss of input power to the rectifier. The batteries shall be flame retardant in accordance with UL 94V2 requirements. The battery cabinet shall have the following features:

c. The battery cabinet shall be the same depth and height as the UPS module. A “Slim” (20” width) battery cabinet is optional for 20 to200kW models, and may contain 1, 2 or 3 strings of batteries.

d. The battery cabinet shall feature a mechanical enclosure of like appearance to the UPS module and shall feature casters for easy installation. Each battery cabinet shall require front access only for installation, service and maintenance. The battery cabinet shall provide bottom cable entry standard and top entry capability via sidecar.

e. Power wiring internal to each battery cabinet shall be factory provided. Each battery cabinet shall feature up to 9 battery trays which can be individually disconnected from the battery cabinet power wiring with quick disconnect devices. Each battery tray shall be firmly secured to the battery cabinet frame with fasteners. Each battery tray shall be removable from the front of the battery cabinet.

f. Up to 4 line and match battery cabinets may be connected to a single UPS, containing 2 or more 50 kW UPMs, Up to 2 battery cabinets may be connected to a single UPS containing only one UPM.

g. For parallel systems, each UPS frame shall have a discrete battery system. A single battery system may not be shared across multiple UPS frames.

h. Each battery cabinet shall feature a DC rated circuit breaker. The circuit breaker within the battery cabinet shall only provide protection to the battery string(s) within that battery cabinet. For battery configurations involving multiple battery cabinets, the batteries in one battery cabinet may be isolated from the DC link via its circuit breaker without disconnecting other battery cabinets from the DC link and the UPS module.

i. The circuit breaker in each battery cabinet shall feature an A/B auxiliary switch. The UPS module shall be capable of monitoring and alarming an open battery cabinet circuit breaker condition.

j. The circuit breaker in each battery cabinet shall feature a 48VDC shunt trip device. The shunt trip shall operate to trip the battery breaker(s) for an emergency power off command or battery disable command.

k. Power and Control wiring between the co-located battery cabinet and the UPS shall be factory provided.

l. The batteries shall be optionally configured with a ¼” spade type connector for attaching sense leads to each jar to facilitate the future addition of a battery monitoring system.

m. Expected battery life: 200 complete full load discharge cycles when operated and maintained within specifications.

5. Internal Batteries: The 50kW UPS frame shall feature internal, valve regulated, high-rate discharge, lead-acid batteries which provide energy to the support the critical load during a momentary loss of input power to the rectifier. The batteries shall be flame retardant in accordance with UL 94V2 requirements.

a. The 50kW frame with internal batteries shall be configurable with either 3, 4, or 5 strings of batteries (12, 16, or 20 battery trays, respectively). Each battery tray shall be removable from the front of the UPS cabinet.

b. The circuit breaker in the 50kW UPS cabinet shall feature an A/B auxiliary switch. The UPS module shall be capable of monitoring and alarming an open battery cabinet circuit breaker condition.

c. The circuit breaker in the 50KW UPS cabinet shall feature a 48VDC shunt trip device. The shunt trip shall operate to trip the battery breaker(s) for an emergency power off command or battery disable command.

d. Expected battery life: 200 complete full load discharge cycles when operated and maintained within specifications.

6. Parallel Systems (20 to 200kW models):Up to 8 UPS modules (UPS "frames") may be paralleled for N+X redundancy, and/or for increased capacity. Maximum capacity in a parallel-for-capacity system is 1600kW. Maximum capacity for a parallel redundant system is 1550kW, N+1.

a. UPS frames are not required to be identical in terms of quantity of internal UPMs. For example, a 50kW UPS may be paralleled with a 100kW UPS.

b. Additional 50kW UPMs may be field-added to any UPS frame in a parallel system.

c. Each UPS frame must have a dedicated battery system, or DC storage system.

d. Each UPS will contain a built-in circuit (Control Area Network, or CAN) for communication of metering and status information between UPS frames. This will not require the use of a separate communication card. Interruption of the CAN bus will not cause the parallel system to fail to support the critical load.

e. Load share balance will be within +/-5% of full load rating.

f. For 2-UPS parallel systems ONLY, an optional sidecar cabinet shall be available to provide 2x module output breakers. A further option provides maintenance bypass (MBS) and maintenance isolation (MIS) switches. This cabinet will be wired and tested with one UPS at the factory, and shall ship attached to that UPS.

2.04 UNINTERRUPTIBLE POWER SUPPLY RATINGS AND OPERATING CHARACTERISTICS*

A. UPS Continuous Ratings. The UPS shall be rated:

UPS Rating (max)	Opt. Rating (1)	Opt. Rating (2)	Opt. Rating (3)	Opt. Rating (4)	Opt. Rating (5)	Opt. Rating (6)	Opt. Rating (7)	Opt. Rating (8)
50 kW	40kW	30kW	20kW	--	--	--	--	--
50 kW+1	40kW	30kW	20kW	--	--	--	--	--
100 kW	90kW	80kW	70kW	60kW	50kW	40kW	30kW	20kW
100 kW+1	90kW	80kW	70kW	60kW	50kW	40kW	30kW	20kW
150 kW	140kW	130kW	120kW	110kW	100kW	90kW	80kW	70kW
	60kW	50kW	40kW	30kW	20kW			
150 kW+1	140kW	130kW	120kW	110kW	100kW	90kW	80kW	70kW
	60kW	50kW	40kW	30kW	20kW			
200kW	190kW	180kW	170kW	160kW	150kW	140kW	130kW	120kW
	100kW	90kW	80kW	70kW	60kW	50kW	40kW	30kW
	20kW							

UPS Rating (max)	Opt. Rating (1)	Opt. Rating (2)	Opt. Rating (3)	Opt. Rating (4)	Opt. Rating (5)	Opt. Rating (6)	Opt. Rating (7)	Opt. Rating (8)
400kW					350kW			
		300kW					250kW	
			200kW					150kW
				100kW				

1. Units may be upgraded to their maximum UPS frame rating when sufficient UPMs are installed and appropriate firmware settings are implemented.
2. UPS Rating (max) is the maximum output possible from the UPS (for a load power factor range of 0.8 lagging to 0.8 leading). The UPS shall not require de-rating when supporting a leading power factor load of 0.8 or greater.
3. The UPS may be ordered with any of the optional ratings, and later upgraded to its corresponding maximum frame rating (50kW, 100kW, 150kW, 200kW, or 400kW). It is recommended that premises wiring should be sized for the maximum possible rating of the UPS (i.e. to match the UPS frame rating).

B. Acceptable UPS input sources: UPS shall support 3-wire grounded Wye sources. A neutral conductor is not used from the source, and is not supplied to the load

1. Single source, single or dual feed: 3-wire grounded neutral wye (TN, TT*)
2. Dual source, dual feed: 3-wire grounded neutral wye (TN, TT*)

*TT sources for the UPS must all share the same ground plane.

C. Rectifier/charger input:

1. Nominal three phase input voltage: 480 Vac:
   a. 3-wire plus ground for 3-wire plus ground output configuration
2. Operating input voltage range: +10%, -15% of average nominal input voltage without battery discharge. Note the UPS shall “power share” with the battery to -30% of nominal voltage, at full rated load.
3. Operating input frequency range shall be 40 to 72Hz.
4. Input power factor 0.99 lagging at rated load.
5. Normal input current limit: The UPS shall have the following programmable input current limit settings while operating in normal mode:
   a. Rectifier/charger input current limit shall be adjustable from 100 to 115% of UPS kW rating.
   b. Battery input current limit shall be adjustable from 5% to 7% of the UPS full load kW rating regardless of the actual load on the UPS.
6. On generator input current limit: The UPS shall have the following programmable input current limit settings while operating in normal mode on generator:
   a. Rectifier/charger input current limit shall be adjustable from 100% to 115% of UPS full load kW rating.
   b. Battery recharge input current limit shall be adjustable from 16.5A to 29.3A per UPS power module.

7. Input current total harmonic distortion (THD) shall be less than 3% at nominal line voltage and 5% nominal source impedance.

8. Power walk-in: Ramp-up to full utility load adjustable from 10 amps per second to 1 amp per second.

D. Bypass input:

1. Synchronizing bypass voltage range shall be +10, -15% of average nominal input voltage.

2. Synchronizing bypass frequency range is +/- 0.5 Hz to +/-4 Hz, user adjustable, and is centered on the nominal frequency. Default setting is +/- 4 Hz.

3. Slew rate: 0.8 Hz per second, maximum.

4. Bypass and rectifier inputs can be supplied from out of phase sources if required.

5. Input surge withstand capability: The UPS shall be in compliance with IEEE 587 (ANSI C62.41), category A & B (6kV).

E. Rectifier/charger output:

1. Nominal DC voltage shall be 432 or 480 VDC (open circuit battery voltage).

2. Capacity: The rectifier/charger shall support a fully loaded inverter and recharge the battery to 90% of its full capacity within 10 times the discharge when input current limit is set at maximum.

3. Low line operation: The rectifier/charger shall be capable of sharing the DC load with the battery when the input voltage falls below the specified operation input voltage range, the “on battery” indicator shall annunciate operation in this mode.

4. DC sensing: DC voltage sensing methods shall be incorporated for providing battery over-voltage protection.

5. Battery charger characteristics: The UPS battery charging system shall have the following characteristics:

a. The charger shall be capable of being configured for several charge modes including:

1) A charging mode that increases battery life by allowing the battery to rest, reducing positive plate corrosion

2) A charging mode floating the battery at a set level, which can be adjusted via software.

b. UPS module will automatically adjust battery shutdown based upon loading and battery capacity.

1) The UPS module shall automatically adjust the final discharge voltage between 1.67 and 1.75 Volts per cell based on the existing load and the rate and length of discharge.

2) The absolute minimum operational voltage is 1.67 V per cell (adjustable upward).

F. UPS output in normal mode

1. Nominal output voltage 480V, 3-phase, 3-wire plus ground at the UPS output terminals, or 4 wire plus ground at the output of the IAC-D cabinet with 208V output transformer. Output wiring configuration is based upon input wiring configuration for systems without transformers.

2. Steady-state voltage regulation (in inverter) shall be within +/- <1% average from nominal output voltage.

3. Transient voltage response shall be per EN62040-3, Class 1, VFI-SS-111.
4. Transient voltage recovery shall be compliant to EN62040-3, Class 1, VFI-SS-111.
5. Linear load harmonic distortion capability: Output voltage THD of less than 1% for 100% linear load.
6. Non-linear load harmonic distortion capability: Output voltage THD of less than 5% for 100% non-linear load when tested using the non-linear load described in IEC 62040-3.
7. Line synchronization range shall be +/- 4Hz, adjustable to+/-0.5 Hz.
8. Frequency regulation shall be +/- 0.1Hz free running.
9. Frequency slew rate shall be 0.8 Hz/second maximum (adjustable).
10. Phase angle control:
    a. Balanced linear load shall be <1 degree from nominal 120 degrees
11. Phase voltage control:
    a. Balanced linear loads shall be +/- 1% from average phase voltage
    b. Unbalanced linear loads shall be less than <2% from average phase voltage for 100% load unbalanced
12. Overload current capability (with nominal line and fully charged battery, non-paralleled systems):
    a. Double Conversion mode: The unit shall maintain voltage regulation for 102% to <110% of resistive/inductive load for 10 minutes, 111% to <125% for 60 seconds, and 126% to 150% for 10 seconds, >151% for 300ms.
    b. Stored energy mode (typically on battery): The unit shall maintain voltage regulation for 102% to <110% of resistive/inductive load for 10 minutes, 111% to <125% for 60 seconds, and >126% for 300ms
    c. Energy Saver System operation: Continuous = 110%. Transient = 1000% peak current for 10ms.
    d. On bypass (single UPS systems): Continuous = 125%. Transient = 1000% peak current for 10ms.
13. Fault clearing current capability: See section 12 above.
14. Static transfer time, inverter to bypass: No break, completed in less than 4ms.
15. Static transfer time, Energy Saver to inverter: No break, completed in less than 4ms maximum, typically <2ms.
16. Common mode noise attenuation:
    a. -65dB up to 20kHz, -40db up to 100kHz
    b. > 100dB with isolation transformer
17. Acoustical noise: Noise generated by the UPS under normal operation shall not exceed 65dbA at one meter from any operator surface, measured at 25 degrees C (77 degrees F) and full load, per ISO 7779 standard.
18. EMI Suppression: The UPS shall meet FCC rules and regulation 47, part 15, for Class A devices, CISPR22, and IEC62040-2 C2 and C3.
19. Electrostatic discharge (ESD): The UPS shall meet IEC61000-4-2 level 3; 4kV contact/8kV air discharge.

20. Efficiency: The UPS incorporate 3-level power converter design for highest possible efficiency. Full load efficiency for non-derated hardware shall be up to 97%, 50% load efficiency shall be 96.5%, and the UPS shall achieve >95.0% efficiency at 25% load. These numbers are for N+0 configurations only.

G. UPS Output with Energy Saver System option

1. The Energy Saver System acts to optimize the internal components of the UPS power train to maximize system efficiency when the bypass source is within the following (adjustable) limits: Voltage: +/-10%, and Frequency: +/-3Hz.

2. Nominal output voltage 480V, 3-phase, 3-wire plus ground at UPS output terminals (or 4 wire plus ground at the output of the IAC-D cabinet with transformer). Output wiring configuration is based upon input wiring configuration for systems without internal transformers.

3. Steady-state voltage regulation shall be within +/- 10% from nominal output voltage.

4. Line synchronization range shall be +/- 4 Hz, adjustable.

5. Frequency regulation shall be +/-4 Hz when bypass source is within the limits in (1) above, and +/- 0.1Hz free running,

6. Overload current capability (with bypass source within the limits of (1) above) Continuous: 110%, Transient: 1000% for 10msec.

7. Static transfer time: No break, typically completed in less than 2ms, including detection time.

8. Acoustical noise: Noise generated by the UPS under normal operation shall not exceed 65dbA at one meter from any operator surface, measured at 25 degrees C (77 degrees F) and full load.

9. EMI Suppression: The UPS shall meet FCC rules and regulation 47, part 15, for Class A devices, CISPR22, and IEC62040-2 C2 and C3.

10. Electrostatic discharge (ESD): The UPS shall meet IEC61000-4-2 level 3; 4kV contact/8kV air discharge.

11. Efficiency: The UPS efficiency shall greater than 99%, over the range of 60kW to 100kW load; for N+0 configurations only.

*Unless otherwise specified, performance data in Sec 2.05 above is measured under conditions of 100% resistive load for fully rated UPS sizes, 25 degrees C ambient temperature, nominal rectifier and bypass input voltages, and battery system floating.

2.05 MECHANICAL AND STRUCTURAL DESIGN

A. Enclosures: The UPS shall be housed in free-standing double front enclosures (safety shields behind doors) equipped with casters and leveling feet. The enclosures shall be designed for computer room applications. Front doors shall have locks to prevent unauthorized entry.

B. Modular construction: The UPS shall be comprised of Universal Power Modules (UPMs), each hardware-rated for 50kW, and each including the rectifier, inverter, and battery converter power and control circuitry. These UPMs shall be draw-out assemblies that can be quickly exchanged or replaced as necessary.

C. Ventilation: The UPS and shall be designed for forced-air cooling. Air inlets shall be on the front of the unit. Air outlet configuration for the UPS, and its accessory cabinet(s) shall be user selectable at time of order to exhaust warm air at the top of the cabinet (row or wall installations), or exhaust at the rear of the cabinet for “hot aisle” configurations. Eighteen inches of clearance over the UPS outlets shall be required for proper air

circulation (top exhaust), or working space (rear exhaust). An air filter shall be mounted in the front door of the UPS module.

D. No back or side clearance or access shall be required for the system. The back and side enclosure covers shall be capable of being located directly adjacent to a wall.

E. Cable entry: Standard cable entry for the 50/100/150kW frame UPS cabinet shall be through the enclosure bottom. Top cable entry shall be facilitated by a sidecar which can be mounted on either side of the 50/100/150kW frame UPS. Standard cable entry for the 200kW and 400kW frame UPSs shall be through the enclosure top or bottom.

F. Front access: All serviceable subassemblies shall be modular and capable of being replaced from the front of the UPS (front access only required). Side or rear access for installation, service, repair or maintenance of the UPS system shall not be required.

G. Service area requirements: The system shall require no more than thirty six (36) inches of front service access room and shall not require side or rear access for service or installation.

H. Structural Support and Anchorage: Contractor shall prepare a deferred design submittal for structural support of the UPS independent of the raised floor structure. Contractor shall determine existing conditions, raised floor elevation above the subfloor, and below floor conditions, so that the UPS floor mount supports can be installed and attached to the subfloor for both structural and seismic anchorage, independent of the raised floor structure. Structural support system will be designed by a licensed California Structural Engineer, such as AJ Engineering, 1601 E. Miraloma Avenue, Placentia CA 92870, familiar with local Codes and Data Center installation requirements. The contractor shall provide all information needed by the SEOR to prepare the design based on the final installed conditions, including consideration of all other existing and new materials and systems to be installed under the UPS, located below and near the UPS. Floor tiles shall be cut and adjusted to complete the installation, and to close all openings in the raised floor to allow for proper air floor when the space below the floor is used for cooling and ventilation.

2.06 CONTROLS AND INDICATORS

A. Microprocessor controlled circuitry: The UPS controls shall have the following design and operating characteristics:

B. Fully automatic operation of the UPS shall be provided through the use of microprocessor controlled Digital Signal Processing. Start-up and transfers shall be automatic functions, and will not require operator intervention.

1. Digital Front Panel Display: The UPS control panel shall be a 7” touch sensitive, backlit LCD front panel display that includes LED indicators for basic UPS status. Large, luminous, color coded LED pillars (vertical bars) shall show the UPS status (green, amber, red), and be visible up to 30m from the UPS. The LCD shall display:

2. UPS status (home screen): the LCD screen shall have a color-coded border (header) that turns red on alarm and shows basic UPS status in the header of the display, visible at all times. The header shall alternately show UPS status output voltage and battery time remaining and be visible constantly in all display screens. The home screen shall show load level, average efficiency, and power consumption in kWh. The home screen shall show a system mimic diagram with a color-highlighted power path, operating mode, and active events.

3. Controls tab: Shall provide touch sensitive button controls, with a confirm prompt, for turning the UPS on and off, transfer to/from bypass, and enabling or disabling the battery charger, initiating a battery test, and enabling or disabling Energy Saver System (ESS).

4. Metering tab: The metering screen shall show voltages currents, temperatures, kW, kVA, and power factor (as applicable) for the UPS input, output, bypass source, and battery. Color coded (green, amber, red) bar graph indicators will accompany power and temperature measurements

5. Logs tab: alarm/event queue, active alarms and alarm history, events, status changes and commands, all timed to the 1/1000th second for tracking and analysis.

6. Statistics tab: Numerically and graphically displays the estimated savings afforded by ESS operation over time.

7. Settings tab: shall provide button access to user adjustable settings such as, but not limited to: date/time, building alarm designations, communications parameter setup, UPS name, user passwords, and display language.

C. Control Panel Lamp Indicators: The UPS control panel shall provide the following monitoring functions with indicator (icon) LED's:

1. NORMAL: This green LED shall indicate that the commercial AC utility or generator source is supplying power to the rectifier and the inverter is supporting the critical load.

2. BYPASS: This amber LED shall indicate that the UPS has transferred the load to the bypass circuit.

3. BATTERY: This amber LED shall indicate that the commercial AC utility or generator source has failed and the battery is supplying power to the inverter, which is supporting the load.

4. ALARM: This red LED and the accompanying audible alarm horn, shall indicate that the UPS detects an alarm condition, outlined in detail in the Logs tab from the home screen and in the operator's manual.

D. Interface panel: The UPS shall be equipped with an interface panel, located behind a protective cover, which provides the following signals and communication features in a Class 2 environment:

1. Alarm contact: A dry contact for annunciating a summary alarm shall be provided for customer use. This contact shall be Form "C" capable of supplying both N/O and N/C contacts. Contact ratings shall be 5A max at a voltage not to exceed 28VDC or 277VAC.

2. RS232 (EIA / TIA-232) and USB communications interfaces: Circuitry shall be provided for one "host", and one "device" USB connector, and one RS232 (EIA / TIA-232) communication port for connection to automated service department diagnostic tools. This port may be used with simple ("dumb") terminals to gain remote access to all unit operation information.

3. Building alarms: Five inputs shall be provided for monitoring the status of external dry contacts. Building alarms shall be set up through the UPS configuration mode function on the UPS front panel display or via the RS232 (EIA / TIA-232) port.

4. External REPO contacts: Shall be provided to connect an external remote emergency power off switch to shut down the UPS and de-energize the critical load. Normally open or normally closed contacts shall be acceptable.

5. Battery control contacts: Contacts shall be provided to connect the battery shunt trip and auxiliary contact signals from a battery breaker or battery disconnect switch.

6. External bypass indicator connection: A connection point shall be provided to acknowledge that an external maintenance bypass has been closed around the UPS, placing the critical load on utility power.

2.07 COMMUNICATIONS

A. Communications Bay: The UPS shall be equipped with field configurable communications bays that will accommodate four (4) plug-in communication devices

B. Remote Monitoring:

1. Optional WEB/SNMP communication capabilities will be available for all systems.

2. The UPS shall be able to be monitored remotely via communications devices. UPS manufacturer shall provide optional communications devices capable of communicating via various industry standard protocols such as RS232, SNMP, BACnet and ModBus. Monitoring of UPS status may also be performed through isolated dry contact Form C relays.

3. The UPS communication capability should be able to integrate into any industry standard Building Management System (BMS) and/or Network Management System (NMS). The UPS must also be able to be monitored via any standard Internet browser.

4. All optional hardware interfaces shall be “Hot-swappable” (UPS maintains power to critical applications while changing interfaces).

C. Shutdown:

1. There shall be a mechanism that provides graceful, orderly, unattended, sequential shutdown of one or multiple computers powered by one UPS. This shutdown shall be performed via in-network or out-of-network means. The order of shutdown shall be user-defined, allowing the maximization of runtime on battery for more critical systems.

2. The UPS shall also be capable of interfacing with an operating system’s built-in shutdown routine. This shall be done through a cable connection to the communication interface card.

D. Notification:

1. There shall be a mechanism to send alerts to key personnel via email or SNMP traps. An alarm notification may also be sent by a network message.

2.08 UPS MODULE PROTECTION

A. Rectifier/Charger and Bypass protection shall be provided through individual fusing of each phase.

B. Battery protection shall be provided by thermal-magnetic molded-case circuit breakers in each battery cabinet (if standard battery pack is provided) or external protective device for an external battery.

C. Electronic current limiting circuitry and fuses in the Inverter circuit shall provide output protection.

D. To comply with agency safety requirements, the UPS module shall not rely upon any disconnect devices outside of the UPS module to isolate the battery cabinet from the UPS module.

PART 3 - PRODUCTS

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions and project documents.

3.02 COMMISSIONING

A. Factory start-up shall be provided on a 5x8 basis (7 x 24 optional). Start-up service shall be provided at no extra charge and shall include three visits to perform all procedures and tests included in the project documents and as specified within UPS Installation and Operation manual. UPS manufacturer representative shall be on site for the services:

1. Pre-Energization: Initial installation pre-energize check to inspect installation and provide guidance to installers as required. This site visit will include the initial energization from a temporary power source for UPS for initial programming, and operational verification tests, and battery charging. Operational training of Owner's personnel will also be completed on this site visit activities will include:

   a. Factory representative and City IOR inspection prior to energization, including AHJ approval to energize.

   b. Loading of software program with Owner approved settings

   c. Entering temporary passwords

   d. Verification of firmware settings

   e. Apply communication settings and establish communications with Owner designated devices. Load software onto Owner's designated devices as required to establish communications. Setup password access for remote devices.

   f. Front display verification

   g. Verification of voltage input and output settings, alarms, ramp rates, and other operational settings.

   h. Owner's personnel training. Allow two hours with Owner's personnel to review operation and answer questions. Provide a pdf of the UPS Owner's manual with operating instructions for use during training.

2. Load Test: Site visit will include load test procedure preparation and review of load test temporary source and load bank connections and installation by the contractor, including grounding. Manufacturers representative will monitor and document the load test setup, load test conditions, and load test results. Perform a 100% rated output load test and verify UPS operations including:

   a. Verify bypass switch operation.

   b. Apply load in multiple steps. Load steps to include simulation of 40kW load add and load shed. Verify the UPS module load sharing. Simulate loss of a module to observe load response.

   c. Verify all load control programming such as walk-in function, source synchronizing, battery load sharing. Program graceful shutdown functions based on the Owner's requirements.

   d. Measure input current THD, and output voltage THD.

   e. Monitor battery charge levels throughout the test.

   f. Monitor and verify all alarms. Simulate conditions to verify alarm functionality without damaging the unit.

   g. Verify all indicating lights and HMI

h. Verify all remote device monitoring and alarm status indication.

3. Data Center Shutdown: Manufacturers representative shall be on site for the duration of the scheduled Data Center shutdown to observe the operation of the EPO, permanent connections and energization of permanent PDU load. Verify alarm notification configuration, communications, monitoring and permanent generator source testing, as time permits. If possible, work with the Owner to implement the graceful shutdown functions during the Owner's planned shutdown of the Data Center.

B. The following procedures and tests shall be performed by Field Service personnel during the UPS startup:

1. Visual Inspection:

a. Visually inspect all equipment for signs of damage or foreign materials.

b. Observe the type of ventilation, the cleanliness of the room, the use of proper signs, and any other safety related factors.

2. Mechanical Inspection:

a. Check all the power connections for tightness.

b. Check all the control wiring terminations and plugs for tightness or proper seating.

3. Electrical Pre-check:

a. Check the DC bus for a possible short circuit.

b. Check input and Bypass power for proper voltages and phase rotation.

c. Check all lamp test functions.

4. Initial UPS Startup:

a. Verify that all the alarms are in a "go" condition.

b. Energize the UPS module and verify the proper DC, walkup, and AC phase on.

c. Check the DC link holding voltage, AC output voltages, and output waveforms.

d. Check the final DC link voltage and Inverter AC output. Adjust if required.

e. Check for the proper synchronization.

f. Check for the voltage difference between the Inverter output and the Bypass source.

g. Optional on site full-load, step-load, and battery discharge tests using supplier furnished load bank, shall also be offered.

5. Operational Training: Refer to 3.02,A,1.

3.03 WARRANTY

A. All components of the UPS system shall be covered by a five-year limited factory warranty and service protection package.

B. Five-year limited factory warranty shall include replacement coverage for the UPS parts for a period of 60 months from shipment or 58 months from start-up, whichever occurs sooner. Labor coverage is for 365 days after product startup.

C. Five-year service protection package shall include 7x24 on-site repair/replacement labor for UPS parts and batteries; 7x24 technical support coverage; and 7x24 remote monitoring

service (with monthly reports for UPS and battery performance). Standard response time shall be 8 hours from receipt of call. Manufacturer shall also offer, as an option, 7x24 on-site service support with guaranteed response times of 4, or 2 hours in certain major metropolitan areas. Additional preventive maintenance visits shall be available as an option for both UPS and battery components.

D. Manufacturer shall also include Start-up services consisting of: 7x 24 Start-up service of UPS and batteries. On-site user training, Site Audit, installation and commissioning of monitoring service, and validation of five-year limited factory warranty will be performed during the start-up.

E. Manufacturer shall also offer an optional service plan to provide 7x24 on-site coverage (preventive and corrective) for UPS and batteries, guaranteed response time, remote monitoring, Web access to service site history, annual Site Audit, UPS and battery preventive maintenance visit, and discounts on upgrade and modification kits. Manufacturer shall also provide an optional battery service plan to provide parts-and-labor coverage for partial and full battery strings, either with preventive maintenance or replacement coverage.

F. Manufacturer shall offer a ten-year limited warranty option. The ten-year option shall be offered as; ten-year term in lieu of five-year term, or option to extend the warranty for an additional five years upon expiration of the original five year term.

END OF SECTION