SECTION 26 05 00 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section Includes:

1. Materials and equipment shall be furnished and installed in support of electrical work described in these plans and specifications including but not limited to, raceways, boxes, enclosures, feeders, branch circuiting, supports, terminal cabinets, sleeves, gutters, panels, transformers, lighting fixtures, controls, relays, contactors, in order to complete and make fully functional the systems described.

2. Complete fire alarm and annunciation system as shown and/or required by the (local jurisdiction having authority, California State Fire Marshal) including monitoring equipment and wiring for central station connection.

3. Lighting systems as shown on the plans and as specified herein, including controls, occupancy sensors, lumen sensors, photocell controls, lamps, dimmers, supports, fasteners, straps, and miscellaneous mounting hardware and support structures for such equipment.

4. Duct banks and raceways for all power and communications systems as shown and/or required. Duct banks shall include all trenching, racking, conduit, concrete, backfill, boxes, pads, substructures required for a fully developed and usable pathway for cables, conductors, as shown on site, etc.

5. HVAC and plumbing electrical: Conduit, conductors and terminations for all line voltage power, line voltage controls and fusible and/or non-fusible safety disconnect switches for HVAC equipment, including but not limited to air conditioners, furnaces, fans, heat pumps, cooling towers, system pumps, condensing units. Provide protective equipment unless otherwise noted, etc. including protective devices.

6. Plumbing Electrical: Conduit, conductors and terminations for plumbing equipment with power requirements including necessary fusible and/or non-fusible safety disconnect devices. Provide motor starters where required unless provided by mechanical specification.

7. Power and Lighting Distribution: Furnish and install power and lighting distribution systems including but not limited to panels, feeders, transformers,
branch circuits, devices, fixtures, disconnect switches, contactors, controls, etc. for a complete working system.

8. Data systems infrastructure including all boxes, raceways, cable tray, wire basket tray, dedicated branch circuits, sleeves and penetrations, etc. as described and as shown in plans, risers, specifications, EIA/TIA standards and/or required for a complete and operating system.

9. Allocation of time to adequately train the Owner on the use and operation of all systems installed within the facility or on the property. Minimum two week advance notice shall be coordinated with the Owner and his representatives. Training shall be as outlined in individual system specifications identified to follow.

B. Related Sections Under Other Divisions:
1. Mechanical Wiring: Control circuit wiring, energy management controls and interlocks for mechanical equipment shall be installed by Mechanical Contractor.
2. Painting of electrical equipment where exposed and required by the Architect to be painted as described elsewhere in the specification.
3. Pole Bases: Contractor shall be responsible to furnish light standard concrete pole bases, rebar, bolt templates and anchor bolt kits for a complete installation. Concrete, rebar, excavation shall be by Contractor in accordance with all parts of this specification.
4. HVAC Control Raceway: Raceways, boxes, and control wiring for thermostats, temperature sensors and control components specified within the mechanical specifications, shall be furnished and installed as required by Division 25 and installed in accordance with the minimum wiring methods allowed for branch circuit wiring in Division 26 (the DDC systems/EMS systems and components are installed in accordance with Division 25).
5. Smoke Fire Dampers: Coordination with Mechanical plans for exact locations and points of connection for power and fire alarm system connections (power and fire alarm connection shall be by Electrical Contractor).
6. Duct mounted smoke detectors: Coordination with Mechanical plans for exact locations and points of connection for power and fire alarm system connections (power and fire alarm connection shall be by Electrical Contractor).
7. Security System: Shall be installed by Owner’s vendor. Contractor shall provide conduits, boxes, stubs to accessible ceilings, dedicated circuit(s) for alarm panel, access control system (key pads, electric locks), etc. as shown and/or required by the Owner’s vendor.
8. Refer to Division 27 for conduit requirements specific to low voltage cabling systems.

1.3 SYSTEM DESCRIPTION

A. The electrical plans indicate the general layout and arrangement; the architectural drawings and field conditions shall determine exact locations. Field verify all conditions
and modify as required to satisfy design requirements as well as code minimums. Maintain all required working clearances as described in CEC Article 110 as well as other applicable articles.

B. Discrepancies shall be brought immediately to the attention of the Architect for clarification. The Architect shall approve any changes. Prior to rough-in, refer to architectural plans that shall take precedence over electrical plans with respect to locations.

1.4 SUBMITTALS AND SHOP DRAWINGS

A. Before construction, submit in (accordance with the General Conditions of this Specification) a complete list of all materials proposed to be furnished and installed under this section. Any material procured without review and approval of the engineer and/or owner’s representative, will solely be at the contractor’s risk.

B. Manufacturers’ specifications, catalog cuts and shop drawings as required to demonstrate compliance with the specifications. Identify specific intended use for each component where submittal may be ambiguous. Submit entire bound submittal at one time; partial submittals will not be accepted. At a minimum, submittals will be required for the following:

1. Utility service/site work equipment including ducts, conduits, fittings, concrete manholes, concrete and fiberglass pull, manhole, boxes, vaults, trench racks, accessories, etc.
2. Distribution equipment including main switchboards, distribution switchgear, transformers, distribution panels and breakers, motor controls, distribution and branch circuit panels, grounding, transient voltage surge suppressors, etc.
3. Electrical equipment including disconnects, fuses, raceways, straps and racks, fittings, conductors, boxes, gutters, devices, plates, etc.
4. Lighting equipment including fixtures, ballasts, lamps, mounting accessories, color charts (where required), etc.
5. Lighting control equipment including low voltage switching system, dimmer switchbank / accessories, occupancy sensing equipment, time clocks, contactors, photocells, lumen sensors, etc.
6. Constructability review letter/comments for lighting acceptance testing as required by Section 26 56 70, LIGHTING ACCEPTANCE TESTING.
7. Complete system component submittals and shop drawings for:
   a. Fire Alarm System
   b. Communication Systems including but not limited to; cable, fiber, terminations, cable management, cable tray, patch panels, equipment racks, specified active electronics (where called for), cabinets, jacks, plates, cable labeling, testing procedure.
8. Conduit including all fittings, etc.
9. Wiring and cable, terminations, etc.
10. Fire rating penetration materials, details, etc.

C. The intent of these specifications is to establish a standard of quality for materials and equipment. Therefore, some items are identified by manufacturer or trade name designation. Substitutions shall be subject to the Architect's approval. Samples of the proposed and substitute materials may be required for inspection prior to approval. Costs, if any, for evaluation of substitutions shall be the Contractor's responsibility. The decision of the Architect shall be final. Where the substitution will affect other trades, coordinate all changes with those trades concerned and pay any additional costs incurred by them as a result of this substitution. Approval of substitutions shall not relieve the Contractor from providing an operational system in accordance with all applicable codes and ordinances.

1.5 DELIVERY, STORAGE AND HANDLING

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

PART 2 - PRODUCTS

2.1 MATERIALS

A. Materials shall be new and bear the label of or be listed by a nationally recognized testing laboratory. The quality and suitability of all materials shall conform to the standards and practices of this trade.

B. Supplied materials shall be of a current manufactured product line. Discontinued products are not acceptable. Where products are identified on the contract documents by part number, supply the current product model or series which meets the specification and intended use of the specified component.

2.2 SUPPORTING DEVICES


B. Concrete Inserts: Kindorf D-255, cast in concrete for support fasteners for loads up to 800 lbs.

C. Pipe Straps: Two-hole galvanized or malleable iron.
D. Luminaire Chain: Campbell Chain 75031, 90-lb. test with steel hooks.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Professionalism and appearance of installations shall be in accordance with accepted practices of this trade. Installation methods shall conform to manufacturers' specifications and recommendations. The Contractor shall man the job with qualified journeymen and helpers in this trade for the duration of the job. It is the Contractor's responsibility to communicate with and keep the job superintendent appraised of changes or clarifications, etc.

B. Employment of any person on any job in the capacity of an electrician is not permitted unless such person has qualified for and holds a valid Journeyman Electrician Pocket Card or General Journeyman Electrician Certificate issued by the State of California Division of Apprenticeship Standards 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 work is such that good supervision can be maintained and the quality of workmanship is the best, as expected by Owner and implied by the latest edition of the National Electrical Code.

2. Before each journeyman electrician commences work, deliver to Owner at the project site, a photocopy of the journeyman's valid Pocket Card.

C. Materials shall be installed in accordance with the manufacturers' specification and recommendations. They must conform to the approval AHJ adopted codes and standards, but not less than the currently adopted CEC and all applicable codes and standards, including but not necessarily limited to California Code of Regulations Title 24, NFPA, National Electrical Manufacturers Association, ANSI, CBC, and any other adopted ordinances of applicable agencies having jurisdiction. Refer to general conditions of specifications.

D. Electrical Contractor shall lay work out in advance in order to avoid unnecessary cutting, chasing, and drilling of floors, walls, ceilings and other surfaces. Work of this nature shall be carefully done so as not to damage work already performed by other trades. Any damage which results must be properly repaired at no extra cost to the
Owner. Such alterations shall not depreciate the integrity of the structure. Approval for cuts or penetrations in structural members shall be by the Architect.

E. All Fixtures, Equipment, and Valves locations shall be designed and Installed to be Accessible, Readily (Readily Accessible). Capable of being reached quickly for operation, renewal, or inspections without requiring those to whom ready access is requisite to take actions such as to use tools (other than keys), to climb over or under, to remove obstacles, or to resort to portable ladders, and so forth.

F. Supporting Devices:
1. Verify mounting height of all luminaires or items prior to installation when heights are not detailed.
2. Install vertical support members for equipment and luminaires, straight and parallel to building walls. Provide independent supports to structural member for electrical luminaires, materials, or equipment installed in or on ceiling, walls or in void spaces or over furred or suspended ceilings.
3. Do not use other trade’s fastening devices as supporting means for electrical equipment, materials or luminaires. Do not use supports or fastening devices to support other than one particular item.
4. Support conduits within 18” of outlets, boxes, panels, cabinets and deflections. Maximum distance between supports not to exceed 8’ spacing.
5. Securely suspend all junction boxes, pull boxes or other conduit terminating housings located above suspended ceiling from the floor above or roof structure to prevent sagging and swaying.
6. Provide seismic bracing per UBC requirements for this building location.
7. Supporting Devices: Safety factor of 4 required for every fastening device or support for electrical equipment installed. Support to withstand four times weight of equipment it supports. Bracing to comply with seismic design category “SDC” as per Structural Engineer.

G. Coordinate work with other trades as required to eliminate any delays during construction. Coordinate changes with other prime contractors to avoid construction conflicts.

H. Engineer’s Field Observation: Site visits during construction for field observations and reports will be conducted by electrical engineer when directed by the Architect. A list of items that need to be addressed will be submitted to the Architect for forwarding to the Contractor. A written response to all items shall be submitted for Owner’s review once complete. When Electrical Engineering representative performs a field observation, the Electrical Contractor shall be present and available to remove equipment covers as needed.

I. Drawings of Record: Provide a full and accurate set of field record drawings marked up in a neat and understandable manner submitted to the Owner Representative, Construction Manager, or Architect upon completion of the work and prior to issuance
of a certificate of completion. The drawings shall dimension all electrical facilities including but not limited to underground conduit, vaults, boxes as well as conduit routing scaled to within 12" of actual field conditions and shall be kept up to date on a daily basis reflecting changes or deviations. Electrical facilities shall be accurately drawn on the plan to scale. Refer to the general conditions of these specifications for additional requirements. Record drawings shall be required to identify both horizontal and vertical dimensions to visible and fixed points such as concrete, asphalt, buildings, sidewalks, etc.

J. Identification: Provide engraved laminated plastic nameplates for all switchboards, panelboards, fire alarm terminal cabinets, telephone and cable television backboards, main devices, control panels, time clocks, contactors and safety disconnect switches accurately identifying each device. Labels shall be attached to the equipment by means of screws or rivets. Self-adhering labels will not be acceptable.

K. Safety: The Electrical Contractor is responsible to maintain equipment in a safe and responsible manner. Keep dead front equipment in place while equipment is energized. Conduct construction operations in a safe manner for employees as well as other work persons or anyone visiting the job site. Provide barriers, trench plates, flags, tape, etc. The Contractor shall hold all parties harmless of negligent safety practices that may cause injury to others on or near the job site.

L. Guarantees: Equipment and labor shall be guaranteed and warranted free of defects, unless otherwise stated to be more restrictive, for a period of one year from the date of final acceptance by the Owner. A written warranty shall be presented to the Architect at the time of completion prior to final acceptance. Equipment deemed to be damaged, broken or failed should be repaired or replaced at no additional cost to the Owner. Materials or system requiring longer than a one-year warranty as described herein shall be separately warranted in separate letters of guarantee stating the duration of warranty.

M. Operating and Installation Manuals: Provide two copies each of manuals, operating and installation instructions for equipment indicated in submittal packages. Instruct the Owner's representative as to the operation and location of equipment necessary to allow them to operate the facility upon final acceptance. This instruction period shall be prearranged with the Owner's representative prior to occupancy of the facility and the weeks prior to training scheduled.

N. Lighting Acceptance Testing: Provide two copies of lighting acceptance testing results and equipment operating manuals as specified in Section 26 56 70, LIGHTING ACCEPTANCE TESTING. Instruct the Owner on operation of control systems.

END OF SECTION 26 05 00
PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Medium voltage cable. Single conductor 15 kV, 133% insulation ethylene propylene rubber (EPR) insulated, metallic tape shield, PVC jacketed, with copper conductors for use in underground distribution systems.

B. Terminations and splices.

1.02 QUALITY ASSURANCE

A. DC proof testing, labeling, and phasing after cable is installed, spliced and terminated, and before energizing in accordance with Section 26 05 53.

B. Reference standards:
   1. ASTM: B3 Soft or Annealed Copper Wire.
   2. ASTM: B8 Concentric Lay-Stranded Copper Conductor, Hard, Medium-Hard or Soft.
   3. NEMA: WC8 Ethylene-Propylene, Rubber-Insulated Wire and Cable for Transmission and Distribution of Electrical Energy.
   4. NEMA: WC26 Wire and Cable Packaging.

C. Cable splicers:
   1. Only experienced personnel shall be allowed to handle the installation, splicing, and terminations of high voltage cable.
   2. Experience records of cable splicers/handlers shall include educational or special instruction courses attended for splicing and any certifications issued by cable manufacturers. Splicing experience shall include a minimum of 5 years of experience as a journeyman cable splicer, with dates and jobs listed. No one shall be permitted to splice or terminate medium voltage cable prior to Owner having...
reviewed the qualifications of the cable splicer. Contractor shall provide Owner, in writing, compliance with these Specifications. All electricians including cable splicers shall have general electrician certification required by the California Division of Apprenticeship Standards.

1.03 RELATED WORK SPECIFIED ELSEWHERE

A. Tests and identification: Section 26 05 53.
B. Medium Voltage-Voltage SF6 Switch: Section 26 05 45.
C. Electrical Duct Bank: Section 26 05 41.
D. Pad Mounted Transformers: Section 26 12 19.
E. Medium Voltage Switchgear: Section 26 13 23.

1.04 SUBMITTALS

A. Procedure: In accord with Division 1 requirements.
B. Warranties: In accordance with Division 1 requirements.
C. Contractor shall furnish cable manufacturer’s catalog cut sheets and written statements from the manufacturer for the specific cable to be furnished that shall include the following information:
   1. Conductor size and stranding.
   2. Type and thickness of the semi-conducting shield.
   3. Type and thickness of insulation.
   4. Type and thickness of insulation shield.
   5. Type and thickness of jacket.
   6. Diameter of the insulated, shielded cable and variations from the average O.D. due to production.
   7. Diameter of the single cable including the jacket.
   8. Diameter over the insulation for single cable.
   9. Recommended minimum bending radius, single conductor.
  10. Manufacturer’s recommendation for:
       a. Maximum pulling tension with conductor pulling eye and cable grip.
       b. Maximum sidewall pressure.
  11. Cable manufacturer’s name and location of plant at which cable will be produced.
  12. Manufacturer’s warranty for cable offered.
1.05 SERVICE CONDITIONS

A. The design and construction of the completed cables shall be such that they will operate satisfactorily at conductor temperatures not exceeding the following, at the hottest portion of the circuit at any time:

<table>
<thead>
<tr>
<th>Type of Operation</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>105°C</td>
</tr>
<tr>
<td>Emergency Overload</td>
<td>140°C</td>
</tr>
<tr>
<td>Short Circuit</td>
<td>250°C (482°F)</td>
</tr>
</tbody>
</table>

B. The normal or continuous rating is based on 100% load factor, 40°C ambient temperature, and soil thermal resistivity of 105°C-cm/watt. The cable shall be capable of meeting the cumulative overload duration of 1500 hours during the lifetime of the cable. The short circuit rating is based on the highest temperature attained by any part of the cable during a short circuit having a duration of 2 seconds, or less.

C. The cable furnished under these Specifications shall be suitable for installation in underground ducts, conduits, and conduit risers (plastic, steel, or concrete), and for direct burial.

D. The cable shall be suitable for operating both in wet and dry locations and in installations with alternate wet and dry conditions. Under wet conditions, alkaline liquid may be present.

E. The cable may be located in areas where atmospheric ozone concentrations up to a maximum of one ppm may be present for extended periods through the year.

F. The minimum temperature at the time of installation may be considered as being above freezing.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Terminations and splices:
1. Quick-Term molded rubber termination kit to make the 8kV stress-cone-type termination; Kit No. 7625-T-110 or 7622-T-110 7655-S-4 from Minnesota Mining Manufacturing Co. (3M) or Owner-approved equivalent from Raychem.

2. Arc-proofing tape: Scotch #7700 or Tomic #43A.

3. Pressure-sensitive glass cloth tape, minimum 1/2 in. wide: Scotch #27 or Tomic #77T.

4. 200A/600A, 15 kV loadbreak elbows and inserts: Elastimold.

5. Preformed rubber boot with nylon type bolts from Myers Products or General Electric.

6. 15kV and 5 kV silicone rubber splice kits: QS-III cold shrink splice kit No. 5418-1000 from 3M or Owner-approved from Raychem.

7. Hand Taped Splice Kits and materials supplied by 3M.

B. High voltage cable:

1. The medium voltage power cable shall have a performance record demonstrating a minimum of thirty-five (35) years successful operating in utility and industrial power cable applications.

2. Acceptable Manufacturers:
   a. Okonite.
   b. Southwire

2.02 MATERIAL AND FABRICATION

A. High voltage cable:

1. Conductors:
   a. The individual compact copper strands shall be uncoated or shall have electrical and mechanical properties that conform to ASTM B-496 for soft annealed copper wire, before stranding.

2. Conductor (strand) shield:
   a. Extruded layer of semi-conducting thermosetting compound with a volume resistivity not in excess of 100 ohm meters at 105°C shall be applied over the conductor. The compound shall have a minimum elongation after an air oven test at 121°C for 168 hours of 100% and a brittleness temperature not warmer than -30°C.
   b. The shield shall be clean stripping from the conductor, and inseparably bonded to the overlying insulation.
c. The thickness of the conductor shield shall be as follows:

<table>
<thead>
<tr>
<th>Conductor Size AWG/KCMIL</th>
<th>Conductor Shield Thickness</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Minimum Point (mils)</td>
</tr>
<tr>
<td>4/0</td>
<td>12</td>
</tr>
<tr>
<td>500</td>
<td>16</td>
</tr>
<tr>
<td>1000</td>
<td>20</td>
</tr>
</tbody>
</table>

3. Insulation:

a. The insulation shall be EPR, a flexible thermosetting dielectric based on an ethylene propylene elastomer. The ethylene content of the elastomer shall not exceed 72% by weight of ethylene, to limit the degree of susceptibility to treeing experienced by highly crystalline materials. The insulation shall be compounded by the cable manufacturer in its own facility using a closed system to ensure maximum cleanliness.

b. The minimum average insulation thickness shall be suitable for 133 percent insulation level. The eccentricity of the cable shall be as follows:

\[
\frac{T_{\text{max}} - T_{\text{min}}}{T_{\text{max}}} < 0.12
\]

c. The insulation shall have heat, moisture, ozone, and corona resistant properties.

d. The insulation shall be homogeneous, solid, free from porosities, voids, and contaminants in number or size greater than allowed in AEIC CS-8.

e. The EPR insulation shall be extruded with the conductor and insulation shields to prevent intersurface contamination. The extrusion operation shall be performed in a manner to permit measurement and accurate control of wall thickness of each layer of compound as the cable is manufactured.

4. Insulation shield:

a. The insulation shield shall be an extruded semi-conducting compound with a volume resistivity not in excess of 500 ohm-meters at 90°C when tested in accord with AEIC CS-8.

b. The thickness of the extruded shield, and the indent on the insulation, shall be as follows:

| Calculated Insulation Shield Thickness (mils) |
c. The extruded shield shall be clean stripping and have a peel strength from the insulation between 6 and 18 lb. per 0.5 in. width when tested in accord with AEIC CS-8. This compound shall have a minimum elongation after an air oven test at 121°C. For 168 hours of 100% and a brittleness temperature not warmer than -30°C.

5. Jacket:
   a. An encapsulated linear low-density jacket shall be provided. This jacket shall be an insulating, black polyethylene compound (such as UCC-6425 or approved equal) meeting the requirements of ICEA S-97-682.
   b. The jacket shall be such that its linear shrinkage shall not exceed the linear shrinkage of the insulation.
   c. The jacket shall be of smooth and uniform composition, free of holes, cracks, blisters, and other imperfections. The jacket shall substantially fill the spaces between the concentric neutral wires and shall be free stripping from the insulation shield and concentric neutral.
   d. When tested in accord with ICEA, the jacket shall meet the following physical requirements:
      1) Physical requirement (unaged):
         (a) Tensile, minimum (psi): 1400.
         (b) Elongation, minimum (%): 350.
      2) Aging requirements after air oven for 48 hours at 100°C:
         (a) Tensile, minimum % of unaged: 75.
         (b) Elongation, minimum % of unaged: 75.
      3) Heat distortion: Air oven, 1 hour at 90°C, % maximum: 25.
      4) Absorption coefficient, minimum: 320.

6. Identification:
a. Each insulated conductor shall incorporate a durable lifetime identification which shows manufacturer’s name and year of manufacture and the insulation thickness in mils, all at intervals not to exceed 2 ft. on the outer jacket.

b. Contractor shall furnish to Owner a description of identification markers or tapes which will be used.

c. Each cable reel tag shall indicate the beginning and ending sequential footage marked on the cable jacket or tape.

7. Production tests and test reports:

a. Conductors shall meet the electrical resistance requirements of ICEA S-97-682, Section 2.5 and ASTM B-496.

b. After the cable has been reeled in its completed form, all single conductor, paralleled, twisted and triplexed cables shall be tested in accord with ICEA S-97-682.

c. Insulation resistance test shall be performed in accord with requirements of ICEA S-97-682, Part 6.28. Each cable shall have an insulation resistance not less than that corresponding to the insulation resistance constant of at least 50,000 megohms-100 ft. at 15.6°C (60°F).

d. Shield resistance shall be measured and recorded from end to end on the completed cable.

e. Each reel of completed shielded power cable shall meet requirements of ICEA S-97-682, Part F.2, and be tested in accord with AEIC CS-8, Part G.

f. Contractor shall furnish to Owner, with each shipment of cable, a manufacturer’s test report together with a statement to the effect that the cable meets all requirements in these Specifications.

g. The cable BIL impulse withstand value shall be in accord with AEIC requirements.

8. Marking on reels: All reels shall be plainly marked with a stamped metal label with manufacturer’s name, description of the cable, including conductor size, voltage rating, length, type and thickness of insulation, gross weight, and destination.

B. Terminations and splices:

1. Splices in manholes: Provide only 15 kV 600 amp or 200 amp loadbreak elbows and connectors. No hand-taped splices are allowed unless specifically shown on plans.
2. 15 kV and 5 kV switchgear: Provide high compression, two-hole long barrel type lugs, 15 kV or 5 kV termination kit, and cover with preformed rubber boot with nylon type bolts.

3. SF6 Switch: Provide 15kV, 600amp elbows and inserts compatible with SF6 switch bushings.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Pull a brush with stiff bristles through each duct to make certain that no particles of earth, sand, or gravel have been left in the duct.

B. Pull a standard mandrel, not less than 12 inches long, with a diameter approximately 1/4 inch less than the inside diameter of the conduit, through each duct prior to installing cables.

C. Pull cables off reels into ducts as straight as possible with due care to avoid twists and kinks.

D. Use feed-in tubes of sufficient length to allow the entering end to be above the top of the manhole in feeding cable into the duct.

E. Do not allow scraping of the cable jacket against manhole edges.

F. Do not exceed the minimum allowable bending radius of twelve times the overall diameter of the cable.

G. Attach the cable to the pulling line through a swivel by means of a factory-installed pulling eye or a suitable cable basket weave grip.

H. Pre-lubricate for the entire conduit duct length with high performance non-carbon based pulling compound prior to the pull.

I. Lubricate cable jacket with high performance non-carbon based pulling compound compatible with the cable jacket material, immediately prior to its entering the duct.

J. Maximum allowable pulling tension if a pulling eye or a basket weave grip is used:
   \[ T_m = 0.008 \times N \times CM \] (lb.)
   \[ N = \text{number of conductors} \]
   1. Do not exceed a \( T_m \) of 1000 lb. with cable basket weave grip over PVC jacket.

K. To limit the sidewall pressure at bends, the pulling tension shall not exceed:
   \[ TB = 200 \times R \] (lb.)
R = radius at bend in ft.

L. Use the following formula for calculating tension on straight pull:

\[ T = 0.5 \times 1 \times w \times N \text{ (lb.)} \]

1 = length of cable run in ft.

w = weight of cable lb./ft.

N = number of conductors

M. Cut the cable at manhole or pullbox where the splice is to be made, leaving enough extra length to go around the manhole once, plus 5 ft.

N. Seal both ends making them watertight, holding the cut end pointing upward during application of the seal unless termination or splice is done immediately.

O. Terminate cables using a stress-relief kit at switchboard and separable connector pad mount SF6 switch.

1. Follow manufacturer’s instructions installing stress-relief cone kits.

2. Clean and dry area at the termination. Train cable into position avoiding sharp bends. Avoid contamination of the cable insulation from moisture. Do not remove sheath from cable until materials and tools are available so that once a termination is started, the operation may proceed without interruption.

3. Use long barrel, high compression, two-hole type lugs for connection of cable.

4. Install preformed rubber boot with nylon type bolts over termination.

P. SF6 switch cable terminators and cable splices in manholes shall be 200 amp load break or 600 amp elbow type. Install the elbow in accord with manufacturer’s recommended method. Train the cables so that the elbow can be removed and parked on a standard parking stand, bushing, or grounding bushing. Provide load break bushing inserts as required.

1. Clean and dry the environment in the area of the splice, and train the cables into position, avoiding sharp bends. Avoid contamination of the joint insulation from moisture. The sheath should not be removed from the cable until all materials and tools are available and all the protective equipment in place, so that once started, the construction of the joint may proceed without interruption.

2. Obtain splicing kit designed specifically for the type of cable installed and shall be approved by the manufacturer of the cable.

3. Properly phase cable connections before splices are made. Each cable in each manhole shall be tagged to identify the feeder number and phase with stainless
steel tags with 1/4 inch letters and numbers stamped into tag. Tags shall be provided 3’ feet from each conduit entrance and shall be visible after installation and fireproofing tape is applied. Phase letter and circuit number shall be verified in the presence of Owner’s representative with a Contractor-furnished split core transformer with phase angle meter.

4. All unused SF6 switch positions shall be terminated with insulating bushings.

Q. Manholes and vaults fireproofing: Individually fireproof and arc-proof all cables, including splices, in manholes and vaults from duct to duct mouth or terminator by the application of layers of fireproof material to the sheath of the jacket of the cable. Thoroughly clean all cable sheaths and jackets prior to the application of fireproofing and arc-proofing material. Wrap cable sheaths and sleeve fittings with 1/2 lapped, one lapped layer of arc-proofing tape. The fireproofing tape shall be held in place after application with a pressure-sensitive glass cloth tape. Spiral wrapping shall be used with maximum spacing of 12 inch between wraps.

3.02 SITE TESTING

A. Perform DC proof testing on all medium voltage cable as prescribed in Section 16030 after installation and before connecting to equipment. Perform tests in the presence of Owner and certify to Owner in writing before acceptance of the cable. Replace all sections of cable failing to comply with test requirements at no additional cost to Owner.

1. Use proper safety precautions in conducting all high potential tests.

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

3.03 WARRANTIES

A. Cable furnished under these Specifications shall be guaranteed against defective materials and workmanship for a period not less than 40 years from date of initial energization of system and shall include labor and travel time for necessary repairs at job site.

END OF SECTION 26 05 13
PART 1 – GENERAL

1.01 SECTION INCLUDES
   A. Conductors for power, lighting, sound, communication and control, including:
      1. Conductors for general wiring.
      3. Flexible cords and cables.

1.02 RELATED WORK SPECIFIED ELSEWHERE
   A. Conductor identification: Section 26 05 53.
   B. Conductor connections and devices: Section 26 05 21.
   C. Wiring Devices: Section 26 27 26.
   D. Grounding: Section 26 05 26.

1.03 REFERENCE SPECIFICATIONS AND STANDARDS
   A. National Electrical Code. Reference Articles 250, 310, and 800.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS
   A. Cable products as manufactured by the following manufacturers only are acceptable in
      meeting specified requirements:
      1. General Cable Co.
      2. Rome Cable.
      3. American Insulated Wire.
      4. BICC Cable Corp.
      5. Belden Inc.

2.02 MATERIAL AND FABRICATION
   A. Conductors for general wiring: Thermoplastic insulation rated for 600V manufactured
      in accord with UL 83.
      1. Copper conductors, 3/4 hard drawn. Type THHN/THWN or XHHN/XHHW where
         required by location. Markings on cables shall be clearly marked with size and type. Markings shall be white lettering with black jacketing for conductor sizes of
PART 3 – EXECUTION

3.01 USE

A. Conductors for general wiring:
   1. Minimum 90°C temperature rated insulation on conductors, except minimum 105°C temperature rated insulation on conductors in conduits exposed on roof.
   2. Stranded conductors at motors and other applications where subject to vibration.
   3. Minimum size conductors for power and lighting: #12 AWG, with THHN/THWN insulation except where noted.
   4. Minimum size conductors for motor control circuits: #14 AWG stranded with THHN/THWN insulation except where noted.
   5. All cable conductors of 3-phase circuits or single-phase shall be of the same type, mixing stranded conductors for some phases with others as solid is not acceptable.

B. Ground conductors:
   1. Bare copper conductor may be used for equipment ground only.
      a. Install ground conductors in all feeder conduits and all non-metallic conduits as required by Electrical Code and Section 26 05 26.
   2. Insulated ground conductors:
      a. Ground conductor insulation color: Green.
      b. Isolated ground conductor insulation color: Green with white stripe.

3.02 INSPECTION

A. Check conduit system for damage and loose connections, replace damaged sections.

B. Check for caps at conduit openings. Make sure that inside of conduit is free of dirt and moisture.

C. Pull mandrel, one size smaller than the conduit, through entire length of all underground conduits prior to conductor installation.

3.03 INSTALLATION

A. Conductors for general wiring:
1. Color code conductors insulation as follows:

<table>
<thead>
<tr>
<th>SYSTEM VOLTAGE</th>
<th>208Y/120</th>
<th>480Y/277</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase A</td>
<td>Black</td>
<td>Brown</td>
</tr>
<tr>
<td>Phase B</td>
<td>Red</td>
<td>Orange</td>
</tr>
<tr>
<td>Phase C</td>
<td>Blue</td>
<td>Yellow</td>
</tr>
</tbody>
</table>

2. For conductors #6 AWG or larger, permanent plastic colored tape may be used to mark conductor end in lieu of coded insulation. Tape shall cover not less than 2 in. of conductor insulation within enclosure.

3. When pulling conductors do not exceed manufacturer’s recommended values.

4. Use polypropylene or nylon ropes for pulling conductors.

B. Prior to energizing, ensure that cables are:

2. Free from short circuits and grounds.

3. Free from mechanical and electrical defects.

C. Test all conductors in accordance with Section 26 05 53.

D. Conductor identification:

1. Feeders: Identify with corresponding circuit designation at over-current device and load ends, at all splices, and in pull boxes.

2. Provide labels as indicated in Section 26 05 53, and on plans and details.

E. Multi-conductor and twin axial cables: Install cables end-to-end without splices.

END OF SECTION 26 05 19
PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Conductor connections and devices.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Conductor connectors for general wiring:
   1. Size Nos. 6 or larger, copper:
      a. Ilsco Corp.
      b. Thomas & Betts Co.
      c. Burndy Corp.
      d. Square D Versa-Crimp.
   2. Size Nos. 1/0 or larger, aluminum:
      a. Thomas Betts Co.
      b. Square D Versa-Crimp.

B. Insulating tape:
   2. Plymouth Rubber Co.

2.02 MATERIAL AND FABRICATION

A. Conductor connectors for general wiring:
   1. Splice and terminate with compression or pressure type connectors and terminal lugs.
   2. Outdoor or wet locations: Silicon filled safety connectors by King Technology, Inc. or Owner-approved equivalent.

B. Multi-conductor cables:
   1. Ring tongue terminal lug with insulated grip and insulation support:

C. Connector sealing packs for splices that require complete protection from dampness and water.
   1. Scotchlok Nos. 3576, 3577 and 3578, by 3M Company.
D. Electrical insulating resin: Scotchcast Electrical Insulating Resin 400 by 3M Company.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Terminate and splice feeder conductors as follows:
   1. Strip insulation by penciling or paring very carefully so as not to damage the conductor.
   2. Remove enough insulation so that conductor can be fully inserted into connector sleeve or terminal lug.
   3. Apply oxide inhibitor recommended by connector manufacturer to all exposed conductors and wire brush to fully penetrate spaces between strands.
   4. Use hydraulic type compression tool: Thomas & Betts Type TBM15 or Square D Versa-Crimp.
   5. Operate pump until bypass has been reached.
   6. Place full amount of crimps on connectors and terminal lugs as recommended by manufacturer.
   7. Use compression type connector and terminal lugs for splices and terminations.
   8. Apply torque values specified by terminal lug manufacturer.
   9. Use “breakaway” type torque wrench to prevent over tightening.

B. Insulate splices with plastic electrical tape: Scotch No. 33+ or Tomic No. 1T.

C. Terminate all control wires with terminal lugs on barriered terminal boards. If splices are needed, use same procedure, installing terminal board in a junction box for protection.

D. Provide lugs for conductors terminating on secondary side of substation.

END OF SECTION 26 05 21
PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes grounding of electrical systems and equipment. Grounding requirements specified in this Section may be supplemented by special requirements of systems described in other Sections.

1.02 SUBMITTALS

A. Product Data: For the following:
   1. Ground rods.
   2. Chemical rods.
   3. Exothermal weld molds, cartridges, materials and accessories.
   4. Mechanical connectors

B. Qualification Data: For firms and persons specified in "Quality Assurance" Article.

C. Field Test Reports: Submit written test reports to include the following:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.03 QUALITY ASSURANCE

A. Testing Agency Qualifications: In accordance with 26 05 53.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in the California Electric Code (CEC) and NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
   1. Comply with UL 467.
   2. Comply with the CEC and NFPA 70 for systems rated less than 600V; for medium-voltage underground construction, also comply with IEEE C2 and IEEE 80 and 81.

PART 2 - PRODUCTS

Grounding and Bonding
2.01 MANUFACTURERS

A. Subject to compliance with requirements, provide products by one of the following:

1. Grounding Conductors, Cables, Connectors, and Rods:
   a. Boggs, Inc.
   b. Chance/Hubbell.
   c. Copperweld Corp.
   d. Dossert Corp.
   e. Erico Inc.; Electrical Products Group.
   f. Framatome Connectors/Burndy Electrical.
   g. Hastings Fiber Glass Products, Inc.
   h. Ideal Industries, Inc.
   i. ILSCO.
   k. Korns: C. C. Korns Co.; Division of Robroy Industries.
   l. Lyncole XIT Grounding.
   m. O-Z/Gedney Co.; a business of the EGS Electrical Group.
   n. Raco, Inc.; Division of Hubbell.
   p. Superior Grounding Systems, Inc.
   q. Thomas & Betts, Electrical.

2.02 GROUNDING CONDUCTORS

A. Insulated building wire type THHN/THWN for grounds routed in conduit with feeders. Size as noted on plans. Insulation to be green in color, unless otherwise noted, or taped ends as allowed by the Code.


C. Equipment Grounding Conductors: Insulated with green-colored insulation.

D. Isolated Ground Conductors: Insulated with green-colored insulation with yellow stripe. On feeders with isolated ground, use colored tape, alternating bands of green and yellow tape to provide a minimum of three bands of green and two bands of yellow.
E. Grounding Electrode Conductors: Soft drawn Bare, stranded copper, unless otherwise indicated.

F. Bare Copper Conductors: Comply with the following:

G. Copper Bonding Conductors as follows:
   2. Bonding Jumper: Bare copper tape, braided bare copper conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
   3. Tinned Bonding Jumper: Tinned-copper tape, braided copper conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

H. Grounding Bus: Bare, annealed copper bars of rectangular cross section, minimum of 1/8 inch thick by 1 inch wide, with insulators.

2.03 CONNECTOR PRODUCTS

A. Comply with IEEE 837 and UL 467; listed for use for specific types, sizes, and combinations of conductors and connected items.

B. Bolted Connectors: Bolted-pressure-type connectors, or compression type.

C. Welded Connectors: Exothermic-welded type, in kit form, and selected per manufacturer's written instructions.

2.04 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel.

B. Ground Rods: Sectional type; copper-clad steel. 1. Size: 3/4” diameter by 120 inches in length.

C. Chemical Electrodes: Copper tube, straight or L-shaped, filled with nonhazardous chemical salts, terminated with a 4/0 bare conductor. Provide backfill material recommended by manufacturer.

PART 3 - EXECUTION

3.01 APPLICATION
A. Use only copper conductors for both insulated and bare grounding conductors in direct contact with earth, concrete, masonry, crushed stone, and similar materials.

B. In raceways, use insulated equipment grounding conductors.

C. Exothermic-Welded Connections: Use for connections to structural steel and for underground connections, except those at test wells.

D. Equipment Grounding Conductor Terminations: Use bolted pressure clamps.

E. Ground Rod Clamps at Test Wells: Use bolted pressure clamps with at least two bolts.

F. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
   1. Use insulated spacer; space 1 inch from wall and support from wall 6 inches above finished floor, unless otherwise indicated.
   2. Locate ground buses to limit grounding conductor lengths not exceeding 15 feet.
   3. All ground buses shall be interconnected with the ground system and bonded together.

G. Underground Grounding Conductors: Use copper conductor, No. 4/0 AWG minimum. Bury at least 24 inches below grade. Duct bank ground conductors shall be encased in the duct bank as shown on the duct bank section cuts on the drawings.

3.02 EQUIPMENT GROUNDING CONDUCTORS

A. Comply with NFPA 70, Article 250, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by NFPA 70 are indicated.

B. Install equipment grounding conductors in the raceways with feeders conductors and branch circuits.

C. Install insulated equipment grounding conductor with circuit conductors for the following items:
   1. Where required by CEC.
   2. Lighting circuits.
   3. Receptacle circuits.
   5. Three-phase motor and appliance branch circuits.
   6. Flexible raceway runs.
   7. Armored and metal-clad cable runs.
D. Busway Supply Circuits: Install insulated equipment grounding conductor from the
grounding bus in the switchgear, switchboard, or distribution panel to equipment
grounding bus bar terminal on busway.

E. Computer Outlet Circuits: Install insulated equipment grounding conductor in branch-
circuit runs from computer-area power panels or power-distribution units.

F. Isolated Grounding Receptacle Circuits: Install an insulated isolated ground conductor
in addition to an equipment grounding conductor between the panel and isolated
grounding receptacle. Terminate isolated grounding conductor at isolated grounding
terminal of the receptacle and isolated ground bus terminal of panelboard. Equipment
grounding conductor shall bond the receptacle enclosure to the equipment grounding
system.

G. Nonmetallic Raceways: Install an equipment grounding conductor in nonmetallic
raceways unless they are designated for telephone or data cables.

H. Air-Duct Equipment Circuits: Install an equipment grounding conductor to duct-
mounted electrical devices operating at 120 V and more, including air cleaners and
heaters. Bond conductor to each unit and to air duct.

I. Water Heater, Heat-Tracing, and Anti-frost Heating Cables: Install a separate
equipment grounding conductor to each electric water heater, heat-tracing, and anti-
frost heating cable. Bond conductor to heater units, piping, connected equipment, and
components.

J. Signal and Communication Systems: For telephone, alarm, voice and data, and other
communication systems, provide No. 2 AWG minimum insulated grounding conductor
in raceway from grounding electrode system to each service location, terminal cabinet,
wiring closet, and central equipment location.

1. Service and Central Equipment Locations and Wiring Closets: Terminate
grounding conductor on a 1/4-by-2-by-12-inch grounding bus.

2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding
terminal.

K. Metal Poles Supporting Outdoor Lighting Fixtures: Provide a grounding electrode in
addition to installing a separate equipment grounding conductor with supply branch-
circuit conductors.

3.03 MEDIUM-VOLTAGE COUNTERPOISE GROUNDING SYSTEM

A. Provide an electrical grounding counterpoise grounding system for the medium-
voltage distribution system which includes substations, duct banks, manholes, SF6
switches and building service transformers. The counterpoise grounding system shall consist of multiple grounding electrodes of driven ground rods, ground ring and concrete-encased electrodes bonded together. Provide a bare grounding conductor extending around the perimeter of the substation building, manhole, transformer, or SF6 switch to form a ground ring. Bond foundation rebar to No. 4/0 AWG bare copper installed in foundation concrete as a concrete-encased electrode. Electrically bond each grounding electrode together. Bond the steel framework of the building, manhole, transformer or SF6 switch to the counterpoise. Connect the counterpoise to the ground bus of each switchboard. Use copper conductor not less than No. 4/0 AWG for counterpoise and for taps. Bury ground ring not less than 18 inches below grade and 24 inches from building or equivalent foundation.

3.04 INSTALLATION

A. Ground Rods: Install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes.
   1. Drive ground rods until tops are 6 inches below finished floor or final grade, unless otherwise indicated.
   2. Interconnect ground rods with grounding electrode conductors. Use exothermic welds, except at test wells and as otherwise indicated. Make connections without exposing steel or damaging copper coating.

B. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

C. Bonding Straps and Jumpers: Install so vibration by equipment mounted on vibration isolation hangers and supports is not transmitted to rigidly mounted equipment. Use exothermic-welded connectors for outdoor locations, unless a disconnect-type connection is required; then, use a bolted clamp. Bond straps directly to the basic structure taking care not to penetrate any adjacent parts. Install straps only in locations accessible for maintenance.

D. Metal Water Service Pipe: Provide insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes by grounding clamp connectors. Where a dielectric main water fitting is installed, connect grounding conductor to street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
E. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with grounding clamp connectors.
   1. Bond interior metal piping systems and metal air ducts to equipment grounding conductors of associated pumps, fans, blowers, electric heaters, and air cleaners. Use braided-type bonding straps.

F. Bond each aboveground portion of gas piping system upstream from equipment shutoff valve.

G. Install one test well for each tie-in between grounding electrode systems. A test well or test location with bolted connections shall be provided for each concrete encased electrode, ground loop and other grounding electrodes. Set top of well flush with finished grade or floor.

H. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70, Paragraph 250-50(c), using a minimum of 40 feet of bare copper conductor not smaller than No. 4/0 AWG. If concrete foundation is less than 40 feet long, loop conductor within the base of the foundation. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to a grounding electrode test well external to concrete.

3.05 CONNECTIONS

A. General: Make connections so galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
   1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer to order of galvanic series.
   2. Make connections with clean, bare metal at points of contact.
   3. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

B. Exothermic-Welded Connections: Comply with manufacturer’s written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.

C. Equipment Grounding Conductor Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.
D. Feeder Conduit Terminations: At metallic enclosures, terminate each metallic conduit containing feeder conductors with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing.

E. Bond electrically noncontinuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless otherwise indicated.

F. Connections at Test Wells: Use compression-type connectors on conductors and make bolted- and clamped-type connections between conductors and ground rods.

G. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer’s published torque-tightening values. If manufacturer’s torque values are not indicated, use those specified in UL 486A and UL 486B.

H. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by connector manufacturer. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.

I. Moisture Protection: If insulated grounding conductors are connected to ground rods or grounding buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.

3.06 UNDERGROUND DISTRIBUTION SYSTEM GROUNDING

A. Duct Banks: Each feeder and branch circuit conduit in a duct bank shall contain equipment grounding conductor(s). In addition, a 4/0 grounding conductor shall be encased in the concrete duct bank and run the full length of the duct bank.

B. Manholes and Hand-holes: Install a driven ground rod close to wall and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed. Where ground rod must be outside the manhole provide a No. 4/0 AWG bare, copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, non-shrink grout.

C. Connections to Manhole Components: Connect exposed-metal parts, such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 2 AWG minimum, stranded, soft-drawn copper conductor. Train conductors level or plumb around
corners and secure to manhole walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits.

D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around perimeter of pad. Bond rods and ground ring to grounding system. Bond pad-mounted equipment and noncurrent-carrying metal items to ground system. Connect all cable shields to grounding system. Use tinned-copper conductor not less than No. 2 AWG for taps to equipment ground pad and other metal parts. Bury ground ring not less than 18 inches below grade and 6 inches from the foundation.

3.07 FIELD QUALITY CONTROL

A. Testing: Engage a qualified testing agency to perform the following field quality-control testing in accordance with Section 26 05 53:

1. Testing: Perform the following field quality-control testing:
   a. After installing grounding system but before permanent electrical circuitry has been energized, test for compliance with requirements.
   b. Inspect completed grounding system at each ground well and test location for proper connections. Test completed grounding system where a maximum ground-resistance level is specified. Measure ground resistance not less than two full days after the last trace of precipitation, and without the soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests, by the fall-of-potential method according to IEEE 81.
   c. Provide drawings locating each ground rod, ground rod assembly and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
   d. Perform tests as specified in Section 26 05 53.
   e. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify the University’s Representative promptly and include recommendations to reduce ground resistance.

2. Submit a report of testing results as specified in Section 26 05 53.
PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Supporting devices for conduit, boxes, and equipment.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Hangers, straps and beam clamps:
   1. Efcor.
   2. Raco, Inc.
   3. Steel City
   4. O.Z./Gedney Co.
   5. Caddy Fastening System by ERICO Products Inc.

B. Channels and fittings:
   1. Kindorf.
   2. Unistrut Corp.

C. Anchors:
   1. Acherman-Johnson Corp.
   2. Phillips Drill Co.
   3. Rawl Products Co.

2.02 MATERIAL AND FABRICATION

A. Hangers, steel cadmium-plated.

B. Straps: One-hole and two-hole malleable iron, hot-dipped galvanized or steel, cadmium- or zinc-plated.

C. Beam clamps, malleable iron, hot-dipped galvanized or cadmium-plated.

D. Channels and fittings:
   1. Channels, hot-dipped galvanized.
   2. Fittings, galvanized.
E. Anchors, self-drilling and expansion bolt types. No wood or fiber plugs or concrete nails are acceptable.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Fasten pad-mounted switchgear, capacitors, switches, and transformers in accord with manufacturer’s recommendation for seismic zone 4. Submit manufacturers details for zone 4 fasteners and attachment or submit details prepared by a California licensed structural engineer.

END OF SECTION 26 05 29
SECTION 26 05 33 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Conduit and fittings.
   2. Outlet boxes.
   3. Weatherproof outlet boxes.
   5. Floor boxes and poke-through.
   6. Cabinets, termination cabinets.
   7. Gutters.
   8. Concrete boxes and vaults.

B. Related Work:
   1. Installation of all wire, cable, conductor, boxes/gutters, pull ropes, fiber optic cable raceway, conduit, innerduct, cable sleeve and duct as described on the plans and/or as specified here-in. This scope shall include pathways to be installed underground on site and offsite, underslab, above grade, both concealed and exposed, overhead concealed and exposed as appropriately applied. Raceways/boxes shall be installed in accordance with their intended and allowed uses and as specified here-in whichever is more restrictive. Size and capacity of all raceway/boxes shall be as specified here-in or as depicted on the drawings, but shall not be less than that required by code. Larger raceway sizes may be specified than code would permit. The specifications shall govern.
   2. Listed products for termination, coupling, extending, benching supports of raceways shall be used.
   3. Raceways/boxes described by this section shall include, but not be limited to, power for site utilities and lighting, site and building communications, controls, fire alarm, security, access control, sound systems, data system, energy management systems, power distribution, lighting, lighting controls, video, CATV, voice communications, intercom, nurse call, HVAC and other building low voltage/communications systems controls as may be required. Raceways, boxes and duct paths required for utility companies shall be installed per plans unless
utility company requirements are more restrictive at which time those requirements shall take precedence.

4. Protection of and cleanliness of pathways and raceways must be assured during the construction process in order to eliminate the possibility of debris entering the conduit, duct, pathway resulting in decreased wire capacity and potential damage to installed conductors and cables.

5. Pathways are shown in a diagrammatic way and are generally accurate as to routing, however, it is the Contractor’s responsibility as a means and methods process to coordinate with all other trades that require space within a building. The Contractor shall obtain approval for installation of raceways routing through structural footings, retaining walls, columns, beams, perlins, grade beams, etc.

6. It is the Contractor’s responsibility to insure that all raceway and boxes systems penetrate fire assemblies and sound rated assemblies in an approved manner using the appropriate and listed products for the purpose.

7. Trenching and backfilling for all underground conduit systems installed by the Electrical Contractor shall be the responsibility of the Contractor. Conduits shall have minimum cover requirement of 36” below finish grade with the exception of site lighting conduits which may be 24” below finish grade minimum. More stringent depth requirements may be imposed by the local agency and utility company and shall be adhered to, and / or this specification or as detailed on the plans. Joint trenching may be utilized where practicable and where permitted by this specification. Concrete, native material and sand shall be used as backfill material and shall be compacted in accordance with and coordinated with the grading and site preparation requirements. Conduits shall rest in a minimum of 4” bed of sand prior to backfill and compaction. Locations of existing underground (UG) utility systems shall be determined by calling Underground Service Alert (USA) at least 48 hours prior to any excavation. Also refer to Section 26 05 46.13, ELECTRIC UTILITY SYSTEMS.

8. Minimum conduit size shall be 1/2” except if plan shows or code requires larger size. Exception: Use minimum 3/4” for underslab and below grade applications outside of building exterior walls.

9. All electrical, control, communications systems shall be installed in metallic conduit system. This shall include but not be limited to all systems described in Section B.3 above, except for voice and data systems which shall be installed as described on these plans and as specified here-in but shall not be less than the recommendations of EIA/TIA standards.

10. All line voltage wiring within the building shall be installed in metallic conduit.

11. All conduit, concrete pads, underground concrete or fiberglass substructures shall be furnished and installed with the approved materials and type for the application. Provide proper traffic control during construction as well as barriers and protection of all excavations and trenching.

12. Empty or future conduits shall be properly plugged with plastic caps or inserts with a 3/8” polyethylene pull rope. Plastic or "duct" tape will not be acceptable.
13. Exterior installations: After conductors are installed, seal conduit ends to prevent entrance of foreign material using pliable duct seal, caps or waterproof expanding foam.

14. All low voltage systems including intercom, fire alarm, public address, etc. shall be in dedicated conduit systems. Voice / Data and Direct Digital Control (DDC) systems for HVAC cabling shall be routed as specified in Section 27 13 00, INTERCOMMUNICATIONS SYSTEMS and as recommended by EIA/TIA standards. It shall be the contractor’s responsibility to provide raceway down walls to outlet boxes and to provide sleeves across inaccessible ceiling spaces.

15. Underground conduits entering building shall have the open end of conduit within building above the elevation of the conduit outside the building such that water cannot enter building through conduit. If such a condition exists, a pull box outside of building footprint shall be installed in conduit route before conduit enters building whereby top of pull box is below finish floor of building and moisture may exit box before entering building.

16. No single conduit run of any type shall exceed 300 degrees of radius bend from termination box to termination box.

17. Separate Raceway System: Provide a separate dedicated raceway system for each system installed, do not combine different systems into a raceway or cable tray system, unless otherwise noted or allowed.

18. Spare, Future Conduits: Conduits labeled conduit only, spare, or for future use, shall be provided with a pull rope, capped at each end, labeled as spare with destination marked, and turned over to the Owner in an unused state. Contractor shall not utilize these conduits for the installation of cabling or conductors as part of this scope of work. Contractor to verify and install at no additional cost to the Owner, additional conduits as required for the installation of the systems being installed.

19. Outlet System: Provide electrical boxes and fittings as required for a complete installation. Including but not limited to outlet boxes, junction boxes, pull boxes, bushings, locknuts, covers and all other necessary components.

20. Code Compliance: Comply with CEC as applicable to construction and installation of electrical boxes and fittings and size boxes according to CEC 312, 314 and 366 except as noted otherwise.

21. Outlets to be flush mounted: Maintain integrity of insulation and vapor barrier. Unless otherwise noted, flush mount all outlet boxes.

22. Provide putty pads of proper type around outlet boxes and/or as detailed on plan to meet sound transmission restrictions and fire ratings of walls.

1.3 SUBMITTALS

A. Provide Shop Drawings and Product Data for the Following Equipment:

1. Conduit and fittings.
2. Outlet boxes.
3. Weatherproof outlet boxes.
5. Floor boxes and poke-through.
6. Cabinets, termination cabinets.
7. Gutters.
8. Concrete boxes and vaults.
9. Fiberglass or composite boxes and vaults.
11. Raceways

1.4 REGULATORY REQUIREMENTS

A. Conform to requirements of the CEC, latest adopted version with amendments by local AHJs.

B. Furnish products listed by UL or other independent and nationally recognized testing firm.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Heavy wall Rigid Non-Metallic Conduit, shall be PVC schedule 40 manufactured in accordance with NEMA Standard TC-2, UL-651 and WC 1094A specifications.

B. Extra heavy wall non-metallic conduit, shall be PVC schedule 80 manufactured in accordance with NEMA Standard TC-2, UL-651 and WC 1094A specifications.

C. Galvanized Rigid Steel (GRS) conduit shall be hot dipped galvanized, zinc coated and shall comply with Underwriters Laboratories UL-6, ANSI Specification C-80.1 and Federal Specification WW-C-581E.

D. Electrical Metallic Tubing (EMT) shall be zinc coated, with a protective coating applied to the inside surface and shall comply with Underwriter Laboratories UL-797 ANSI Specification C-80.3 and Federal Specification WW-C-563A.

E. Electrical Non-Metallic Tubing (ENT), shall be listed to requirements of U.L. 1653, in accordance with CEC Article 362, and meet requirements of BI National Standard CAN/CSA-C22.2 No. 227.1-U.L. 1653. ENT shall be rated for 90 degrees C conductors and shall be recognized for use in 2-hour fire resistance non-load bearing and load bearing wall assemblies. ENT shall be recognized for through-penetration firestop systems as classified to meet U.L. and ICC building codes.
F. Flexible Metal Conduit (FMC) shall be continuous wound reduced wall galvanized steel produced to UL standards.

G. Liquid tight flexible metal conduit shall have a thermoplastic cover over a galvanized steel core containing an integral copper ground in sizes to 1 1/4” and shall be in compliance with UL standards and CEC Article 350.

H. Surface mount raceway shall only be used where shown on the plans. The raceway and cover shall be white colored by Wiremold but be capable of being over-painted in the field if required. The raceway and fittings shall meet all requirements of CEC Article 386 and be U.L. listed. Raceway shall be mechanically connected to structure with backing and anchor bolts.

I. Manufacturers:
1. Outlet Boxes: Bowers, Raco, Steel City or equal.
2. Weatherproof Outlet Boxes: Bell, Red Dot, [Carlon] or equal.
3. Floor Boxes: Wiremold/Walker, Hubbell, Steel City, or equal.
5. Box Extension Adapter: Bell, Red Dot, [Carlon] or equal.
6. Conduit Fittings: O-Z Gedney, Thomas & Betts, or equal.
7. Vaults: Christy, Brooks, Utility Vault or equal.
8. Putty pads: 3M, Hilti, or equal.
9. Heavy wall rigid non-metallic conduit, Carlon, Certainteed, R&G Sloane or equal.
10. Extra heavy wall non-metallic conduit, Carlon, Certainteed, R&G Sloane or equal.
11. Galvanized Rigid Steel (GRS) conduit shall be hot dipped galvanized, zinc coated and shall comply with Underwriters Laboratories UL-6, ANSI Specification C-80.1 and Federal Specification WW-C-581E.
12. Electrical Metallic Tubing (EMT) shall be zinc coated, with a protective coating applied to the inside surface and shall comply with Underwriter Laboratories UL-797 ANSI Specification C-80.3 and Federal Specification WW-C-563A.
13. Flexible Metal Conduit (FMC), Alflex, American Flexible Conduit or equal.
14. Liquid tight flexible metal conduit, Anacanda (type UA), Electri-flex Liquatite or equal.
15. Surface mount raceway, Wiremold, Three Compartment Series 5500 or equal
16. Floor Boxes, Single Gang, Walker/Wiremold 880 CS Series or approved equal.
17. Floor Boxes, Multiple Gang, Walker/Wiremold RFB Series or Walker Omnibox multi-service floor box with carpet plates, and/or water resistant device covers.
18. Masonry Boxes, outlets in concrete, Raco Series 690 or equal.
19. Floor Boxes, Poke-Thru, Hubbell PT7 Series, Walker/Wiremold RC4 Series, or approved equal unless otherwise noted.
20. Floor Boxes, Poke-Thru, Furniture Feed, Walker/Wiremold RC9 Series or approved equal.
2.2 OUTLET BOXES

A. NEMA 1 gutter, junction and pull boxes shall be fabricated from code gage steel finished in grey enamel with screw cover fronts and concentric knockouts in all sides.

B. NEMA 3R gutter, junction and pull boxes shall be fabricated from code gage galvanized steel with screw cover fronts and concentric knockouts in the bottom only. Any penetrations to the side, top or back shall be weatherproofed in an approved manner such as "MYERS" gasketed type hub or equal.

C. Steel outlet boxes and plaster rings shall be galvanized rigid assemblies, either one piece pressed or factory welded construction containing the size and number of knockouts required. Steel outlet boxes shall be manufactured, sized and installed in accordance with CEC Article 314. Device Outlet: Installation of one or two devices at common location, minimum 4” square, minimum 1 1/2” deep. Single or 2 gang flush device plaster ring. Raco Series 681 and 686 or equal.

D. Luminaire Outlet: minimum 4” square with correct plaster ring depth, minimum 1 1/2” deep with 3/8” luminaire stud if required. Provide proper depth plaster ring on bracket outlets and on ceiling outlets.

E. Multiple Devices: Three or more devices at common location. Install 1 piece gang boxes with 1 piece device plastering. Install one device per gang unless otherwise allowed.

F. Construction: Provide galvanized steel interior outlet wiring boxes, of the type, shape and size, including depth of box, to suit each respective location and installation; constructed with stamped knockouts in back and sides, and with threaded holes with screws for securing box covers or wiring devices. Boxes shall be properly secured to the structure such that they are flush with the finish surface. Boxes shall be made structurally secure by means of the proper fastening devices.

G. Accessories: Provide outlet box accessories as required for each installation, including mounting brackets, wallboard hangers, extension rings, plaster rings, luminaire studs, cable clamps and metal straps for supporting outlet boxes, compatible with outlet boxes being used and meeting requirements of individual wiring situations.

2.3 JUNCTION AND PULL BOXES

A. Construction: Provide galvanized sheet steel junction and pull boxes, with screw-on covers; of the type shape and size, to suit each respective location and installation; with welded seams and equipped with steel nuts, bolts, screws and washers.

B. Location:
1. Install junction boxes above accessible ceilings for drops into walls for receptacle outlets from overhead.

2. Install junction boxes and pull boxes as required to facilitate the installation of conductors and limiting the accumulated angular sum of bends between boxes, cabinets and appliances to 300 degrees.

3. Locations: Junction boxes shall be located only where necessary and only in equipment rooms, closets, and accessible attic and underfloor spaces. A horizontal distance of 24" shall separate outlet boxes on opposite sides of occupancy separation walls, fire-rated walls or partitions.

4. Labeling: Junction box covers shall be marked with indelible ink indicated the circuit numbers passing through the box.

2.4 CONDUIT FITTINGS

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

B. Steel boxes may allow for field knock-out modifications, but shall in all other ways conform to code requirements.

2.5 FLOOR BOXES - SINGLE GANG

A. Construction: Deep cast iron fully adjustable before and after concrete pour with all required components for complete activation. Verify required components for application of service fittings, covers, monuments, and the like, attached to floor boxes.

B. Activations:
   1. Flush: Provide brass duplex or single signal cover, hinged with set screw lock. Carpet or tile finish ring.
   2. Monuments: Provide stainless steel monuments with power receptacle or data grommet as noted.
   3. Coordinate specific application of systems as noted on Drawings.

2.6 FLOOR BOXES - MULTIPLE GANG

A. Construction: Deep cast iron, fully adjustable before and after pour. Equal to Walker/Wiremold RFB Series or Walker Omnibox multi-service floor box with carpet plates, and/or water resistant device covers. Verify color. Partition for different power or signal applications. Provide required power receptacle devices and signal grommets or receptacles as noted. Flange type shall be compatible with floor covering for either carpet or vinyl as required and shall be brass type not polycarbonate.
B. Floor mounted boxes shall be water tight and cast iron when installed in grade level concrete slab floor, fully adjustable with interior and exterior leveling screws. Receptacle flange shall be brass with a duplex lift lid. Flange type shall be compatible with floor type. Before installation, coordinate exact location with Architect.

2.7 FLOOR BOXES - POKE-THRU

A. Fire rated for 4 hour, dual service, flush brass cover and service fitting prewired specification grade receptacle, voice/data jacks, as specified.

B. Furniture Feed: Fire rated per floor assembly rating, finish flange and service head assembly.

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

A. Precast concrete or polymer concrete type with full bottoms and draining into gravel drywell. Open bottom splice/pull boxes 24” x 36” and smaller shall be open bottom, with minimum 12” of gravel below for drainage.

B. Flushmount in hardscape and 1” above grade in softscape.

C. Provided with correct traffic type lid, i.e., full vehicular, intermediate incidental vehicular or pedestrian-rated as applicable stamped with “ELECTRIC”, “LIGHTING”, COMMUNICATIONS”, etc. cover identification as shown on the drawings or as applicable. All boxes or vaults located in streets, driveways, sidewalks wider than 8’, and turf areas where mowing takes place shall be traffic rated.

D. Provided with brass hold-down bolts in cover.

E. Provided with necessary box extensions to gain proper depth.

F. Seal all conduit in underground boxes with duct seal after conductors have been installed.

2.9 IN-GRADE UTILITY COMPANY BOXES AND VAULTS

A. In-grade boxes and pads for utility company, shall be as specified by the respective utility company with all of the company’s requirements and construction methods met.

2.10 PUTTY PADS

A. Intumescent moldable firestop putty designed to protect electrical outlet boxes.
B. Designed to install around outside of outlet boxes.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Conduit systems listed below are for use in installations where they are permitted to be used by CEC and/or other occupancy restrictions. The below installation methods do not intend to suggest that these materials be installed in conflict with any applicable code. Special attention to applications shall be made in building types such as Educational, Health Care, wet location, hazardous locations, assembly occupancy and multi-story, but not limited to these. Requirements which are more restrictive than the CEC may be called for by the drawings and / or these specifications. These requirements must be adhered to. The Electrical Contractor shall be responsible to use the proper conduit system for the application. Exposed conduit is not allowed below ceilings or above slab of floor, without the permission and approval of the Architect. All conduits shall be concealed except in electrical and telecommunication rooms or where shown to be surface mounted. Exposed conduit (where allowed) shall be run square and plumb with building lines in an approved manner. Support roofmount conduits, where allowed, with minimum 12” wide redwood blocks set in mastic unless otherwise detailed in roof requirements or as specified in roofing specification, by the Architect. Strap conduits to blocks with proper sized conduit straps. Spacing of support shall be a minimum as provided for in the CEC. All exposed conduit mounted below 8’ above finished grade shall be strapped at a minimum of 5’ spacing.

B. Non-Metallic Rigid Conduit shall be used in concrete slabs, below concrete slabs on grade, or underground outside of a building slab or foundation. Maintain minimum depth requirements and cover with appropriate fill material. Minimum 4” of bedding and cover of backfill material 1/4” size grain and smaller maximum. Conduit shall be heavy wall Schedule 40 or 80, rigid PVC only. Rigid utility P&C duct shall not be used in any application. Properly sized grounding conductors shall be installed per CEC article 250, in all non-metallic conduit branch circuit and feeder runs. PVC conduit shall be formed or field bent only with the use of properly approved bending tools such as to not decrease the internal bore of the conduit. All conduits shall be cut square and reamed of burrs. Approved and compatible glue shall be used on all PVC fittings to attain watertight joints. All non-metallic conduit runs over 150’ in length and over 1 1/4” trade size conduit shall utilize galvanized rigid steel elbows.

C. Galvanized Rigid Steel (GRS) conduit shall be used where exposed less than 8’–0” above finished grade to 18” below finished grade and where subject to physical damage. Conduits shall be cut square and reamed to remove burrs and sharp edges. Strap conduit below 8’ above grade at 5’ intervals. Unless otherwise noted, threadless setscrew and threadless weathertight fittings may be used in lieu of threaded fittings.
All threaded ends entering a junction box of any type shall require one locknut on the inside and one on the outside of the enclosure and be provided with a plastic bushing or grounding bushing where necessary for proper grounding. Where exposed to moisture, a watertight hub or other approved method shall be required. All conduits shall be stubbed up straight and uniform into junction boxes, panels, cabinets, etc., and shall be (GRS) properly supported and strapped. All GRS conduit located below grade, shall be tape wrapped.

D. Electrical Metallic Tubing (EMT) shall be used as allowed by code and as permitted by this specification. It shall not be in contact with soil or the concrete slab on the ground floor of any structure. Connectors and couplings shall be steel insulated set screw type where installed in indoor dry locations not subject to moisture. Where the potential for moisture is present, compression type weathertight fittings are required. One hole conduit straps are permitted from 1/2” to 1” and two hole conduit straps are required for size 1 1/4” and larger. EMT shall not be allowed in areas subject to severe physical damage. Install copper ground wire sized per CEC 250-122 in all EMT conduits.

E. Flexible conduit may be used where concealed in building construction or above dropped ceilings, but shall meet the following criteria: No individual circuit path from distribution panel to last device shall exceed a cumulative length of 6’ of flexible conduit from start to end. Flexible conduit shall not exceed a total directional change of 270 bending degrees in any one run between conduit terminations. Squeeze type or Jake type steel flex fittings of a grounding type are required. Flexible conduit must be supported in accordance with CEC. Where exposed to the weather, moisture, or spray down flexible conduit shall be of the liquidtight type. Fittings shall be manufactured for use with liquidtight flexible conduit. All motor connections shall be made with liquidtight flex. Flexible conduit may not be used where exposed except for last 2’ of equipment connection and unless otherwise noted or approved. A copper ground wire sized per CEC 250-122 shall be installed in all flexible conduit runs. Flexible conduit may not be used exposed. Weatherproof liquid tight conduit shall not be used at roof level for equipment connections with lengths exceeding 24” nor shall it be used to circumvent a rigid conduit system in a horizontal direction. Connect recessed lighting fixtures to conduit runs with a maximum of 6’ of flexible metal conduit extending from junction box to fixture. “Master” “Slave” fixtures are permitted to use manufactured flexible cable of longer dimension up to 12’ between “Master” and “Slave” only and only as a U.L. listed system component.

F. Underground conduits and transition to above grade/slab shall be as follows:
1. PVC elbows allowed if top of elbow is minimum 18” BFG or below top of slab, otherwise GRS elbows are required.
2. GRS elbows are required if conduit run is 150’ or greater.
3. GRS risers are required from elbow below grade to equipment (device, outlet, panel, cabinet, etc.) above grade.
4. GRS elbows/risers to be PVC coated or 10 MIL taped wrapped (1/2” lapped) to 3” above finish grade or top of slab.

G. Conduit Supports: Conduit runs may be supported by one-hole and two-hole straps or supports as manufactured by Unistrut, Minerallac, Caddy or equals. Supports may be fastened by means of anchors, shields, beam clamps, toggle bolts, or other approved methods appropriate for the application and size of conduit. Pipe nailers (J-hooks) may only be used for 1” conduit and smaller and only in wood frame construction. Conduit support methods are subject to review by the engineer and authority having jurisdiction for adequacy. Installations deemed inadequate shall be corrected by the contractor at no cost to the Owner.

H. Bends and offsets shall be made with approved tools for the type of conduit being utilized. Bends shall be made without kinking or destroying the smooth bore of the conduit. Parallel conduits shall be run straight and true with bends uniform and symmetrical. Minimum radii shall be per CEC 344-24.

I. Conduit Stub-outs below grade shall be capped with plastic cap, and identified by placing a pull box marked with correctly identified utility such as “Elec”, “Tel”, etc. Dimension for exact location on field record drawings. Provide lids for proper field application (i.e. traffic, incidental, pedestrian).

J. Conduit Seals: Where below grade conduits enter structure through slab or retaining wall of building or basement, seal the inside of each conduit as follows:
1. Provide damming material around conductors 3” into conduit.
2. Fill 3” of conduit with 3M #2123 sealing compound.
3. Wrap conductors where they exit the conduit with 3M #2229 “Scotch Seal” mastic tape. Lap tape to approximate diameter of the raceway and wrap outside of conduit opening with (minimum) one turn.
4. Use conduit sealing bushings type CSB (O-Z/Gedney) or equal.
5. Empty conduits shall be sealed with standard non-hardening duct seal compound and then capped to prevent entrance of moisture and gases and to meet fire resistance requirements.
6. Provide cable drip loop minimum 12” high.

K. Marker tape: Place plastic yellow marker tape at 12” below finish grade along and above buried conduits. Label tape “CAUTION: ELECTRICAL LINES BELOW” or similar wording.

L. Electrical and communications systems raceways routed underground shall not occupy the same trench as plumbing utilities such as sewer, water, storm drain, gas or other wet or dry gaseous utility system. A minimum of 12” of undisturbed earth is required. Where utilities must cross in closer proximity to each other due to physical constraints, 6” minimum crossing distances are allowed, however 18” on all sides of a utility crossing must be concrete encased.
M. Duct bank defined here-in shall be four or more conduits in a common trench, conduit spacers and saddles shall be required in all trenches where more than two conduits over 2” in diameter travel in the same trench. Proper spacing between systems as outlined above shall be required and spacers shall be located each 5’ (maximum) along trench route from point to point.

N. Conduits, routed below footings, slabs, grade beams, columns, and other structural elements shall be installed in strict compliance with structural details and criteria shown on structural plans. Clearances below structural elements and sleeves through structural elements must be carefully planned to avoid conflict and must be approved by the structural engineer if conflict arises.

O. All conduit or raceways passing through fire rated walls, floors, or ceilings shall be installed with a listed penetration method which protects the opening to the same rating as the assembly and is non-hardening.

P. Expansion Joints
1. Conduits 3” and larger, that are secured to the building structure on opposite sides of a building expansion joint, require expansion and deflection couplings. Install the couplings in accordance with the manufacturer’s recommendations.
2. Provide conduits smaller than 3” with junction boxes on both sides of the expansion joint. Connect conduits to junction boxes with sufficient slack of flexible conduit to produce 5” vertical drop midway between the end. All conduit shall have a copper green grounding bonding conductor installed.

Q. Seismic Joints
1. At seismic joints, provide conduits rigidly secured to the building structure on opposite sides of a building expansion joint with junction boxes or approved fittings, on both sides of the joint. Connect conduits to junction boxes with sufficient slack flexible conduit such that these slack conduits are 1 1/2 times the distance between conduit ends. Flexible conduit shall have a copper green ground bonding jumper installed.

R. Location: Locate boxes and conduit bodies so as to ensure accessibility of electrical wiring.

S. Anchoring: Secure boxes rigidly to the substrate upon which they are being mounted, or solidly embed boxes in concrete or masonry.

T. Special Application: Provide weatherproof outlets for locations exposed to weather or moisture.

U. Knockout Closures: Provide knockout closures to cap unused knockout holes where blanks have been removed.
V. Mount outlet boxes, unless otherwise required by ADA, or noted on drawings, the following distances above the finished floor:
1. Receptacles, Telephone, TV & Data outlets. (measured to bottom of outlet box): +15”.
2. Outlet above counter (measured to top of outlet box): +46”.
3. Control (light) Switches. (measured to top of outlet box): +48”.
5. Fire Alarm Visuals: the lower of +80” to bottom of lens, or 6” below ceiling.
6. Other Outlets: As indicated in other sections of specifications or as detailed on drawings.

W. Coordinate all electrical device locations with the architectural floor plan and interior and exterior elevations to prevent mounting devices within elements that they may conflict such as cabinetry, mirrors, planters, etc.

X. Size outlet and junction boxes to minimum wire fill space requirements. Upsize box as required to allow ease of wire installation and device installation.

Y. Outlet and junction boxes in fire rated walls shall be gauged and spaced so as not to exceed the maximum penetration allowed by the assembly without compromising the fire rating. If a conflict arises relative to a specific condition, the contractor shall follow the requirements of the fire authority and ask for guidance from the design team. At no time should a larger box be installed prior to resolution of conflict.
PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Concrete encased 12,470V or 4160V power duct banks where indicated on Contract Drawings.
B. Communication duct banks where indicated on the Contract drawings.
C. Trenching, concrete encasement and slurry backfill for all power and communications duct banks shall be required.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Excavating and backfilling for utilities: Section 02320.
B. Concrete: Section 03 30 00.
C. Manholes and Pullboxes: Section 16312
D. Grounding: Section 26 05 26.
E. Underground utilities marking: Section 02505.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Duct, fittings and spacers:
   1. Carlon, An Indian Head Co.
   2. Queen City Plastics, Inc.
   3. Robintech Inc.
   4. R & G Sloane Manufacturing Co. Inc.
   5. Allied Tube and Conduit.

2.02 MATERIAL AND FABRICATION

A. PVC duct Schedule 40 (UL listed only): Manufactured in accord with NEMA Standard TC-2 and WC-1094 specifications.
   1. Cemented fittings.

3. Riser sweeps for power and communication ducts shall be rigid galvanized steel or Schedule 80 PVC.

4. Communications conduit shall be Class C Commercial Telephone Duct, 20 feet length, belled on one end, with high tensile strength and good impact qualities. Must conform to requirements for AT&T-8546 and GTE-8343 specifications.

B. Rigid steel conduit, elbows and nipples:

1. Threaded, hot-dipped galvanized conduit manufactured in accord with ANSI C80.1 and UL 6.

2. Threaded, hot-dipped galvanized fittings manufactured in accord with ANSI C80.4.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Excavate in accord with Section 02320.

B. Exercise care in excavating, trenching, and working near existing utilities. Hand dig around all energized, pressurized and active campus underground utility lines.

C. Installation of duct banks:

1. Duct banks for primary electrical power and communication systems shall consist of multiple, single, round bore ducts. Ducts shall consist of PVC Schedule 40 conduits, UL approved only. All fittings and couplings shall be of the same type and manufacturer of the duct, with UL approval.

2. Galvanized steel conduits installed below grade shall be painted with two coats of Koppers bitumastic paint before installing in ground.

3. All conduit risers into switchgear pad, transformer pad, communication pull boxes or enclosures shall be rigid galvanized steel and have a radius of 60 in. minimum, unless indicated otherwise on Drawings.

4. Concrete encased duct bank shall be completely encased in a minimum of 3 in. of concrete. Concrete shall be Class "B" red tint for high voltage power (6 lb. tint per cu. yd.), and Class "B" no tint for communication, 2500 psi at 28 days. Duct banks shall be of a monolithic construction top to bottom and side to side, but not necessarily end to end. All PVC duct shall be protected prior to installation.
5. Prefabricated, interlocking intermediate and base spacers for Schedule 40 PVC conduit shall be used, made of specification grade high-density polyethylene. Spacers shall be installed not more than 5 ft. center-to-center along entire length of duct bank. Each conduit shall be supported by spacers.

6. At connection to manholes, dowel concrete encasement with one No. 4 reinforcing bar 36 in. long per duct.

7. Duct banks shall be securely anchored to prevent movement during placement of concrete.

8. Where connection to bulkhead of duct bank is made to vaults or existing duct banks, the concrete encasement shall be doweled with one No. 4 reinforcement rod 36 in. long per conduit to the existing encasement.

9. Duct bank trench shall be shored, framed and braced for installing ducts. Frames, forms, and braces shall be either wood or steel. Variations in outside dimensions of the completed duct bank shall not exceed 2 in. on the vertical or the horizontal from dimensions shown on Drawings. Remove all forms and bracing after 24 hours and before backfilling.

10. Do not place backfill for a period of at least 24 hours after pouring of concrete. Backfill material shall be a concrete slurry mix to achieve 100% compaction and as shown on the plans.

11. Duct banks shall be laid to a minimum grade slope of 4 in. per 100 ft. This slope may be from one manhole to the next or both ways from a high point between manholes, depending upon the contour of the finished grade. See respective profile drawings.

12. Duct banks shall be installed so that the top of the concrete encasement shall be not less than 36 in. below finished grade or pavement for high voltage power duct bank and 24 in. below grade or pavement for communications duct bank.

13. Changes in direction of runs either vertical or horizontal shall be accomplished by long sweep bends having a minimum radius of curvature of 30 ft., except that manufactured long radius bends may be used in runs of 100 ft. or less on approval from Owner. Duct bank elevation shall be adjusted for duct bank entrances into all manholes and pullboxes. Contractor shall provide, at his own expense, suitable backfill material to bring such excavation to required grade.

14. Communications duct bank shall have no more than 180 degrees of bends between access points including all pullboxes, manholes, vaults, and buildings.
15. Duct joints in concrete encasement may be placed side by side horizontally, but shall be staggered at least 6 in. vertically. All joints shall be made in accord with manufacturer’s recommendations for the particular type of duct and coupling selected. In the absence of specific recommendations, various types of duct joints shall be made by the following method:

a. Plastic duct connections shall be made by brushing a plastic solvent cement on the inside of a plastic coupling fitting and on the outside of duct’s ends. The duct and fitting shall then be slipped together with a quick one-quarter turn to set the joint.

16. The electrical system ground conductor shall be a minimum No. 4/0 AWG bare stranded copper cast in duct bank 3 inches below top of concrete, entering each manhole, and grounded to a rod and ground ring in each manhole using exothermic method as indicated on Drawings. The electrical system ground shall be connected to substations ground loops. A minimum of 15 ft. pigtail shall be provided at each stub-up location noted on Drawings.

17. After the duct line has been completed, three each nonflexible mandrels not less than 12 inches long having a diameter approximately 1/4 inch less than inside diameter of the duct shall be pulled through each duct; after which a brush with stiff bristles shall be pulled through each duct to make certain that no particles of earth, sand or gravel have been left in the line. Leave a 3/8 inch minimum polypropylene pull rope in each duct for future use.

18. Pavement for roadways, parking lots, pedestrian paths and hardscape shall be saw cut at full depth, in straight and uniform lines, 12 to 18 inches wider than the trench on both sides after completion of the duct bank installation and prior to replacement of paving.

19. Underground utilities marking: Install in accord with Section 02505.

20. Replace all hardscape, landscape, turf and vegetation removed for installation of duct banks to existing condition prior to installation of duct banks and as shown on the project drawings. Take photographs of existing conditions prior to installation of all duct banks.

END OF SECTION 26 05 41
PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Testing of SF6 Switches: Section 26 05 53.

1.02 DESCRIPTION

A. This Section includes Specifications for purchasing, installing, testing and energizing the equipment. Contractor shall conform to all requirements of this Section, including quality assurance, submittals, product handling, and warranties, as applicable for the specific extent of furnishing or installing responsibilities. Contractor shall confirm and verify with Owner all installation conditions that may affect furnishing specified equipment. Contractor shall confirm and verify with Owner all characteristics (including specific models, types, and similar properties) and conditions of equipment that may affect installing equipment.

B. Contractor-purchased equipment: Three-phase, gang operated, 15kV, 600A, 60 Hz., dead front, front access pad mounted sectionalizing switchgear. The switchgear shall consist of a single self-supporting outdoor enclosure, SF6 insulated switch with linear puffer switches.

1. The SF6 Padmount Style Resettable Fault Interrupter Switch shall be manufactured by Canada Power Products – no other equal.

1.03 APPLICABLE STANDARDS

A. All portions of ANSI, IEEE, NEMA and ASTM standards for padmount switch with accessories. B. Article 490.21(E) in the California Electric Code, which specifies that the interrupter switches in combination with power fuses or circuit breakers shall safely withstand the effects of closing, carrying and interrupting all possible currents up to the assigned maximum short-circuit rating.

1.04 SUBMITTALS

A. Shop drawings for equipment provided under this Section:

1. Shop drawings shall indicate the following:

   a. Physical dimensions and elevations showing:

      1) High Voltage compartments and termination.
      2) Anchor bolt locations.
3) Ground pad locations.
4) Location of accessories.
5) Total weight and center of gravity.

2. Complete Bill of Materials for switch and all accessories with component rating data.

3. When manufacturer’s reference numbers are different from those specified, provide correct cross reference number for each item. Shop drawings shall be clearly marked and noted accordingly.

4. When equipment and items specified include accessories, parts and additional items under one designation, shop drawings shall be complete and include required components.

5. Submit shop drawings as soon as practicable after signing contracts. Shop drawings must be approved before purchase and construction of equipment.

6. Shop drawings, which are not complete or not properly checked, will be rejected.


B. Instruction Manuals:

1. Upon completion of work, and before final acceptance of the system, furnish to Owner/Engineer for approval, 3 instruction and maintenance manuals.

2. Manual shall include the following:
   a. Manufacturer’s operating and maintenance instructions and parts lists of items or equipment. Where manufacturer’s data includes several types or models, applicable type or model shall be designated.
   b. Wiring diagrams for systems.
   c. Additional information, diagrams or explanations as designated under respective equipment or systems specification section.
   d. Instruct Owner’s representative in operation and maintenance of equipment. Instruction shall include a complete operating cycle on all apparatus. Allow a minimum of four hours for site training of Owner’s personnel.
   e. Operation manuals and instructions to Owner are of prime importance and shall be provided prior to request for final payment.

1.05 GUARANTEE

A. Guarantee for one year after energization of equipment, all equipment, materials, and workmanship to be free from defect.

B. Provide replacement parts for components found defective at no extra cost to Owner.
1.06 SITE CONDITIONS

A. Temperature: 30° - 110°F.
B. Elevation: Less than 500 feet above sea level.
C. Seismic Zone: 4 (CBC).
D. Precipitation: 30" per year.
E. Location: The project site is located approximately 5 miles off the Pacific Ocean.

PART 2 - PRODUCTS

2.01 MANUFACTURER

A. Acceptable Manufacturers: Canada Power Products. No other known equal.
B. Pad-mounted gear shall be in accordance with the one-line diagram and shall conform to the project specifications.
C. Pad-mounted gear shall consist of a single self-supporting enclosure, containing SF6 switch with necessary accessory components, completely factory-assembled, and all other necessary components. Interrupter switches shall be enclosed within an inner grounded steel compartment for electrical isolation and for protection from contamination. Switch terminals shall be equipped with bushings rated 600 amp continuous. Resettable Fault Interrupter positions shall be equipped with deepwell bushings rated 200 amp continuous to provide for load break elbow connection. No protective device elements shall be installed in the SF6 switch tank where they are not accessible or removable without entering the tank. Bushings and bushing wells shall be mounted on walls of inner compartment and shall extend into termination compartment. Termination compartments shall be as follows: one for each 3-phase switch, one for each 3-phase set of 200A RFI, and one for each 3-phase set of bus terminals.
D. Conductors and load break elbows for the potential transformers shall be included.
E. Equipment Description

Item: 1  S201-13-A Replacement  Quantity: 1

Manufacturer: Canada Power Products, no other equal.

Description:

- 15KV, 95KV BIL
- 2-600A PufferPak switched ways, 2-RFI 200A ways.
- 3 phase, 2 position (open-close)
Padmount Enclosure will be 12-gauge mild steel, tamper-resistant single side access with 3-point latch, double doors and a hinged hood. Equipped with stainless steel hardware, wind stops, padlock provisions and a penta-head bolt. The enclosure will be completely removable from the switch to facilitate installation, maintenance and, if necessary, replacement. Enclosure to be painted Munsell#7.0GY 3.29/1.5 and meet ANSI C57.12.28.

Factory filled with SF6 gas.

Removable Operating handles with padlock provision in the open and closed position, capable of operation by hookstick or rope with direction of movement clearly indicated.

One (1) removable fiberglass operating handle

Stainless steel nameplates providing information including ratings, contact position indication, circuit configuration and phase identification.

Colour coded pressure gauge for visual indication of normal operating range, enclosed in a protective housing to prevent damage.

Viewing window which provides fault interrupter position status.

Brass fill valve for field addition of SF6 protected and sealed with a removable cap.

Clamp type ground lugs, one for each set of bushings.

Stainless steel switch tank for maximum corrosion resistance.

200 Amp deepwell or 600 Amp apparatus welded bushings, with protective shipping caps (elbows and inserts furnished by Contractor).

Lifting and mounting provisions.

Parking stands on 200 Amp ways.

Motor-operators for SCADA switching.

Motor-operators, voltage and current sensors for Automatic Load Transfer switching.

Fault interrupter remote status.

Resettable Fault Interrupters with vacuum fluorescent display control box and trip unit.

Canada Power Products Trip Controls for Resettable Fault Interrupters.

Dual ratio 600:0.5A and 200:0.5A current transformers for Canada Power Products Trip Controls.

Potential Transformers for control and monitoring equipment, including conductors and loadbreak elbows.

Window for RFI close-open position indication.

Item: 2   S160-13-A Replacement    Quantity: 1

Manufacturer: Canada Power Products, no other equal.
Medium Voltage SF6 Switch

Description:

- 15KV, 95KV BIL
- 3-600A PufferPak switched ways, 3-RFI 200A ways.
- 3 phase, 2 position (open-close)
- Padmount Enclosure will be 12-gauge mild steel, tamper-resistant single side access with 3-point latch, double doors and a hinged hood. Equipped with stainless steel hardware, wind stops, padlock provisions and a penta-head bolt. The enclosure will be completely removable from the switch to facilitate installation, maintenance and, if necessary, replacement. Enclosure to be painted Munsell#7.0GY 3.29/1.5 and meet ANSI C57.12.28.
- Factory filled with SF6 gas.
- Removable Operating handles with padlock provision in the open and closed position, capable of operation by hookstick or rope with direction of movement clearly indicated.
- One (1) removable fiberglass operating handle
- Stainless steel nameplates providing information including ratings, contact position indication, circuit configuration and phase identification.
- Color coded pressure gauge for visual indication of normal operating range, enclosed in a protective housing to prevent damage.
- Viewing window which provides fault interrupter position status.
- Brass fill valve for field addition of SF6 protected and sealed with a removable cap.
- Clamp type ground lugs, one for each set of bushings.
- Stainless steel switch tank for maximum corrosion resistance.
- 200 Amp deepwell or 600 Amp apparatus welded bushings, with protective shipping caps (elbows and inserts furnished by Contractor).
- Lifting and mounting provisions.
- Parking stands on 200 Amp ways.
- Motor-operators for SCADA switching.
- Motor-operators, voltage and current sensors for Automatic Load Transfer Switching.
- Fault interrupter remote status.
- Resettable Fault Interrupters with vacuum fluorescent display control box and trip unit.
- Canada Power Products Trip Controls for Resettable Fault Interrupters.
- Dual ratio 600:0.5A and 200:0.5A current transformers for Canada Power Products Trip Controls.
• Potential Transformers for control and monitoring equipment, including conductors and loadbreak elbows.
• Window for RFI close-open position indication.

F. Ratings:
1. Ratings for all integrated pad-mounted gear shall be as shown below:
   a. kV, Nominal Operating Voltage: 12.47
   b. kV, Maximum Rated: 15
   c. kV, BIL 95
   d. Main Bus Continuous, Amperes 600
   e. Three-Pole Interrupter Switches:
      1) Line Switches, Amperes 600
      2) Momentary Ratings (ASYM) 40 KA
      3) Fault-Close Current (ASYM) 40 KA
      4) One Second Rating (SYM) 25 KA
      5) Rated Frequency 60 Hz.
   f. Resettable Fault Interrupter Ratings:
      1) Tap Switches, Amperes 200
      2) Momentary Ratings (ASYM) 19.2 KA
      3) Fault-Close Current (ASYM) 19.2 KA
      4) One Second Rating (SYM) 12 KA
      5) Rated Frequency 60 Hz.

G. Enclosure:
1. Pad-mounted gear enclosed shall be unitized monocoque (not structural-frame-and bolted-sheet) construction of 11-ga hot-rolled, pickled and oiled steel sheet to maximize strength, minimize weight, and inhibit corrosion. Structural joints and butt joints shall be welded and external seams shall be ground flush and smooth. Gas-metal-arc welding process shall be employed to eliminate alkaline residues and to minimize distortion and spatter.
2. Base shall consist of continuous 90-degree flanges, turned inward and welded at corners, for bolting to concrete pad.
3. Door openings shall have 90 degree flanges, facing outward, that shall provide strength and rigidity as well as deep overlapping between doors and door openings to guard against water entry.
4. Gasketing shall be provided between roof and enclosure to guard against entry of water and airborne contaminants and shall discourage tampering or insertion of foreign objects.

5. Provide heavy coat of insulating "no-drip" compound to inside surface of roof to minimize moisture condensation.

H. Doors:

1. Doors shall be constructed of 11-ga hot-rolled, pickled and oiled steel sheet.

2. Door-edge flanges shall overlap with door-opening flanges to discourage tampering or insertion of foreign objects.

3. Doors shall have minimum of 2 stainless steel hinges with stainless-steel hinge pins and interlocking hinge supports for full length of door to provide strength, security, and corrosion resistance. Mounting hardware shall be stainless steel and shall not be externally accessible to guard against tampering.

4. Doors shall be hinged at sides to swing open with minimum effort. Doors hinged at top requiring significant effort to lift open shall not be allowed.

5. In consideration of controlled access and tamper resistance, each door (or set of double doors) shall be equipped with automatic three-point latching mechanism.

6. Pentahead socket wrench or tool shall be required to unlatch door.

7. Latching mechanism shall have provisions for padlocking that incorporate a means to protect padlock shackle from tampering and shall be coordinated with the latches such that:

   a. It shall not be possible to unlatch mechanism until padlock is removed and it shall not be possible to insert padlock until mechanism is completely latched closed.

8. Provide each door with galvanized steel door holder located above door opening. Holder shall be hidden from view when door is closed and it shall not be possible for holder to swing inside enclosure.

I. Finish:

1. After pretreatment, protective coatings shall be applied to resist corrosion and protect steel enclosure. To establish capability of finishing system to resist corrosion and protect the enclosure, representative test specimens shall satisfactorily pass the following tests:

   a. 4000 hrs of exposure to salt-spray testing per ASTM B 117 with underfilm corrosion not to extend more than 1/32" from scribe and loss of adhesion from bare metal not to extend more than 1/8" from scribe.

   b. 1000 hrs of humidity testing per ASTM D 2247 with no blistering as evaluated per ASTM D 714.
c. 500 hrs of accelerated weathering testing per ASTM G 53 with no chalking as evaluated per ASTM D 659 and no more than 15% reduction of gloss as evaluated per ASTM D 523.
d. Crosshatch adhesion testing per ASTM D 3359 Method B with no loss of finish.
e. 160-inch-pound impact adhesion testing per ASTM D 2794 with no chipping or cracking.
f. Scab corrosion testing for 35 cycles with exposure to specific salt mist, temperature, and relative humidity conditions for designated time intervals followed by air blow-off adhesion test per ASTM D 1654 with creepage from scribe not to extend more than 1/16" and no unusual surface failure.
g. Oil resistance testing consisting of 72-hour immersion bath in mineral oil with no shift in color, no streaking, no blistering, and no loss of hardness.
h. 3000 cycles of abrasion testing per ASTM 4060 with no penetration to substrate.

2. Certified test abstracts substantiating above capabilities shall be furnished upon request.

3. After finishing system has been properly applied and cured, welds along enclosure bottom flange shall be coated with wax-based anticorrosion moisture barrier for added corrosion resistance.

4. Finish shall be olive green, Munsell 7GY3.29/1.5

5. To guard against corrosion, hardware (including door fittings, fasteners, etc.), operating-mechanism parts, and parts subject to abrasive action from mechanical motion, shall be of stainless-steel materials. Do not use Cadmium-plated ferrous parts.

6. Enclosure shall conform to requirements of ANSI C57.12.28 for degree of tamper resistance.

J. Bushings and Bushing Wells:


2. Bushings and bushing wells shall be cycloaliphatic epoxy resin with characteristics and restrictions as follows:
   a. Operating experience of at least 10 years under similar conditions.
   c. Adequate strength for short-circuit stress established by test.
   d. Conformance with applicable ANSI standards.
e. Homogeneity of cycloaliphatic epoxy resin throughout each bushing or bushing well to provide maximum resistance to power arcs. Ablation due to high temperatures from power arcs shall continuously expose more material of same composition and properties so no change in mechanical or electrical characteristics takes place because of arc-induced ablation.

3. Bushings and bushing wells shall be mounted so semiconductive coating is solidly grounded to the enclosure.

4. Bushings rated 600 amp continuous shall have removable threaded stud so bushings are compatible with 600-amp elbow systems - those requiring a threaded stud as well as those that do not.

K. Terminiations

1. Termination compartments for bus shall have bushing wells to permit connection of elbows. Bushing wells shall be mounted on interior wall at minimum height of 25” above enclosure base. All terminations shall be accessible and 36” unobstructed.

2. Termination compartments for bushings rated 600 amp continuous shall be of adequate depth to accommodate two 600-amp elbows mounted piggyback, encapsulated surge arresters or grounding elbows mounted on 600-amp elbows having 200-amp interfaces, or other similar accessory combinations without need for an enclosure extension.

3. Termination compartments for bushing wells rated 200 amperes continuous shall be of an adequate depth to accommodate 200-ampere elbows mounted on portable feedthrus or standoff insulators, or other similar accessory combinations without need for an enclosure extension.

4. Termination compartments shall be provided with one parking stand for each bushing or bushing well. Parking stand shall be located immediately adjacent to associated bushing or bushing well and shall accommodate standard feed-thru and standoff insulators, and other similar accessories. 200A positions shall accommodate installation of bushing CT’s without field modification.

5. Equip each termination compartment for switch with viewing window to allow visual inspection of interrupter switch blades and allow positive verification of switch position.

L. Interrupter Switches:

1. Interrupter switches shall be enclosed in inner steel compartment and shall be provided with bushings rated 600 amp continuous to permit connection of elbows external to switch compartment.

2. Resettable Fault Interrupter switches shall have two-time duty-cycle fault-closing rating equal to or exceeding short-circuit rating of pad-mounted gear. Ratings shall define ability to close interrupter switch twice against 3-phase fault with asymmetrical current in at least one phase equal to rated value, with switch
remaining operable and able to carry and interrupt rated current. Tests substantiating these ratings shall be performed at maximum voltage with current applied for at least 10 cycles.

3. Interrupter switches shall be externally operable. Each switch shall be padlockable. Stops shall be provided to prevent over travel and guard against damage to interrupter switch quick-make quick-break mechanism. Provide labels to indicate switch position in switch operating-hub packet.

4. Each interrupter switch shall be provided with folding switch-operating angle. Switch-operating handle shall be secured to inside of switch-operating-hub pocket by brass chain. Folded handle shall be stored behind closed switch-operating-hub access cover.

5. SF6 gas shall be used as a dielectric and interrupting medium.

6. A brass SF6 fill valve, protected and sealed with a removable cap, shall be located on the switch front panel.

7. Viewing windows shall be provided for positive confirmation of visible break of switch operator positions.

8. Interrupter switches shall use quick-make quick-break mechanism installed by switch manufacturer. Quick-make quick-break mechanism shall be integrally mounted on switch frame, and shall swiftly and positively open and close interrupter switch independent of switch-operating-hub speed.

9. Each interrupter shall be completely assembled and adjusted by switch manufacturer on single rigid mounting frame. Frame shall be welded steel construction such that frame intercepts leakage path which parallels open gap of interrupter switch to positively isolate load circuit when interrupter switch is in the open position.

10. Interrupter switch contacts shall be backed up by stainless steel springs to provide constant high contact pressure.

11. Provide interrupter switches with single blade per phase for circuit closing including fault current, continuous current carrying, and circuit interrupting. Spring-loaded auxiliary blades shall not be permitted. Interrupter switch blade supports shall be permanently molded in place in a unified insulated shaft constructed of same cycloaliphatic epoxy resin as insulators.

12. Circuit interruption shall be accomplished by use of interrupter which is positively and inherently sequenced with blade position. It shall not be possible for blade and interrupter to get out of sequence. Circuit interruption shall take place completely within interrupter, with no external arc or flame. Any exhaust shall be vented in controlled manner through deionizing vent.

13. Switch operators shall be manually operable in the event of loss of control power. The operator mechanism shall be located on the outside of the switch tank and shall be easily replaceable.
14. The switch tank shall be hermetically sealed and filled with SF6 gas to a pressure of 10 psig. A permanent style pressure gauge shall be installed on the unit for verification of positive pressure. The tank shall be constructed of stainless steel with all welded construction.

M. Fuses:

1. Fusible elements shall be non-aging and non-damageable so it is unnecessary to replace unblown companion fuses on suspicion of damage following a fuse operation.
2. Arcing accompanying fuse operation shall be contained within fuse, and arc products and gases shall be contained within exhaust control device during fuse operation.
3. Fusible elements for refill units or fuse units shall be helically coiled to avoid mechanical damage due to stresses from current surges.
4. Fusible elements, that carry continuous current, shall be supported in air to help prevent damage.
5. To protect fuse-handling mechanism from corrosion, all mechanism parts shall be painted or made of corrosion-resistant materials, or otherwise be protected from corrosion. Latches and pivots shall be stainless steel or zinc-nickel plated steel with nylon or plastic bushings.
6. Opening into component compartment shall be covered by fuse-access panel in both open and closed positions to help prevent inadvertent access to high voltage.
7. Access to fuse sections shall be such that replacement of fuses in one compartment shall not require opening of interrupter switch.
8. Cable guides shall be provided in each termination compartment for a set of fuses to prevent cable from interfering with rotation of fuse-access panel.
9. Provide fuse-handling tool as recommended by fuse manufacturer.
10. Provide spare set of fuses for each potential transformer.
11. Fuses shall be accessible without having to de-energize or disassemble the switch.

N. Controls:

1. Each 200A RFI switch shall be equipped with one (1) electronic power fuse and relay emulator with three (3) bushing mounted window type current transformers.
2. Overcurrent sensing shall be accomplished with an electronic trip control. The control shall be Canada Power Products (no acceptable equal). The controls shall use current transformers external to the tank to sense the load currents. The current transformers will provide power to the electronic trip control. No external power shall be required. The current transformers shall be dual ratio 600:0.5A and 200:0.5A. In order to provide immunity to system voltage disturbances (i.e.
transients) the control will not be sensitive to system voltage conditions. The control shall be fully operable and meet the specified time-current curves when energized. Trip controls shall include a vacuum fluorescent display (VFD) with keypad as the user interface.

3. The VFD shall be legible at $-40^\circ C$ without the need for a heater (Operating range $-40^\circ C$ to $+65^\circ C$). The external current transformers on the switch will energize the display, when load current is flowing. In the event the switch is de-energized, a 9V-lithium battery shall be included to allow operation of the display and keypad for data gathering and parameter setting. The keypad shall be used to select the following parameters: TCC Fuse Curves, TCC Fuse Rating, Instantaneous Trip, Ground Fault Pick-Up, Ground Fault Delay and Protection Mode. The VFD shall display the above data as well as the cause of trip. The electronic control shall have the ability to store up to 64 different TCC curves. Trip selection to be available in 12 positions from 10 to 450 amps.

4. Instantaneous trip values shall be in multiples of 1.5-12 times the current transformers primary ratings in increments of 50% of the current transformer primary rating with values from 300A to 7200A. Ground fault trip settings shall range from 10-30% of the current transformer primary rating in increments of 5% of the current Transformer primary rating. Ground fault time delay shall be selectable in 10 settings from .05 to 1.0 seconds.

5. A RS232 port shall be provided for communication with external devices.

6. A manual trip button shall be supplied to electrically trip the interrupter. Provisions for remote trip shall be provided.

2.02 LABELING

A. External doors and hinged bolted panels providing access to high voltage shall be provided with "Danger - High Voltage - Keep Out" signs. Internal doors shall be provided with warning signs indicating, "Switch Blades may be Energized in any Position".

B. SF6 switch assembly shall be provided with nameplate indicating the manufacturer's drawing number and the following: voltage ratings (KV nominal; KV, maximum design; KV, BIL); main bus continuous rating (amperes); short-circuit ratings (amperes, rms symmetrical and MVA three-phase symmetrical at rated nominal voltage); and the monetary and fault-closing ratings (amperes, rms asymmetrical).

C. Submit identification labels for switch, switch ways, cable terminations, and all other required labels to Owner for approval as required in Section 16030. Owner reserves the right to modify identification label prior to approval of shop drawings or labels.

PART 3 - EXECUTION
3.01 INSPECTION

A. Visually inspect equipment and components at time of delivery. Replace damaged components at no additional cost to Owner.

3.02 INSTALLATION

A. Contractor to install equipment per manufacturer’s recommendations and as indicated. Coordinate final locations of equipment with Owner and General Contractor and review final locations with Engineer prior to setting equipment.

B. Switch tanks, mounting frames and operating mechanisms shall be solidly bonded to the station ground counterpoise in accordance with ANSI C37.72 and Section 16450.

C. Protect equipment during installation to prevent twisting or deformations, exposure to damaging environments, and work of other trades. Maintain protection until completion of construction.

D. Equipment shall have passed applicable acceptance tests before energization as required in the project specification Section 26 05 53.

3.03 ADJUSTMENTS AND CLEANING

A. Immediately prior to final inspection, make final adjustments and thoroughly clean equipment. Refinish damaged enclosures to original quality.

B. Provide painted covers and hardware with reinforcement against deflection to close openings in all SF6 switch support structures. All corroded covers shall be replaced with new covers and new fastening hardware. Stainless Steel hardware shall be used in all outdoor and wet areas and where subject to flooding. Paint color to match existing.

3.04 ACCEPTANCE TESTING

A. Inspect, test and submit test reports on equipment and work in accordance with Section 26 05 53 of this specification and manufacturer’s recommendations. Apply settings to all trip units and electronic controls in accordance with the Owner’s Coordination Study. Request settings four weeks prior to performing any tests and making any settings. Adjust or replace equipment as needed to comply with manufacturer’s specifications and submit new test reports.

END OF SECTION 26 05 45
PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Provide all work required to list, procure, fabricate and install all nameplates, labels, tags, and identifiers for power and communications cable and equipment shown on the drawings.

B. Complete all acceptance and start-up tests for power and communications cabling and equipment. For additional requirements refer to Division 27 Section, Voice and Data Communication.

C. The work includes planning, listing of all identifiers, installation, testing of all cable and equipment and documentation.

1.02 SUBMITTALS

A. Test Reports: In accordance with Division 1 requirements.

1.03 DEFINITION

A. Circuit designation: This term is construed to mean panel designation and circuit number, i.e.: LA-13.

1.04 SAFETY AND PRECAUTIONS

A. All parties involved must be cognizant of applicable safety procedures. This document does not include any procedures, including specific safety procedures. It is recognized that an overwhelming majority of the tests and inspections recommended in these specifications are potentially hazardous. Individuals performing these tests shall be capable of conducting the tests in a safe manner and with complete knowledge of the hazards involved.

B. Safety practices shall include, but are not limited to, the following requirements:

1. All applicable provisions of the Occupational Safety and Health Act, particularly OSHA 29CFR 1910.


3. Applicable state and local safety operating procedures.

4. Owner’s safety practices.

5. ANSI/NFPA 70E, Standard for Electrical Safety Requirements for Employee Workplaces.

C. A safety lead person shall be identified prior to commencement of work.
D. A safety briefing shall be conducted prior to the commencement of work.

E. All tests shall be performed with the apparatus de-energized and grounded except where otherwise specifically required to be ungrounded or energized for certain tests.

F. The testing organization shall have a designated safety representative on the project to supervise operations with respect to safety.

1.05 SYSTEM FUNCTION TESTS

A. It is the purpose of system function tests to prove the correct interaction of all sensing, processing, and action devices.

B. Perform system function tests upon completion of the acceptance tests on specified equipment.
   1. Develop test parameters and perform tests for the purpose of evaluating performance of all integral components and their functioning as a complete unit within design requirements and manufacturer’s published data.
   2. Verify the correct operation of all interlock safety devices for fail-safe functions in addition to design function.
   3. Verify the correct operation of all sensing devices, alarms, and indicating devices.

1.06 THERMOGRAPHIC SURVEY

A. Equipment to be inspected shall include all current-carrying devices.
   1. Visual and Mechanical Inspection
      a. Perform thermographic survey when load is applied to the system.
      b. Remove all necessary covers prior to thermographic inspection. Use appropriate caution, safety devices, and personal protective equipment.
   2. Provide a report which includes the following:
      a. Description of equipment to be tested.
      b. Discrepancies.
      c. Temperature difference between the area of concern and the reference area.
      d. Probable cause of temperature difference.
      e. Areas inspected. Identify inaccessible and/or unobservable areas and/or equipment.
      f. Identify load conditions at time of inspection.
      g. Provide photographs and/or thermograms of the deficient area.
      h. Recommended action.
3. Test Parameters
   a. Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1°C at 30°C.
   b. Equipment shall detect emitted radiation and convert detected radiation to visual signal.
   c. Thermographic surveys should be performed during periods of maximum possible loading. Refer to ANSI/NFPA 70B, Section 20.17.

4. Test Results
   a. Suggested actions based on temperature rise can be found in NETA-ATS Table 100.18.

1.07 TESTS AND ADJUSTMENTS

A. All test equipment shall be in good mechanical and electrical condition.
   1. The testing organization shall have a calibration program which assures that all applicable test instruments are maintained within rated accuracy for each test instrument calibrated.
   2. The firm providing calibration service shall maintain up-to-date instrument calibration instructions and procedures for each test instrument calibrated.
   3. The accuracy shall be directly traceable to the National Institute of Standards and Technology (NIST).
   4. Instruments shall be calibrated in accordance with the following frequency schedule:
      a. Field instruments: Analog, 6 months maximum. Digital, 12 months maximum.
      b. Laboratory instruments: 12 months maximum.
      c. Leased specialty equipment: 12 months maximum.
      d. Dated calibration labels shall be visible on all test equipment.
      e. Records, which show date and results of instruments calibrated or tested, must be kept up to date.
   5. Calibrating standard shall be of better accuracy than that of the instrument tested.

B. Field test metering used to check power system meter calibration must be more accurate than the instrument being tested.

C. Accuracy of metering in test equipment shall be appropriate for the test being performed.
D. Waveshape and frequency of test equipment output waveforms shall be appropriate for the test and the tested equipment.

E. Testing and adjustments of equipment shall be made by an Owner-approved independent testing firm. Testing firm shall meet the criteria for full membership of the International Electrical Testing Association (NETA). All equipment acceptance tests for power apparatus shall be made in accordance with the latest version of NETA-ATS, Acceptance Testing Specification. Submit testing firm qualifications to Owner for approval.

F. Prior to energizing, test all systems. Test to ensure systems are:
   1. Free from short circuits and grounds.
   2. Free from mechanical and electrical defects.

G. Adjust all equipment for its intended use and rating as defined in manufacturer's specifications and test procedures.

H. Adjust distribution transformer taps under full load operating conditions, to provide nominal operating voltages at the loads. (+5% for light loads, nominal at full load).

I. Ground systems:
   1. Visual and mechanical inspection: Verify ground system is in compliance with Drawings and Specifications.
   2. Electrical tests:
      a. Perform fall-of-potential test or alternative in accord with IEEE 81, latest version, on the main grounding electrode or system.
      b. Perform point-to-point tests to determine resistance between main grounding system and all major electrical equipment frames, system neutral, and/or derived neutral points.
   3. Test values:
      a. The resistance between main grounding electrode and ground shall be no greater than 10 ohms. Additional rods shall be installed and bonded to grounding system and driven to a depth of 50 ft. or refusal, whichever comes first.
      b. Investigate point-to-point resistance values which exceed 0.5 ohm.
      c. Record all test values and provide certified copies to Owner.

J. Cable Insulation Resistance Test:
1. Make insulation resistance tests on all power cables using a self-contained instrument such as the direct-indicating ohmmeter of the generator type, or “megger” such as manufactured by J.G. Biddle Company, or Owner-approved equivalent. Insulation resistance values shall be at least 75% of shop test records.
   
a. Apply the following test voltages for 1 minute, except where specified otherwise herein, in accord with procedure recommended by manufacturer of test equipment and as specified herein.

<table>
<thead>
<tr>
<th>Rated Circuit Voltage</th>
<th>Megger Voltage (DC)</th>
<th>Minimum Megger Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>600 volts</td>
<td>500 volts</td>
<td>600 kilohms</td>
</tr>
<tr>
<td>4160 volts</td>
<td>2500 volts</td>
<td>1000 megohms</td>
</tr>
<tr>
<td>15,000 volts</td>
<td>5000 volts</td>
<td>5000 megohms</td>
</tr>
</tbody>
</table>

2. Record all test values and provide certified copies to Owner.

3. Replace cables not meeting specified resistance values.

K. Medium-voltage cables:

1. Visual and mechanical inspection before testing cables:
   a. Compare cable data with Drawings and Specifications.
   b. Inspect exposed sections of cables for physical damage.
   c. Inspect for shield grounding, cable support, and terminations when cables are disconnected from any apparatus. Cables shall be positioned to minimize surface leakage current and corona.
   d. Verify that visible cable bends meet manufacturer’s minimum allowable bending radius.
   e. Inspect for adequate fireproofing in common cable areas.
   f. Visually inspect splice jacket and insulation condition.

2. Electrical tests:
   a. Perform a shield-continuity test on each power cable by ohmmeter method.
   b. Perform an insulation-resistance test utilizing a megohmmeter with a voltage output of at least 2500 volts. Individually test each conductor with all other conductors and shields grounded. Test duration shall be 1 minute.
c. Perform a DC high-potential test on all cables. Adhere to all precautions and limits as specified in the applicable NEMA/ICEA standard for the specific cable. Perform tests in accord with ANSI/IEEE 400. Test procedure shall be as follows, and the results for each cable test shall be recorded as specified herein. Test voltage shall be 50 Kv but shall not exceed 80% of cable manufacturer's factory test value or the maximum test voltage of 55 kV.

1) Ensure that the input voltage to the test set is regulated.

2) Current-sensing circuits in test equipment shall measure only the leakage current associated with the cable under test and shall not include internal leakage of the test equipment.

3) Record wet- and dry-bulb temperatures or relative humidity and temperature.

4) Test each section of cable individually.

5) Individually test each conductor with all other conductors grounded. Ground all shields.

6) Terminations shall be adequately corona-suppressed by guard ring, field reduction sphere, or other suitable methods as necessary.

7) Ensure that the maximum test voltage does not exceed the limits for terminators specified in IEEE 48 or manufacturer’s specifications.

8) Apply a DC high-potential test in at least five equal increments until maximum test voltage is reached. No increment shall exceed the voltage rating of the cable. Record DC leakage current at each step after a constant stabilization time consistent with system charging current.

9) Raise the conductor to the specified maximum test voltage and hold for 15 minutes on shielded cable. Record readings of leakage current at 30 seconds and 1 minute, and at 1 minute intervals thereafter.

10) Gradually reduce the conductor test potential to zero and measure residual voltage at discrete intervals.

11) Apply grounds for a time period of at least 60 minutes and adequate to drain all insulation stored charge.

3. Test values:

a. Shielding shall exhibit continuity. Investigate resistance values in excess of 10 ohms per 1000 ft. of cable.

b. Investigate any failed high-potential test.

c. Record all test values and report of repairs made and provide certified copies to Owner.
L. Transformers Dry-Type

1. Visual and Mechanical Inspection:
   a. Compare equipment nameplate data with drawings and specifications.
   b. Inspect physical and mechanical condition.
   c. Verify removal of any shipping bracing after final placement.

2. Inspect all bolted electrical connections for high resistance using one of the following methods:
   a. Use of low-resistance ohmmeter in accordance with Section 5 (Electrical Tests).
   b. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer’s published data.
   c. Perform thermographic survey.

3. Perform specific inspections and mechanical tests as recommended by manufacturer.

4. Verify correct equipment grounding.

5. Electrical Tests:
   a. Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable, in accordance with Section 1 (Visual and Mechanical Inspection).
   b. Perform insulation-resistance tests, winding-to-winding and each winding-to-ground.
   c. Calculate polarization index.
   d. Perform turns-ratio tests at all tap positions.
   e. Perform winding resistance tests on all tap positions.

6. Test Values:
   a. Compare bolted connection resistance to values of similar connections.
   b. Bolt-torque levels should be as 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. Insulation-resistance test values at one minute should not be less than 5000 megohms.

e. The polarization index shall be greater than 1.5 and shall be recorded for future reference.

f. Turns-ratio test results shall not deviate more than one-half percent from either the adjacent coils or the calculated ratio.

g. Windings-resistance test results, after factoring in temperature correction, should compare within one percent of factory obtained results except in instances of extremely low resistance values.

M. Transformers, Liquid Filled

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 presence of PCB content labeling.
   e. Verify removal of any shipping bracing after placement.
   f. Verify the bushings are clean.
   g. Inspect impact recorder prior to unloading, if applicable.
   h. Test dew point of tank gases, if applicable.
   i. Verify that alarm, control, and trip settings on temperature and level indicators are as specified.
   j. Verify that cooling fans and/or pumps operate correctly and that fan and pump motors have correct overcurrent protection, if applicable.
   k. Verify operation of alarm, control, and trip circuits from temperature and level indicators, pressure relief device, gas accumulator, and fault pressure relay, if applicable.
   l. Inspect bolted electrical connections for high resistance using one of the following methods:
      1) Use of low-resistance ohmmeter.
      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.
      3) Perform thermographic survey.
m. Verify correct liquid level in tanks and bushings.

n. Verify that positive pressure is maintained on gas-blanketed transformers.

o. Perform inspections and mechanical tests as recommended by the manufacturer.

p. Test load tap-changer if applicable.

2. Electrical Tests

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable.

b. Perform insulation-resistance tests, winding-to-winding and each winding-to-ground, with test voltage in accordance with NETA-ATS Table 100.5. Calculate polarization index.

c. Perform turns-ratio tests at all tap positions.

d. Perform excitation-current tests in accordance with test equipment manufacturer’s published data.

e. Measure the resistance of each high-voltage winding in each no-load tap-changer position. Measure the resistance of each low-voltage winding in each load tap-changer position, if applicable.

f. Remove a sample of insulating liquid in accordance with ASTM D 923. Sample shall be tested for the following.

1) Dielectric breakdown voltage: ASTM D 877 and/or ASTM D 1816
2) Acid neutralization number: ANSI/ASTM D 974
3) Interfacial tension: ANSI/ASTM D 971 or ANSI/ASTM D 2285
4) Color: ANSI/ASTM D 1500
5) Visual Condition: ASTM D 1524
6) 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.

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. 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. Insulation-resistance test values at one minute should be in accordance with NETA-ATS Table 100.5.

e. The polarization index shall be greater than 1.0 and shall be recorded for future reference.

f. Turns-ratio test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio.

g. Temperature corrected winding-resistance measurements should compare within one percent of factory obtained results.

h. Core insulation values should not be less than 1.0 megohm at 500 volts dc.

i. Insulating liquid test results shall be in accordance with NETA-ATS Table 100.4.

j. Evaluate results of dissolved-gas analysis in accordance with ANSI/IEEE C57.104. Use results as baseline for future tests.

k. Compare grounding impedance device results to manufacturer’s published data.

N. Switchgear and Switchboard Assemblies

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.

e. Verify that fuse and/or 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 current and voltage transformer ratios correspond to drawings.

g. Inspect bolted electrical connections for high resistance using one of the following methods:

   (1) Use of low-resistance ohmmeter.

   (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.
(3) Perform thermographic survey.

h. Confirm correct operation and sequencing of electrical and mechanical interlock systems.

(1) Attempt closure on locked-open devices. Attempt to open locked-closed devices.
(2) Make key exchange with devices operated in off-normal positions.

i. Lubrication requirements

(1) Verify appropriate lubrication on moving current-carrying parts.
(2) Verify appropriate lubrication on moving and sliding surfaces.

j. Inspect insulators for evidence of physical damage or contaminated surfaces.

k. Verify correct barrier and shutter installation and operation.

l. Exercise all active components.

m. Inspect mechanical indicating devices for correct operation.

n. Verify that filters are in place and/or vents are clear.

o. Perform visual and mechanical inspection of instrument transformers.

p. Inspect control power transformers.

(1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
(2) Verify that primary and secondary fuse or circuit breakers ratings match drawings.

q. Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.

2. Electrical Tests

a. Perform electrical tests on instrument transformers in accordance with Section 7.10.

b. Perform ground-resistance tests in accordance with Section 7.13.

c. Perform resistance measurements through bolted electrical connections with a low-resistance ohmmeter, if applicable, in accordance with Section 7.1.1.

d. 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.

e. Perform an overpotential test on each bus section, each phase to ground with phases not under test grounded, in accordance with manufacturer’s published data. If manufacturer has no recommendation for this test, it shall be in accordance with NETA-ATS Table 100.2. The test voltage shall be applied for one minute.
f. Perform insulation-resistance tests on 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 or control devices that can not tolerate the applied voltage, follow manufacturer’s recommendation.

g. Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 ampere flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.

h. Determine accuracy of all meters and calibrate watthour meters in accordance with Section 7.11. Verify multipliers.

i. Perform phasing check on double-ended or dual-source switchgear to insure correct bus phasing from each source.

j. Control Power Transformers

   (1) Perform insulation-resistance tests. Perform measurements from winding-to-winding and each winding-to-ground. Test voltages shall be in accordance with NETA-ATS Table 100.1 unless otherwise specified by manufacturer.

   (2) Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to a rated secondary voltage source. Verify correct potential at all devices.

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

   (4) Verify correct function of control transfer relays located in switchgear with multiple control power sources.

k. Voltage Transformers

   (1) Perform insulation-resistance tests. Perform measurements from winding-to-winding and each winding-to-ground. Test voltages shall be in accordance with NETA-ATS Table 100.1 unless otherwise specified by manufacturer.

   (2) Perform secondary wiring integrity test. Verify correct potential at all devices.

   (3) Verify secondary voltages by energizing primary winding with system voltage.

l. Verify operation of cubicle switchgear/switchboard space heaters.

3. Test Values

   a. Compare bus 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 bus by more than 50 percent of the lowest value.

d. Insulation-resistance values for bus and control power transformers 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 minimum should be investigated. Overpotential tests should not proceed until insulation-resistance levels are raised above minimum values.

e. Bus insulation shall withstand the overpotential test voltage applied.

f. Insulation-resistance values for control wiring shall be a minimum of 2.0 megohms.

O. Switches, Air, Medium Voltage, Metal-Enclosed

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 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.

   (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.

   (3) Perform thermographic survey.

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 Tests
   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable.
   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 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.

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 should 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 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 NETA-ATS Table 100.1.
   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.

P. Capacitors
   1. Visual and Mechanical Inspection
Tests and Identification

a. Compare equipment nameplate data with drawings and specifications.

b. Inspect physical and mechanical condition.

c. Inspect anchorage, alignment, and grounding.

d. Verify the units are clean.

e. Verify that capacitors are electrically connected in their specified configuration.

f. Inspect bolted electrical connections for high resistance using one of the following methods:
   (1) Use of low-resistance ohmmeter.
   (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.
   (3) Perform thermographic survey.

2. Electrical Tests

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable.

b. Perform insulation-resistance tests from phase terminal(s) to case for one minute. Test voltage and minimum resistance shall be in accordance with manufacturer’s published data or NETA-ATS Table 100.1.

c. Measure the capacitance of all terminal combinations.

d. Confirm automatic discharging in accordance with NFPA 70 National Electrical Code Article 460.

3. Test Values

a. Compare bolted connection resistances to values of similar connections.

b. Bolt-torque levels should be in accordance with 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. Insulation-resistance values should be in accordance with Table 100.1.

e. Investigate capacitance values differing from manufacturer’s published data.
f. In accordance with NFPA 70 National Electrical Code Article 460, residual voltage of a capacitor shall be reduced to 50 volts after being disconnected from the source of supply:

<table>
<thead>
<tr>
<th>Rated Voltage</th>
<th>Discharge Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; or = to 600 volts</td>
<td>1 minute</td>
</tr>
<tr>
<td>&gt; 600 volts</td>
<td>5 minutes</td>
</tr>
</tbody>
</table>

Q. Direct-Current Batteries, Valve-Regulated Lead Acid

1. Visual and Mechanical Inspection
   a. Verify ventilation of battery room or enclosure.
   b. Compare equipment nameplate data with drawings and specifications.
   c. Inspect physical and mechanical condition.
   d. Inspect anchorage, alignment, and grounding.
   e. Verify adequacy of battery support racks or cabinets, mounting, anchorage, and clearances.
   f. Verify the units are clean.
   g. Verify the application of an oxide inhibitor on battery terminal connections.
   h. Inspect bolted electrical connections for high resistance using one of the following methods:
      (1) Use of low-resistance ohmmeter.
      (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.
      (3) Perform thermographic survey.

2. Electrical Tests
   a. Perform resistance measurements through all bolted connections with a low-resistance ohmmeter, if applicable.
   b. Measure negative post temperature.
   c. Measure charger float and equalizing voltage levels.
   d. Verify all charger functions and alarms.
e. Measure each monoblock/cell voltage and total battery voltage with charger energized and in float mode of operation.

f. Measure intercell connection resistances.

g. Perform internal ohmic measurement tests.

3. Test Values

a. Compare bolted connection resistances to values of similar connections.

b. Bolt-torque levels shall be in accordance with manufacturer’s published data.

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. Charger float and equalize voltage levels shall be in accordance with the battery manufacturer’s published data.

e. Monoblock/cell voltages should be in accordance with manufacturer’s published data.

f. Monoblock/cell internal ohmic values (resistance, impedance, or conductance) should not vary by more than 25 percent between identical monoblocks/cells that are in a fully charged state.

R. Direct-Current Systems, Chargers

1. Visual and Mechanical Inspection

a. Compare equipment nameplate data with drawings and specifications.

b. Inspect for physical and mechanical condition.

c. Inspect anchorage, alignment, and grounding.

d. Verify the unit is clean.

e. Inspect all bolted electrical connections for high resistance using one of the following methods:

   (1) Use of low-resistance ohmmeter.

   (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.

   (3) Perform thermographic survey under load.

f. Inspect filter and tank capacitors.
(1) Verify operation of cooling fans. Clean filters if provided.

2. Electrical Tests
   a. Perform resistance measurements through all bolted connections with a low-resistance ohmmeter, if applicable.
   b. Verify float voltage, equalize voltage, and high voltage shutdown settings.
   c. Verify current limit.
   d. Verify correct load sharing (parallel chargers).
   e. Verify calibration of meters.
   f. Verify operation of alarms.
   g. Measure and record input and output voltage and current.
   h. Measure and record AC ripple current and/or voltage imposed on the battery.

3. Test Values
   a. Compare bolted connection resistances to values of similar connections.
   b. Bolt-torque levels shall be in accordance with manufacturer’s published data or NETA-ATS Table 100.12.
   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. Float and equalize voltage settings shall be in accordance with the battery manufacturer’s published data.
   e. Current limit shall be within manufacturer’s recommended maximum.
   f. Ripple current should not exceed battery manufacturer’s recommendations.
   g. Charger shall be capable of manufacturer’s specified full load at rated voltages.

S. SF6 Switch
   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. Inspect and service mechanical operator and SF6 gas insulated system in accordance with the manufacturer’s published data.

f. Verify correct operation of SF6 gas pressure alarms and limit switches, if applicable, as recommended by the manufacturer.

g. Measure critical distances as recommended by the manufacturer.

h. Inspect bolted electrical connections for high resistance using one of the following methods:

   (1) Use of low-resistance ohmmeter,

   (2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer’s published data.

   (3) Perform thermographic survey.

i. Verify that each fuse has adequate mechanical support and contact integrity.

j. Verify that fuse sizes and types correspond to drawings.

k. Verify operation and sequencing of interlocking systems.

l. Lubrication requirements

   (1) Verify appropriate contact lubrication on moving current-carrying parts.

   (2) Verify appropriate lubrication on moving and sliding surfaces.

m. Test for SF6 gas leaks in accordance with manufacturer’s published data.

n. Record as-found and as-left operation counter readings, if applicable.

2. Electrical Tests:

a. Perform resistance measurements through accessible bolted electrical connections with a low-resistance ohmmeter.

b. Perform a contact/pole-resistance test.

c. Perform insulation-resistance tests at 5kVDC on each pole, phase-to-phase and phase-to-ground with switch closed and across each open pole for one minute.

d. Perform overpotential test across each gas bottle with the switch in the open position in accordance with manufacturer’s published data.

e. Verify open and close operation from control devices, if applicable.

3. Test Values:

a. Compare bolted connection resistances to values of similar connections.

b. Bolt-torque levels shall be as 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. If the manufacturer’s data is not available, 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.

e. Critical distances of operating mechanism should be in accordance with manufacturer’s published data.

f. The gas interrupters shall withstand the overpotential voltage applied.

g. The insulation shall withstand the overpotential test voltage applied.

h. Insulation-resistance values for control wiring shall be a minimum of 2.0 megohms.

T. Circuit Breakers, Air, Insulated-Case/Molded-Case

1. 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 of the following methods:
      (1) Use of low-resistance ohmmeter,
      (2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer’s published data.
      (3) Perform thermographic survey.
   g. Inspect operating mechanism, contacts, and arc chutes in unsealed units.

2. Electrical Tests
   a. Perform insulation-resistance tests on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed and across each open pole for one minute. Test voltage shall be in accordance with manufacturer’s published data or NETA-ATS Table 100.1.
b. Perform a contact/pole-resistance test.
c. Perform adjustments for final setting in accordance with coordination study.
d. Determine long-time pickup and delay by primary current injection.
e. Determine short-time pickup and delay by primary current injection.

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 adjacent poles or similar breakers by more than 50 percent of the lowest value.
   d. Circuit breaker insulation resistance should be in accordance with NETA-ATS Table 100.1.
   e. Insulation-resistance values for control wiring shall be a minimum of 2.0 megohms.
   f. Trip characteristic of breakers 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. Circuit breakers exceeding specified trip time at 300 percent of pickup shall be tagged defective.
   g. Instantaneous pickup values of molded-case circuit breakers shall be within the tolerances shown in NETA-ATS Table 100.8.
   h. Minimum pickup voltage on shunt trip and close coils should be in accordance with manufacturer’s published data. In the absence of manufacturer’s published data, refer to NETA-ATS Table 100.20.

U. Circuit Breakers, Vacuum, 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 the unit is clean.

e. Perform all mechanical operational tests on both the circuit breaker and its operating mechanism.

f. Measure critical distances such as contact gap as recommended by manufacturer.

g. Inspect bolted electrical connections for high resistance using one of the following methods:
   (1) Use of low-resistance ohmmeter,
   (2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer’s published data.
   (3) Perform thermographic survey.

h. Lubrication requirements
   (1) Verify appropriate lubrication on moving current-carrying parts.
   (2) Verify appropriate lubrication on moving and sliding surfaces.

i. Record as-found and as-left operation counter readings.

2. Electrical Tests

a. Perform insulation-resistance tests on each pole, phase-to-phase and phase-to-ground with circuit breaker closed and across each open pole for one minute. Test voltage shall be in accordance with manufacturer’s published data or NETA-ATS Table 100.1.

b. Perform a contact/pole-resistance test.

c. Perform minimum pickup voltage tests on trip and close coils in accordance with NETA-ATS Table 100.20.

d. Verify trip, close, trip-free, and antipump functions.

e. Trip circuit breaker by operation of each protective device.

f. Perform vacuum bottle integrity (overpotential) test across each vacuum bottle with the breaker in the open position in strict accordance with manufacturer’s published data. Do not exceed maximum voltage stipulated for this test. Provide adequate barriers and protection against x-radiation during this test. Do not perform this test unless the contact displacement of each interrupter is within manufacturer’s tolerance. (Be aware that some dc high-potential test sets are half-wave rectified and may produce peak voltages in excess of the breaker manufacturer’s recommended maximum.)

g. 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.

h. Perform an overpotential test in accordance with manufacturer’s published data.

3. Test Values
   a. Bolt-torque levels should be in accordance with NETA-ATS 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. If manufacturer’s data is not available, investigate any values which deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.
   c. Circuit breaker insulation resistance should be in accordance with NETA-ATS Table 100.1.
   d. Contact displacement shall be in accordance with factory recorded data marked on the nameplate of each vacuum breaker or bottle.
   e. The interrupter shall withstand the overpotential voltage applied.
   f. Insulation-resistance values for control wiring shall be a minimum of 2.0 megohms.
   g. Power-factor or dissipation-factor test results shall be compared to manufacturer’s published data. In the absence of manufacturer’s published data the comparison shall be made to similar breakers.
   h. Power-factor or dissipation-factor test results and capacitance test results should be within ten percent of nameplate rating for bushings.
   i. The insulation shall withstand the overpotential test voltage applied.

V. Instrument Transformers
   1. Visual and Mechanical Inspection
      a. Compare equipment nameplate data with drawings and specifications.
      b. Inspect physical and mechanical condition.
      c. Verify correct connection of transformers with system requirements.
      d. Verify that adequate clearances exist between primary and secondary circuit wiring.
      e. Verify the unit is clean.
f. Inspect bolted electrical connections for high resistance using one of the following methods:
   (1) Use of low-resistance ohmmeter.
   (2) Verify tightness of accessible bolted electrical connections by calibrate torque-wrench method in accordance with manufacturer’s published data or NETA-ATS Table 100.12.
   (3) Perform thermographic survey.

g. Verify that all required grounding and shorting connections provide contact.

h. Verify correct operation of transformer withdrawal mechanism and grounding operation.

i. Verify correct primary and secondary fuse sizes for voltage transformers.

j. Lubrication requirements
   (1) Verify appropriate lubrication on moving current-carrying parts.
   (2) Verify appropriate lubrication on moving and sliding surfaces.

2. Electrical Tests - Current Transformers

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable.

b. Perform insulation-resistance test of each current transformer and wiring-to-ground at 1000 volts dc. For units with solid-state components, follow manufacturer’s recommendations.

c. Perform a polarity test of each current transformer.

d. Perform a ratio-verification test using the voltage or current method in accordance with ANSI/IEEE C57.13.1.

e. Perform an excitation test on transformers used for relaying applications in accordance with ANSI/IEEE C57.13.1.

f. When applicable, perform insulation-resistance and dielectric withstand tests on the primary winding with the secondary grounded. Test voltages shall be in accordance with NETA-ATS Tables 100.5 and 100.9 respectively.

g. Verify that current circuits are grounded and have only one grounding point in accordance with ANSI/IEEE C57.13.3.

3. Electrical Tests – Voltage Transformers

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable.
b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Test voltages shall be applied for one minute in accordance with NETA-ATS Table 100.5. For units with solid-state components, follow manufacturer’s recommendations.

c. Perform a polarity test on each transformer to verify the polarity marks or H1-X1 relationship as applicable.

d. Perform a turns ratio test on all tap positions, if applicable.

4. 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. 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. Insulation-resistance measurement on any instrument transformer shall be not less than that shown in NETA-ATS Table 100.5.

e. Polarity results shall agree with transformer markings.

f. Compare measured burdens to instrument transformer ratings.

g. Ratio accuracies shall be within 0.5 percent of nameplate or manufacturer’s published data.

h. The insulation shall withstand the overpotential test voltage applied.

i. Capacitance of capacitor sections of coupling-capacitance voltage transformers shall be in accordance with manufacturer’s published data.

j. Power-factor or dissipation-factor shall be in accordance with test equipment manufacturer’s published data.

W. Metering Devices

1. Visual and Mechanical Inspection

a. Compare equipment nameplate data with drawings and specifications.

b. Inspect physical and mechanical condition.

c. Verify tightness of electrical connections.
d. Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case-shorting contacts, as applicable.

e. Verify the unit is clean.

f. Verify freedom of movement, end play, and alignment of rotating disk(s).

2. Electrical Tests

a. Verify accuracy of meters at all cardinal points.

b. Calibrate meters in accordance with manufacturer's published data.

c. Verify that current transformer and voltage transformer secondary circuits are intact.

X. Protective Relays

1. Visual and Mechanical Inspection

a. Compare equipment nameplate data with drawings and specifications.

b. Inspect relays and cases for physical damage. Remove shipping restraint material.

c. Tighten case connections. Inspect cover for correct gasket seal. Clean cover glass. Inspect shorting hardware, connection paddles, and/or knife switches. Remove any foreign material from the case. Verify target reset.


2. Electrical Tests

a. Perform insulation-resistance test on each circuit-to-frame. Determine from the manufacturer's instructions the allowable procedures for this test for solid-state and microprocessor-based relays.

b. Inspect targets and indicators.

(1) Determine pickup and dropout of electromechanical targets.
(2) Verify operation of all light-emitting diode indicators.
(3) Set contrast for liquid-crystal display readouts.

c. Instantaneous Overcurrent Relay

(1) Determine pickup.
(2) Determine dropout.
(3) Determine time delay.

d. Time Overcurrent

(1) Determine minimum pickup.
(2) Determine time delays at two points on the time current curve.

e. Control Verification

Verify that each of the relay contacts performs its intended function in the control scheme including breaker trip tests, close inhibit tests, 86 lockout tests, and alarm functions.

f. System Tests

After the equipment is initially energized, measure magnitude and phase angle of all inputs and compare to expected values.

g. Test Values

(1) Use manufacturer’s recommended tolerances when other tolerances are not specified.
(2) When critical test points are specified, the relay shall be calibrated to those points even though other test points may be out of tolerance.

1.08 TEST REPORT

A. Prepare a test report and submit in accordance with Section 16010.

B. The test report shall include the following:

1. Summary of project.
2. Description of equipment tested.
3. Description of tests.
4. Test data.
5. Analysis and recommendations.

C. Test data records shall include the following minimum requirements:

1. Identification of the testing organization.
2. Equipment identification.
3. Humidity, temperature, and other conditions that may affect the results of the tests and/or calibrations.
4. Date of inspections, tests, maintenance, and/or calibrations.
5. Identification of the testing technician.
6. Indication of inspections, tests, maintenance, and/or calibrations to be performed and recorded.

7. Indication of expected results when calibrations are to be performed.

8. Indication of “as-found” and “as-left” results, as applicable.

9. Sufficient spaces to allow all results and comments to be indicated.

1.09 LABELING AND IDENTIFICATION

A. Provide engraved plastic nameplates and vinyl identification tagging systems for all communications, data, and electrical site utilities pull and splice boxes, manholes, vaults, equipment, apparatus, and other items installed for this project and as indicated on the project plans, schematics, single-line diagrams.

B. Provide equipment and circuit designation on nameplates with minimum letter and plate sizes as indicated. Electrical distribution system equipment, conduit and wire, pullboxes, manholes, and vaults shall have identification. Equipment number or plan identification shall be unique and as shown on the plans and based on the Campus Numbering Scheme. There shall be no duplication of identification numbers such as “LP-11” shall not be used in an addition if the building already has an “LP-11”. Labels shall be based on the Campus Electrical Equipment Numbering and Identification Scheme included in this Section. Equipment nameplates and tags shall remain visible after completion of construction. The Contractor shall submit an editable Microsoft Excel Spreadsheet listing of all nameplates and tags to be provided and installed for this project for review and approval by the Campus prior to installation of any identification labels or tags.

C. Provide engraved plastic nameplates (color to be determined by the Campus) for all equipment, panels, switchboards, transformers and apparatus with 1/4 in. minimum height letters indicating:

1. Circuit designation at branch overcurrent devices in distribution panelboards, switchboards, and metering switchgear.

2. Circuit designation of panel, equipment controlled or device controlled on disconnect switches and on circuit breakers, starters and controls which are individually enclosed.

3. Designation of pull and splice boxes, control and terminal cabinets as indicated on plans.

4. Equipment and device designation on front of switchboards, distribution and panelboards, and metering switchgear for each section.
D. Secure nameplates with at least two rivets. Use of silicone cement adhesive is acceptable.

E. Data and Communications Cabling:
   1. Reflective vinyl markers such as Tech Products, Inc., black legend with yellow background for copper communication cables and black legend with orange background for data and fiber optic cabling. Letters shall be attached to heavy vinyl sheeting and attached to cable with tie-wrap at four points. Lettering shall be at least ¼ inch high. Mark with black permanent marker to indicate a decimal point where required. Labels shall include all information required in detail provided in the project plans.
   2. Copper Communication/Data Cable: Designation of total copper cable pair count.
   3. Line Count (when cable is part of branch connection from phone switch).
   4. Fiber Optic Cable: Designation of fiber cable total strands and mode type. If multimode, micrometer value shall be included (i.e. 50 or 62.5).
   5. Building numbers of final termination points.

F. 600 V Conductor Identification:
   1. Feeders: Identify with the corresponding circuit designation at overcurrent device and load ends, at all splices and in pull boxes.
   2. Branch circuits: Identify with the corresponding circuit designation at the overcurrent device and at all splices.
   3. Control wires: Identify with the indicated number and or letter designation at all terminal points and connections, including manufacturer pre-wired control sections and cabinets.
   4. For identification of conductors use plastic coated self-sticking markers such as Thomas & Betts E-Z Code, or field marked labels such as manufactured by Tech Products.

G. Medium Voltage Cables and Equipment:
   1. Lettering on each tag shall be engraved at least ¼ inch high. Reflective vinyl markers such as manufactured by Tech Products, Inc., with black legend with yellow background, shall be used when applied to a heavy vinyl sheeting and attached with tie-wrap at four points.
   2. MV Cable Tags shall be connected to cables by non-ferrous cable ties and include the following minimum information at each termination, splice and where
exposed in manholes, vaults and pullboxes. The following minimum information shall be provided at each location:

a. Circuit Identification based on the Campus Numbering Scheme

b. Phase of each conductor by letter (A, B, C)

c. Phase by Color Code
   (1) A = Yellow Tape – 1 ring
   (2) B = Red Tape – 2 rings
   (3) C = Blue Tape – 3 rings

d. Both end termination points of a cable segment (e.g., Main Sub, HV-3, & MH8) shall be identified in manholes and pullboxes. e. The total cable length shall be provided at each termination end. Where cables include T-splices, the length to the T-splice location from each termination end to the location of the T-splice shall be provided.

3. Equipment in manholes, buildings, and substations shall be labeled with engraved nameplates having red background and white letters. The Contractor shall provide new nameplates to replace existing nameplates on existing equipment where the equipment or circuit designation has changed. The new nameplates shall match existing nameplates in size, color, and font size, and material. Nameplates shall be permanently attached using silicone adhesive.

4. An embossed brass tag with manhole number shall be permanently mounted inside the manhole and legible from outside the manhole with the cover removed.

H. Medium Voltage Equipment Identification:

1. The Contractor shall provide identification labeling in accordance with the Campus provided numbering scheme and as required by the Campus in order to accomplish the following:

   a. Establish a unique identifier for all system components and eliminate possible duplication.

   b. Identify equipment by type as listed in the following table:

<table>
<thead>
<tr>
<th>Mark or Tag</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>12 kV or 4.16 kV Distribution Circuit</td>
<td>A</td>
</tr>
<tr>
<td>RFI</td>
<td>Resettable Fault Interrupter</td>
<td>RFI-01</td>
</tr>
<tr>
<td>MH</td>
<td>Electrical Manhole</td>
<td>MH-1</td>
</tr>
<tr>
<td>PB</td>
<td>Electrical Pullbox</td>
<td>PB-1</td>
</tr>
<tr>
<td>S</td>
<td>Sulfur Hexafluoride Gas Switch</td>
<td>S-001-14-A (S=Switch,</td>
</tr>
</tbody>
</table>

Tests and Identification
### Tests and Identification

<table>
<thead>
<tr>
<th>PANEL</th>
<th>Power/Lighting Panel</th>
<th>PANEL-PR</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>Transformer</td>
<td>T-033-134Y-A</td>
</tr>
</tbody>
</table>

c. Allows for the addition of new devices by type in an ordered manner.

d. Facilitates the creation of computer database to keep records on equipment.

e. Reduces confusion when referring to a piece of equipment and enhance communication.

2. Existing device numbers shall be reused when replacing equipment. Consult with the Campus on device number assignment before labeling equipment. The Campus is continually adding device numbers so tracking and controlled assignment of identification information is required.

3. New and future equipment shall be assigned a number during the design phase of a project to minimize the need for new nameplates after construction.

END OF SECTION 26 05 53
EXHIBIT 26 09 95A - Pre-Functional Checklist Sample
Cal Poly - Vista Grande Dining Facility

System Type: ___________________________ Lighting Fixtures and Control Sensors

A. Submittal / Approvals

Submittal. The above equipment and systems integral to them are complete and ready for functional testing. The checklist items are complete and have been checked off only by parties having direct knowledge of the event, as marked below, respective to each responsible contractor. This prefunctional checklist is submitted for approval, subject to an attached list of outstanding items yet to be completed. A Statement of Correction will be submitted upon completion of any outstanding areas. None of the outstanding items preclude safe and reliable functional tests being performed.

<table>
<thead>
<tr>
<th>Tag</th>
<th>Inspection Item</th>
<th>All Zones (see below)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lighting Fixtures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.01</td>
<td>Fixtures are properly supported for seismic zone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.02</td>
<td>Proper lamp (and ballast) type is installed in each fixture to match fixture schedule and specifications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Lighting Controls - General</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.01</td>
<td>Lighting control is installed per manufacturer recommendations (attach recommendations to this checklist)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.02</td>
<td>Lighting control is calibrated per manufacturer checklist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Lighting Control - Switches</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.01</td>
<td>Light switches are located per plans</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.02</td>
<td>Light switches are labeled with proper ID to match drawings or field changes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.03</td>
<td>Light switch is controlling the fixtures in the area indicated on design drawings</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Pre-functional checklist items are to be completed as part of start-up & initial checkout, preparatory to functional testing.
- This checklist does not take the place of the manufacturer's recommended checkout and start-up procedures or report
- Items that do not apply shall be noted with the reasons on this form (N/A = not applicable, BO = by others)
- If this form is not used for documenting, one of similar rigor shall be used.
- General contractor shall assign checklist sections to the respective sub-contractors.
- General contractor shall be responsible to see that the checklist items by their sub-contractors are completed and checked off.

Approvals. This filled-out checklist has been reviewed. Its completion is approved with the exceptions noted in the issues log.

B. Documentation

Verify if the following items have been submitted:

- Manufacturer's cut sheets
- O&M manuals

C. Installation Checks

Check if Okay. Enter "N/A" if not applicable. Enter note number if deficient.

Date
<table>
<thead>
<tr>
<th>Tag</th>
<th>Inspection Item</th>
<th>All Zones (see below)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Occupancy Sensors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.01</td>
<td>Correct Sensor Model applied to the area being controlled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.02</td>
<td>Correct Switch Pack model has been used for the sensor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.03</td>
<td>Unit location is not prone to interference from air registers or exhaust fans</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.04</td>
<td>Unit location is not prone to interference from room furniture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.05</td>
<td>Unit location is not prone to false signal from adjoining halls or other spaces</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.06</td>
<td>Unit wiring is per manufacturer's wiring instructions</td>
<td></td>
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</tr>
<tr>
<td>4.07</td>
<td>Sensitivity adjusted per manufacturer recommendation</td>
<td></td>
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<tr>
<td>4.08</td>
<td>Timing adjusted to no less than 15-minutes</td>
<td></td>
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<tr>
<td>4.09</td>
<td>Low Voltage wiring is Plenum rated or in conduits as specified in Plans/Specs</td>
<td></td>
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<tr>
<td>4.10</td>
<td>The number of fixtures controlled (and total connected wattage) does not exceed sensor capacity</td>
<td></td>
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<tr>
<td>4.11</td>
<td>Mounting location and height are not conflict with sensor's capability</td>
<td></td>
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</tr>
<tr>
<td>4.12</td>
<td>Switchpack used is of the correct voltage (120/277 V)</td>
<td></td>
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</tr>
<tr>
<td>4.13</td>
<td>Switchpack location is easily located for future service/inspection</td>
<td></td>
<td></td>
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<tr>
<td>4.14</td>
<td>Where specified, sensor interfaces with the building lighting control relay panel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Photocell Sensors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.01</td>
<td>Mounting location conforms to manufacturer recommendations</td>
<td></td>
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<tr>
<td>5.02</td>
<td>If photocell unit provides an analog signal, accuracy is verified using a pre-calibrated foot candle meter. Reading verified at four different lighting levels including (a) Full day light, (b) Early evening, (c) dusk, and (d) completely dark to make sure the readings are correct.</td>
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<tr>
<td>5.03</td>
<td>Wiring connections at both the sensor and at the controller are tight</td>
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<tr>
<td>5.04</td>
<td>Maximum length of wiring between sensor and controlled load are per manufacturer's recommendations</td>
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<tr>
<td>5.05</td>
<td>Photocell unit does not have direct sun exposure</td>
<td></td>
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</tbody>
</table>
D. Lighting Zones

For all zones, verify that the respective switch and/or sensor is installed and functional. Enter "N/A" if not applicable. Enter note number if deficient.

Add additional sheets as necessary.

**Installed** - Sensor/switch is installed and placed properly.

**Functional** - Sensor/switch is functional and operation is satisfactory. Sensor/switch has been calibrated per specifications.

<table>
<thead>
<tr>
<th>Tag</th>
<th>Zone/Room</th>
<th>Push Button / Toggle Switch</th>
<th>Motion Sensor</th>
<th>Daylight Sensor</th>
<th>Key Switch</th>
<th>Timer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Installed</td>
<td>Functional</td>
<td>Installed</td>
<td>Functional</td>
<td>Installed</td>
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</tbody>
</table>

E. Notes
PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. System specific commissioning
2. Electrical Systems to be commissioned are (a) occupancy sensors for lighting and/or HVAC control, (b) daylight harvesting controls, (c) other programmable lighting controls, (d) electrical metering systems, (e) interface with building energy management system.

B. Related Sections:

1. Section 01 91 15, “General Commissioning Requirements”
2. Section 01 33 00, “Submittal Procedures”
3. Section 01 70 00, “Project Closeout”

1.2 DESCRIPTION OF WORK – refer to 01 91 15

1.3 SUBMITTALS – refer to 01 91 15

PART 2 – PRODUCTS – refer to 01 91 15

PART 3 – EXECUTION

3.1 COMMISSIONING PROCESS AND PROCEDURES – refer to 01 91 15

3.2 PRE-FUNCTIONAL CHECKLIST

A. Pre-Functional Test is defined under Section 01 91 15. Only the sample checklists are provided in this section as Exhibit-26 09 95-A as an indication of the format and rigor of the required pre-functional checklists and documentation. Though not developed specifically for this project, they show the extent of checks involved associated with typical installations. Actual Pre-Functional Checklist shall be prepared by the CA upon review of all the contractor submittals, including manufacturer’s installation instructions.

B. These checklists do not take the place of the manufacturer’s recommended checkout and start-up procedures or report or those used by the Testing Agency.

C. Regardless of whether the CA includes them or not, checks, inspections, safety measures, quality control measures and start-up procedures recommended by the manufacturer shall be implemented by the Contractor prior to initiation of the commissioning activity.
D. The Commissioning Coordinator (CC) employed by the Contractor shall be responsible for directing all Pre-Functional Check lists provided by the CA. The CC shall engage subcontractors and vendors service representatives with expertise in the specific equipment or system to determine whether the equipment or system passes the checks detailed in the Pre-Functional Checklist.

E. CC shall communicate the actual schedule for the execution of the Pre-Functional Checks to the CA as provided under Section 01 91 15.

F. The Commissioning Authority (CA) may choose to participate in the inspection of items along with the Contractor and his specialty subcontractors and vendors, including the Testing Agency. In addition, CA reserves the right to inspect any or all of the items on his own in order to satisfy that the installation conforms to the design objectives and the system is ready for Functional Testing.

G. For additional information on how the Pre-Functional Checklists fits within the overall framework of Commissioning as well as the Contractor’s obligations under the same, please see Section 01 91 15.

3.3 FUNCTIONAL PERFORMANCE TEST PROCEDURES (FPTs)

3.4 FUNCTIONAL PERFORMANCE TESTING

A. Contractor shall assist the Testing Agency and the Commissioning Authority (CA) in developing the Working Functional Performance Test (FPT) Procedures as specified in Section 01 91 15. Electrical Acceptance testing shall be generally based on specification and other procedures determined by the Testing Agency. For any given equipment or system, subcontractors and equipment suppliers associated with and specializing in the specific equipment are required to participate in developing the working procedures for the indicated FPTs. It is conceivable that for certain equipment and systems, multiple subcontractors and specialties may be required to participate to contribute to the development of the Functional Test. Contractor shall extend his full cooperation to the CA in securing the subcontractor or supplier resources necessary to develop and implement the Functional Tests.

B. The Contractor’s Commissioning Coordinator is required to manage the subcontractors in developing the Working FPT Procedures and Data Forms, and in performing all FPTs.

C. Only the sample functional tests are provided in this section as Exhibit-26 09 95-B as an indication of the format and rigor of the required for functional tests and documentation. Though not developed specifically for this project, they show the extent of checks involved associated with typical installations. Actual functional test reports for the project shall be prepared by the CA upon review of all the contractor submittals, including manufacturer’s installation instructions.

D. Contractor shall conduct functional tests for 100% of the systems to be commissioned shall be subject to the Functional Tests.

E. CA shall develop the Functional Test following review of all contractor submittals. The Functional Test documents shall be made available to the immediately upon the successful completion of the Pre-Functional Check Lists and correction of all issues identified in the Pre-Functional Checklist.

F. Refer to Section 01 91 15 for additional requirements regarding Functional Tests.

END OF SECTION
Exhibit 26 09 05-B
Functional Test Procedures Sample
Cal Poly - Vista Grande Dining Facility

System: Lighting Controls (Occupancy Sensors)
Date: ____________

1. Objective:
   a. Confirm satisfactory operation of lighting occupancy sensors.

2. Equipment:

<table>
<thead>
<tr>
<th>EQUIPMENT ID</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
</tr>
</tbody>
</table>

3. Participants

<table>
<thead>
<tr>
<th>NAME</th>
<th>COMPANY</th>
<th>FUNCTION</th>
<th>ROLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td></td>
<td>Party filling out this form and witnessing the test</td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
<td>Party operating equipment and executing the test</td>
</tr>
</tbody>
</table>

4. Prerequisite Checklist:

<table>
<thead>
<tr>
<th>ITEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Lighting controls have been started up and prefunctional checklists submitted and approved ready for functional testing:</td>
</tr>
<tr>
<td>2. Luminaries controlled by occupancy sensors are wired and powered</td>
</tr>
<tr>
<td>3. All control system functions for these systems are programmed and operable per contract documents, including final setpoints and schedules.</td>
</tr>
<tr>
<td>4. Occupants (if any) notified that testing is in progress and lights may switch on and off.</td>
</tr>
<tr>
<td>5. All A/E punchlist items for this equipment corrected.</td>
</tr>
<tr>
<td>6. These functional test procedures reviewed and approved by installing contractor.</td>
</tr>
<tr>
<td>7. Record made of all values (i.e., setpoints, control parameters, limits, delays, schedules, etc.) changed to accommodate testing. Attach as necessary.</td>
</tr>
</tbody>
</table>
# 5. Procedure:

<table>
<thead>
<tr>
<th>Proced. ID</th>
<th>Sequence/Test</th>
<th>Expected Response</th>
<th>Actual Response</th>
<th>Pass (Y/N)</th>
<th>Note #</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Occupancy Control</td>
<td></td>
<td>All lighting occupancy sensors are functional and operating per design: YES / NO</td>
<td>(SEE TABLE BELOW FOR ROOM-BY-ROOM RESULTS)</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>TEST CONDITIONS:</strong> To expedite the test, place the sensor in “Test” mode (if available) to reduce the timer delay. Also, turn on HVAC air flow (i.e., full flow) to create the worst-case operating conditions.</td>
<td></td>
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<tr>
<td></td>
<td>1) LIGHTS OFF: Exit the room and ensure it remains vacant. Verify that lights in the controlled zone turn off after the “time delay” expires. If lights do not turn off, the sensitivity on the sensor may be too high.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>2) LIGHTS REMAIN OFF: Confirm lights remain off – with movement in an adjacent space (i.e., outside of the controlled lighting zone). If lights are falsely triggered on, the sensitivity setting on the sensor may be too high.</td>
<td></td>
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<td></td>
<td>3) LIGHTS ON: Re-enter the room after confirming that the lights were turned off. Verify that lights come on automatically when movement is detected. If lights do not turn on the sensitivity on the sensor may be too low.</td>
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<td></td>
<td>4) RESTORE SETTINGS: Following completion of tests, restore the sensor settings to normal operating conditions. Repeat tests for all occupancy sensors.</td>
<td></td>
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</tr>
</tbody>
</table>
## Test Results:

<table>
<thead>
<tr>
<th>Count</th>
<th>Room ID</th>
<th>Sensor Installed (YES/NO)</th>
<th>Sensor is functional per tests outlined above (YES/NO)</th>
<th>Comments (Document any changes to the default settings)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
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<td>2</td>
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<tr>
<td>20</td>
<td></td>
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</tr>
</tbody>
</table>
| Count | Room ID | Sensor Installed (YES/NO) | Sensor is functional per tests outlined above (YES/NO) | Comments  
(Document any changes to the default settings) |
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**Notes:**
PART 1 – GENERAL

1.01 SECTION INCLUDES

A. This Specification outlines the electrical, mechanical, and safety requirements of three phase, 60 Hz, "less flammable" fluid-immersed, such as Enviro-Temp or BioTemp, 55°C/65°C rise self-cooled, tamper-resistant, radial connected, pad-mounted transformers having 12,470V or 4160V delta wound high voltage primary winding with primary disconnect and primary current limiting fusing, and 480Y/277V or 208Y/120V solidly grounded wye wound secondary winding. Voltage ratings to be as shown on plans.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Submittals: Division 1 requirements.

B. High voltage cable, terminations, and splices: Section 26 05 13.

1.03 DESCRIPTION OF WORK

A. This Section includes Specifications for purchasing installing, testing and energizing the transformer and equipment. Contractor shall conform to all requirements of this Section, including quality assurance, submittals, product handling, and warranties, as applicable for the specific extent of furnishing or installing responsibilities. Contractor shall confirm and verify with Owner all installation conditions that may affect furnishing specified equipment. Contractor shall confirm and verify with Owner all characteristics (including specific models, types, and similar properties) and conditions of equipment that may affect installing equipment.

1.04 QUALITY ASSURANCE

A. Manufacturer’s qualifications: All manufacturers, if awarded a purchase order, are required to perform or provide ANSI tests on one transformer, representative of each VA size and secondary voltage to be furnished. Tests shall demonstrate 100% compliance with requirements of ANSI C57.12.00 and C57.12.90. The cost of tests and certified test reports shall be borne by manufacturer and be made a part of the quoted transformer price.

B. Workmanship and material:
1. The intent of this Specification is to secure for Owner apparatus of first-class workmanship in all respects. All components shall be manufactured, fabricated, assembled, and finished with workmanship of the highest quality throughout and in accord with the best recognized correct practice.

2. All materials shall be new, of first-class quality and suitable for conditions specified.

3. All materials used in manufacture of the apparatus shall conform to the latest standard of the American Society for Testing Materials (ASTM).

4. All electrical design, materials, tests, and construction shall conform to the latest applicable standards of the American National Standards Institute (ANSI), the National Electrical Manufacturers Association (NEMA), unless specifically excluded by this Specification. In case of conflicting requirements of these standards, the more stringent shall apply.

5. Manufacturer’s agent shall notify Owner in writing if manufacturer has any reason for deviating from the above standards. Contractor shall state exactly the nature of the change and the reasons for making the change.

6. The finished product shall be complete in all respects and shall fully conform to the description thereof set forth in this Specification.

C. Reference standards: Except as otherwise specified herein, all construction, characteristics, requirements, test, definitions, terminology, VA, and voltage designations shall be in accordance with the latest edition of the following ANSI, NEMA, and Factory Mutual Standards. Transformers covered by this Specification shall conform to relevant sections of the latest revision of applicable industry standards, including but not limited to the following:

1. ANSI: C57.12.00 General Requirements for Liquid-Immersed Distribution and Power Transformers.

2. ANSI: C57.12.26 Requirements for Pad-mounted Compartmental-Type, Self-Cooled, Three Phase Distribution Transformers for Use with Separable Insulated High-Voltage Connectors, High-Voltage, 24940 grounded Y/14400 volts and below, 2500 KVA and smaller.


7. ANSI: C57.92 IEEE Guide for Loading Mineral Oil Immersed Power Transformers Up to and Including 100 MVA with 55 oC or 65 oC Average Winding Rise.


9. NEMA: TR1 Transformers, Regulators and Reactors.

10. Factory Mutual: Transformer Loss Prevention Data Sheet S-4/14-B.

1.05 SUBMITTALS

A. Procedure: In accord with Division 1 requirements.

B. Drawings:
   1. Manufacturer’s agent shall provide manufacturer’s certified drawings no later than 6 weeks after receipt of order. Drawings shall be identified with purchase order number and manufacturer’s control number.
   2. Record drawings shall be provided and include nameplate drawings and the transformer outline.

1.06 PRODUCT HANDLING

A. A transformer rated 45-1000 KVA shall be placed on a hardwood pallet with 4 in. x 4 in. minimum skids to facilitate handling with forklifts. The pallet cross members shall be bolted (not nailed) to the skids. The pallet assembly shall help protect transformer from damage when shipped on flatbed trailers. Side or rear loading shall be on the purchase order. Transformers rated 1500-5000 KVA shall be loaded and unloaded with an overhead crane and shall be shipped on flat bed trailers.

B. The apparatus shall be shipped in assembled units insofar as is consistent with good shipping practices.

C. When items must be disassembled for shipment, they shall be match-marked. All units and their containers shall be piece-marked and shall show the purchase order number.
D. Contractor shall notify Owner at least 7 days in advance as to when the apparatus is to be installed at the final location.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Three-phase, pad-mounted, “less flammable” fluid-immersed, such as Enviro-Temp or BioTemp, 55°C rise, 12,470V-480Y/277V or 12,470V-208Y/120V or 4160V-480Y/277V or 4160V-208Y/120V high voltage transformers:
   1. General Electric.
   2. ABB
   3. Cooper Power Systems

2.02 MATERIAL AND FABRICATION

A. Ratings: The required transformer KVA shall be as indicated on Drawings and shall be one of the following KVA ratings:

<table>
<thead>
<tr>
<th>KVA</th>
<th>45</th>
<th>75</th>
<th>112.5</th>
<th>150</th>
<th>225</th>
</tr>
</thead>
<tbody>
<tr>
<td>KVA</td>
<td>300</td>
<td>500</td>
<td>750</td>
<td>1000</td>
<td>1500</td>
</tr>
<tr>
<td>KVA</td>
<td>2000</td>
<td>2500</td>
<td>3750</td>
<td>5000</td>
<td></td>
</tr>
</tbody>
</table>

B. All transformers shall be braced for seismic zone 4.

C. Cooling class: OA.

D. Primary voltage: 4160 volts.

E. BIL:
   1. 95 kV (12,000 volts primary delta windings).
   2. 60 kV (4160 Y/2400 secondary windings).
3. 30 kV (480 Y/277, 480 delta volts and lower voltage secondary windings).

F. Taps, in additional to nominal voltage:
   1. 45-500kVA transformers: Four 2 ½%, two above and two below high voltage rating.

G. Winding connections: Primary windings shall be delta-connected and secondaries shall be wye-connected.

H. Impedance voltage:

<table>
<thead>
<tr>
<th>KVA Rating</th>
<th>% Impedance Voltage</th>
<th>% Impedance Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>45 - 500</td>
<td>4.75 (minimum)</td>
<td>4.95 (nominal)</td>
</tr>
<tr>
<td>750 - 5000</td>
<td>5.65 (minimum)</td>
<td>5.75 (nominal)</td>
</tr>
</tbody>
</table>

I. Transformer insulating fluid:
   1. Dielectric Fluid Oil furnished in the transformer shall be inhibited new oil such as Enviro-Temp or BioTemp and meet the minimum requirements as specified in Table 1, "Functional Property Requirements," of ASTM D3487 and ANSI C57.106.
   2. All transformer oil shall be bulk tested for polychlorinated biphenyls (PCBs) in accord with ASTM D4059 and certified, upon request, as having no detectable level of PCB.
   3. The transformer name plate should state that PCBs are "Less than 1PPM."
   4. Transformer oil shall be Factory Mutual Research Corporation (FMRC) approved as a “less flammable” transformer insulating fluid.
   5. Transformers shall be factory-filled and shipped complete to job site.

J. Pad-mounted enclosure:
   1. The enclosure shall be designed to achieve a high degree of integrity. The pad-mounted transformer shall consist of the transformer tank with high- and low-voltage terminating compartments. Assemble all three of these components as an integral unit, tamper-resistant and weatherproof, suitable for mounting on a pad without additional housing, fencing, or other provisions to make the installation safe. There shall be no exposed screws, bolts, or other fastening devices that are externally removable. There shall be no opening where objects may be inserted.
to contact live parts. The completely assembled transformer will resist unauthorized entry.

2. A welded tank cover is acceptable provided it is equipped with handhole openings with the following dimensions:
   a. 45 - 500 KVA: One 14 in. x 24 in. opening.
   b. 750 - 5000 KVA: Two 14 in. x 24 in. hand holes (one centered behind high-voltage compartment and one behind low-voltage compartment).

3. A bolted tank cover may be furnished in place of handhole(s). The bolted cover assembly shall consist of a reusable nitrile gasket retained in place by a retaining strip welded to the interior of the tank flange. Carriage bolts shall be concealed by a wrap-around "nut guard" accessible from the interior of the cabinet.

4. Enclosure paint finish shall be in accord with Finishing Guidelines for Pad Mounted Equipment. The finish paint coat shall be green (Munsell 7GY 3.29/1.5).

5. Before coating, all welds shall be cleaned to remove welding flux and splatter. Surfaces shall be washed and prepared by a chemical-etching phosphate coating process, or be sand blasted, grit blasted or shot blasted.

6. The transformer cabinet, compartment door and sill and base frame shall be manufactured from 304L series stainless steel.

7. Stainless steel (or SS 304L) shall be identified on the nameplate.

8. The front plate shall be stenciled SS to denote stainless steel. Letter height shall be approximately 2 in. Lifting lugs, door handles, latching assembly and all exposed hardware shall be constructed of noncorrosive material.

K. Windings: Transformer primary and secondary windings shall have copper conductors.

L. Transformer bushings:
   1. High voltage bushings shall be Universal bushing wells without inserts. Bushing wells shall be suitable for bushing inserts and load break or non-load break separable connectors.

   2. High voltage bushings shall be arranged for radial feed or loop feed as indicated on Drawings. Bushing assemblies shall be rated for full 200 amperes, momentary 10,000 amperes RMS 1/2 second, three-phase duty.

   3. Bushings shall be externally removable and leads shall be of sufficient length to permit field replacement of bushings without opening the tank.

   4. All primary bushings shall be installed with three stud external clamps.
5. Parking stands shall be welded to the tank wall beside bushings in accord with ANSI C57.12.26.

6. Low-voltage line and neutral bushings shall be one-piece epoxy or fiberglass polyester material with tinned plated copper or aluminum terminal spades provided with NEMA spaced holes. The minimum number of usable holes per phase shall be in accord with the following table:

### NUMBER OF HOLES BASED ON SECONDARY VOLTAGE

<table>
<thead>
<tr>
<th>KVA</th>
<th>480 Y/277, 208Y/120, 480D</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>4</td>
</tr>
<tr>
<td>75</td>
<td>6</td>
</tr>
<tr>
<td>150</td>
<td>6</td>
</tr>
<tr>
<td>225</td>
<td>6</td>
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<tr>
<td>300</td>
<td>6</td>
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<td>500</td>
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<td>750</td>
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<tr>
<td>2500</td>
<td>10</td>
</tr>
<tr>
<td>3750</td>
<td>12</td>
</tr>
<tr>
<td>5000</td>
<td>12</td>
</tr>
</tbody>
</table>

7. The low-voltage bushing shall be bolted on and externally clamped.

8. Insulated, vertical, mechanical supports shall be installed on each 8, 10 and 12 hole low-voltage terminal spade and shall be attached to a horizontal steel support angle brace located above the spades. The support system shall be disconnected from each low-voltage terminal spade during shipment to prevent damage to the low voltage bushings.

9. The low voltage neutral bushing (where required) shall be the same insulation class as phase bushings.

M. Accessories:
1. The inside base of the transformer sill shall have a flange for anchoring the cabinet to the pad.

2. The transformer shall be equipped with an externally operated no-load tap changer. The operating handle shall give permanent visual indication of the voltage position and have a provision for securing it at the desired position.

3. A 25°C. oil level indicator shall be provided in the low-voltage compartment.

4. A dial-type liquid temperature gauge shall be provided in the low-voltage compartment.

5. A drain valve with a built-in sampling device shall be provided in the low-voltage compartment.

6. A 1 in. NPT upper plug (or cap) for filling and pressure testing shall be provided in the low-voltage compartment.

7. A captive and recessed hex-head bolt shall be provided for securing the high- and low-voltage compartment doors.

8. The BIL rating of the transformer and notation of current limiting and Bayonet fuses in the circuit diagram shall be included on the nameplate of fused transformers.

9. The transformer shall be equipped with a pressure relief device that will automatically relieve tank pressures that exceed 10 psig.

10. A pressure vacuum gauge shall be provided in the low voltage compartment.

N. Factory tests:

1. Certified test reports on a comparable transformer, showing compliance with the requirements of ANSI C57.12.00 and C57.12.90 shall be available on request.

2. The transformer shall be designed and manufactured to have audible sound levels equal to or less than those described by NEMA TRI. Certified test reports shall be available upon request for the unit supplied or for an essentially identical unit showing compliance to NEMA Standard TR-1.

3. Contractor shall provide manufacturer certified test reports for each transformer provided that include the following data:
Transformer Number (As indicated on Drawings)

<table>
<thead>
<tr>
<th>Serial Number</th>
<th>Impedance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catalog Number</td>
<td>No-Load Loss at 85° C.</td>
</tr>
<tr>
<td>KVA</td>
<td>Total Losses at 85° C.</td>
</tr>
</tbody>
</table>

Primary Voltage

4. Owner shall be allowed access to manufacturer’s shops and also to those of manufacturer’s suppliers to inspect the apparatus and workmanship, to witness tests, and to obtain other desired information. Inspectors representing Owner shall be given every facility to inspect the work during all stages of manufacture, testing, and shipment.

5. Inspection of the apparatus may be at manufacturer’s shops and/or those of its suppliers, or upon receipt at destination at the option of Owner. Inspection by Owner at the aforesaid shops will not be made except on special request by Owner. The waiving of inspection thereof shall in no way relieve manufacturer of the responsibility of furnishing apparatus in accord with this Specification.

6. Manufacturer shall inform Owner of the progress of the work and shall give Owner ample advance notice of appropriate times for inspections and/or tests. Specified tests will be approved and may be supervised by Owner.

7. Manufacturer shall furnish to Owner, if so requested and at no additional cost, shop and mill reports when specified.

8. Costs of all tests made in the shops are to be borne by manufacturer.

O. Guaranteed transformer losses:

1. No-load losses shall be calculated and provided to the owner.

2. Load losses shall be calculated and provided to the owner.

3. The transformer shall be a lower impedance low loss transformer. Loss data (estimated) shall be provided with the approval submittal.

P. Install a hook stick operable primary load break disconnect switch.

Q. Install primary fuse holders with current limiting fuses sized in accord with the transformer kVA rating and the project one line diagram and provide one spare set of fuses.
PART 3 – EXECUTION

3.01 GENERAL

3.02 INSPECTION

A. Examine area to receive transformers to verify there is adequate clearance for installation.

B. Examine surfaces for conditions that will adversely affect execution, permanence, and quality of work of this Section.

C. Do not proceed with work until unsatisfactory conditions have been corrected.

3.03 PRODUCTION TESTING

A. Each pad-mounted transformer unit shall be factory-tested in accord with ANSI Standard C57-12.90 and visually-inspected for looseness, defects in components and proper assembly, proper switch operation, etc. Manufacturer shall correct all deficiencies before shipment.

3.04 INSTALLATION

A. Install pad-mounted transformers plumb and in straight, horizontal and vertical alignment, anchored to precast floor slab with adequate concrete inserts and 5/8 in. anchor bolts.

B. Jacking provision: Suitable jacking pads or equivalent jacking facilities shall be provided on the tank for all sizes.

C. Rolling provision: The transformer base shall be so arranged for rolling in two directions - parallel to, and at right angles to the centerline of the high voltage bushings.

D. Lifting provision: Lugs of adequate strength and size shall be attached to the tank and so arranged to provide a balanced lift.

E. Mounting provision: The base of the transformer assembly shall be provided with a suitable flange to permit anchoring the unit on the pad from within the terminating compartment. Construct the transformer assembly for lifting, skidding, or sliding into place without disturbing previously-installed entrance cables, accomplished by means
of a removable sill bolted to the tank and removable only after gaining access to the compartment.

3.05 SITE TESTING

A. Performance tests made in the field are to be under conditions to be mutually agreed upon by Owner and Contractor.

B. Contractor shall provide certified copies of all performance tests to Owner.

C. When specific performance tests are required, the work on the apparatus involved shall not proceed beyond that point until Owner has reviewed and approved certified reports of all performance tests or waived such review and approval.

D. Provide all the services of an Independent Test Laboratory as required in Section 16030 and all acceptance necessary tools, cables, and equipment to perform the site performance tests from NETA ATS listed in Section 26 05 53.

3.06 WARRANTIES

A. Equipment furnished under these Specifications shall be guaranteed against defective parts and workmanship under terms of manufacturer’s standard warranty, but in no event shall it be for a period of less than 1 year from date of initial energization of system and shall include labor and travel time for necessary repairs at job site.

END OF SECTION 26 12 19
PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Switchgear assembly, including draw-out breaker sections complete with circuit breakers will be provided by Contractor. Contractor is responsible for purchasing, receiving, transporting and installing all equipment.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Site grading: Division 2.
B. Structural concrete pad work: Division 3.
D. Submittals: Division 1.

1.03 QUALITY ASSURANCE

A. Installer qualifications: Minimum 5 years of continuous experience in application, erection, fabrication, installation, or setting of specified (i.e., identical material types) work of similar complexity; experience in application, erection, fabrication, installation, or setting of similar (i.e., non-identical material types) work or work of less complexity are not acceptable. Also refer to specific requirements of this specification.

B. Assembly/system products qualifications:

1. All equipment to be furnished under these Specifications shall be new and not used prior to delivery, except where necessary for testing, installation, and adjustment of equipment.

2. All necessary material and equipment not specifically detailed in these Specifications but desirable, necessary, or required to ensure this equipment will perform satisfactory for the intended work shall be itemized and included.

C. Manufacturer shall perform the work included in this Section in strict accord with requirements of manufacturer’s Quality Control Program.

D. Factory tests:

1. The switchgear shall be completely factory-tested and calibrated as a system prior to shipment.

2. Perform all tests after assembly is complete.
3. Submit certified test results in duplicate.
4. Test shall include, but not be limited to, manufacturer’s standard.

E. Switchgear assemblies and major components shall be tested in accord with requirements given in ANSI C29.1, C37.09, C37.20, C37.34, C37.41, C57.13, and C62.1.

F. Requirements of regulatory agencies:

1. In addition to complying with other legal requirements, switchgear shall conform to or exceed applicable requirements of the latest edition of the following codes and standards:
   a. All portions of American National Standards Institute (ANSI), Institute of Electrical and Electronic Engineers (IEEE), National Electric Code (NEC) as amended by the state of California, and National Electrical Manufacturers Association (NEMA) standards applicable to the basic switch and fuse components.
2. Bear UL labels.
4. External doors shall be provided with “CAUTION - HIGH VOLTAGE” permanent signs.

G. Reference specifications and standards:

1. ANSI: C29.1 Test Methods for Electrical Insulators.
2. ANSI: C37.04 Rating Structure for AC High-Voltage Circuit Breakers.
4. ANSI: C37.11 Requirements for Electrical Control for AC High-Voltage Circuit Breakers.
5. ANSI: C37.20.2 Standard for Metal-Clad and Station-Type Cubicle Switchgear.
6. ANSI: C37.20.3 Metal-Enclosed Interrupter Switchgear.
7. ANSI: C37.30 Definitions and Requirements for High-Voltage Air Switches, Insulators, and Bus Supports.
8. ANSI: C37.31 Indoor Apparatus Insulators.
9. ANSI: C57.13 Requirements for Instrument Transformers.
12. NEMA: E1 2 Instrument Transformers.
13. NEMA: SG 4 AC High-Voltage Circuit Breakers.

1.04 SUBMITTALS
A. Procedures: In accord with Division 1 requirements.
B. Submit detailed shop drawings with:
   1. Manufacturer’s descriptions, catalog data and information, including model numbers or item identification.
   2. Manufacturer’s general arrangement and detail drawings for the switchgear assembly and prime components.
   3. Manufacturer’s schematic wiring and interconnection diagrams.
   4. Protection devices, coordination data curves, and settings available data.
   5. Operation and maintenance manual, including spare parts list.
   6. Factory Production Test Reports.
   7. Field Acceptance Test Reports.

1.05 PRODUCT HANDLING
A. In accord with manufacturer’s instructions.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS
A. The following manufacturers are acceptable. No other known equal is acceptable without written consent of the Owner:
   1. General Electric
   2. Siemens

2.02 MATERIALS AND EQUIPMENT
A. Assembly shall be comprised of an integrated line-up of walk-in outdoor metal-clad switchgear. The switchgear assembly shall consist of two mains and a tie circuit breaker with draw-out circuit breakers for branch load distributions systems (bays). Provide surge arresters, bus and connections, instrument transformers, meters, relays, control wiring, and accessory devices as shown on the drawings.

B. Ratings: The double-ended switchgear with the tie circuit breaker assembly shall have the following ratings:

1. kV, nominal: 12.47kV and 4.16 kV. Voltage as shown on plans.
2. kV, maximum: 15kV and 4.76 kV. Voltage as shown on plans.
3. kV, BIL: 95 for 15kV equipment.
5. Short-circuit ratings:
   a. Amperes, RMS symmetrical maximum: 23K.
   b. MVA three-phase symmetrical at rated nominal voltage: 500.
   c. Duty-cycle fault-closing amperes, RMS asymmetrical: 37K.

C. Construction stationary structure:

1. In establishing requirements for the enclosure design, consideration shall be given to all relevant factors such as controlled access; tamper resistance; corrosion resistance; protection from ingress of rodents, insects, and weeds; and the possibility of arcing faults within the enclosure.
   a. The switchgear line-up shall be comprised of the required number of metal-clad sections, assembled together to form a rigid self-supporting structure with barriers of painted steel between units.
   b. Each metal-clad section shall consist of the required number of structures; segregated by grounded metal barriers into separate compartments for circuit breakers, instrument transformers, main bus, instruments and relays, and incoming service connections.
2. Doors and panels:
   a. Each circuit breaker and voltage transformer compartment shall be provided with a formed, hinged front door with handle and three-point lockable latch. Each door shall be furnished with a stop to hold the door in the open position. Circuit breaker and instrument transformer compartment doors shall not hinder withdrawal of the element from the compartment when the door is open and door-stop set.
b. Relays, instruments, meters, and secondary control devices shall be mounted on formed front-hinged panels and provided with handle lockable latch, and stop to hold panel in the open position. Equipment mounted on the panel shall be isolated by grounded metal barriers from all primary circuit elements.

c. Access to main bus, incoming service connections, feeder cable terminations, current transformers, bushings, and other stationary devices shall be provided with hinged, bolted panels.

3. Circuit breaker compartment:

a. Circuit breaker compartment shall be designed to house a draw-out type circuit breaker element. Welded guide rails for positioning the circuit breaker shall be provided as an integral part of the compartment.

b. Automatic shutters shall be provided in the compartment to prevent accidental contact with the stationary primary disconnecting contacts when the circuit breaker element is withdrawn from the Connected position.

c. A ground bus shall extend into the compartment to automatically ground the circuit breaker frame in the Connected and Test positions. The ground bus shall maintain the circuit breaker frame grounded during the transition between all positions.

d. Means shall be provided for positively holding the circuit breaker element in place when it is in either the Connected or Test/Disconnected position within the compartment. Mechanical interlocks shall also prevent incorrect movement of a closed circuit breaker to or from the designated positions within the compartment, and prevent electrical closing of the circuit breaker within the compartment unless it is in the Connected or Test position. Provision shall be made for padlocking the circuit breaker element in the Test/Disconnected position with a 1/4 in. diameter x 1 in. shackle padlock.

e. Circuit breaker compartments shall only permit the interchange of circuit breaker removable elements of the same type and rating.

4. Voltage transformer compartment: Designed to house the specified transformer assembly. Compartment door shall be furnished with interlock to prevent access to the transformer and primary fuses unless they are disconnected from the primary circuit. The Connected/Disconnected positions shall be clearly visible when the compartment door is closed. Means shall be provided to prevent accidental access to the stationary primary contacts when the transformer and fuses are not in the Connected position.
5. Main bus:
   a. The main three-phase bus shall be comprised of electrical grade copper. Bus shall be fully insulated over its entire length with flame-retardant, non-hygroscopic, track-resistant insulation. All bus tap connections, including bus taps and circuit breaker connections, shall be silver-plated, with current density equal 1000A per sq. in. (155a.cm2) of cross-section for said copper.
   b. The main bus and connections shall be braced to withstand the mechanical stresses associated with rated short-circuit momentary currents without deformation or damage to supports.
   c. Bus compartments with the metal-enclosed sections shall be isolated to metal-clad switchgear standards and that all bus bars within the metal-enclosed sections shall be insulated per metal-clad standards.

6. Ground bus: A copper ground bus, not less than 2 in. x 1/4 in., shall extend the length of the switchgear sections with all bolted joints silver-plated. In each switchgear unit, where power buses enter or leave the switchgear at the top, a copper ground bus, not less than 1 in. x 1/8 in., shall be extended from the main ground bus up to the top of the unit. All joints in the ground bus shall be made with a minimum of two bolts.

7. Bus transition units: Provided with the switchgear assembly as required by manufacturer’s design of line-up. The transition unit structures shall be full-height with front and rear bolted panels. Front panel shall be in line with those of the adjacent switchgear sections.

D. Medium-voltage AC circuit breakers:

1. Circuit breakers shall comply with requirements given in ANSI C37.04, C37.11, and NEMA SG 4.

2. Type: The circuit breakers shall be indoor, three-pole, draw-out type, with sealed vacuum, AC motor-charged spring-operated mechanisms. Circuit breakers of the same rating shall be physically and electrically interchangeable.
   a. The Siemens Type GMI circuit breaker for use in Upper Substation shall be keyed to match the existing cells. The breaker controls and control voltages shall match the existing upper switchgear.
   b. The GE PowerVac circuit breakers for the new Lower Substation switchgear shall be keyed to match the existing circuit breakers in the Middle Substation.

3. Acceptable Manufacturers, No known equal:
   a. General Electric PowerVac for Lower Substation. Quantity as shown on plans.
b. Siemens Type GMI Vacuum Breaker for Upper Substation. Quantity one (1).

4. Ratings: The circuit breakers shall be rated on a symmetrical current basis and have the following ratings and required related capabilities and defined in ANSI C37.04:

a. General Electric Circuit Breakers:
   1) Nominal operating voltage, kV, RMS: 12.47 kV or 4.16 kV. Voltage as shown on plans.
   2) Rated maximum voltage, kV, RMS: 15 kV or 4.76 kV. Voltage as shown on plans.
   3) Rated continuous current at 60 Hz amperes, RMS: 1200.
   4) Nominal MVA Class: 500
   5) Required symmetrical current interrupting capability at nominal operating voltage, kilo-amperes, RMS, minimum: 23.
   6) Required closing and latching capability, kilo-amperes, RMS, minimum: 37.
   7) Rated interrupting time, cycles, maximum: 5.
   8) Rated permissible tripping delay, seconds: 2.

b. Siemens Type GMI Vacuum Breaker:
   1) Nominal operating voltage, kV, RMS: 12.47 kV.
   2) Rated maximum voltage, kV, RMS: 15 kV.
   3) Rated continuous current at 60 Hz amperes, RMS: 1200.
   4) Nominal MVA Class: 500
   5) Required symmetrical current interrupting capability at nominal operating voltage, kilo-amperes, RMS, minimum: 23.
   6) Required closing and latching capability, kilo-amperes, RMS, minimum: 37.
   7) Rated interrupting time, cycles, maximum: 5.
   8) Rated permissible tripping delay, seconds: 2.

5. Insulation structure: Materials used for circuit breaker insulation shall be of a type that are noncombustible, non-hygroscopic and tracking resistant. The mechanical strength and physical characteristics of the insulation structure shall match the
stresses imposed by the circuit breaker required closing and latching current capability.

6. Removable assembly:
   a. The circuit breaker removable elements shall be truck-mounted or cradle-mounted with pull-bar or handles suitable for manual removal and insertion of the element out of and into the stationary compartment.
   b. The removable element shall be provided with a fully interlocked, manually-operated racking mechanism to move the circuit breaker between the Test/Disconnected, and Connected positions. A clearly-visible position indicator shall be provided.
   c. It shall be impossible to insert a circuit breaker of incorrect rating in any bay.
   d. The removable element frame shall be provided with a full front metal shield to prevent access to any live primary bus or load terminals when the circuit breaker is in the Connected position.
   e. The circuit breaker removable element’s primary disconnecting contacts shall be provided with heavy-duty, self-aligning, spring-loaded, silver-plated, copper disconnect fingers that engage with the line- and load-side stationary disconnecting contacts.
   f. The circuit breaker interrupters shall be provided with means for determining contact wear without dismantling.
   g. Control wiring connections, from circuit breaker compartment to the removable element, shall have provisions for maintaining or automatically reinstating circuit continuity when the removable element is moved between the Connected and Test positions. Suitable means shall be provided for simultaneous disconnection of control wiring connections when the removable element is fully withdrawn from the compartment.
   h. Circuit breakers shall be provided with auxiliary switches for functions specified and as indicated, plus two spare switches wired to control compartment.

7. Operating mechanism:
   a. The circuit breaker operating mechanism shall be of the motor-charged, spring-operated type. The design of the mechanism shall prevent overcharging and ensure that the release of stored energy for closing the circuit breaker main contacts is prevented unless the mechanism has been fully charged. The design shall be mechanically trip-free. Energy storage shall
be sufficient for an opening-closing-opening operation at the maximum symmetrical current interrupting capability of the circuit breakers.

b. The spring-operated mechanism shall be automatically recharged within 15 seconds after each circuit breaker closing operation. Mechanism shall have provisions for manually charging the closing springs.

c. The stored-energy mechanism shall be provided with a mechanical indicator to show the Charged and Discharged status of the closing springs. An interlock shall be provided to prevent the complete withdrawal of the circuit breaker removable element from the stationary compartment when the mechanism is in a fully charged state; or alternatively, automatically discharge the stored energy when the removable element is withdrawn from or inserted into the compartment.

d. Each mechanism shall be provided with four-digit, non-resettable mechanical register type operation counter to record each circuit breaker close/open cycle.

e. The mechanism shall be provided with Open and Close mechanical control pushbuttons, mounted on the removable element escutcheon plate, for test purposes and for use in emergency. The mechanism shall also be furnished with an easily readable mechanical position indicator, mounted on the removable element, to indicate the Open and Closed positions of the main moving contacts.

8. Circuit breaker control:

a. The circuit breakers shall be designed for local electrical operation at 48 volts DC nominal control power supply.

b. The closing mechanism shall be provided with spring release coil, anti-pump relay, and spring charging motor suitable for operation over a voltage range of 38V to 56V. The tripping mechanism shall be provided with a shunt trip coil suitable for operation over a voltage range of 28V to 56V.

E. Surge Arresters:

1. Type: Surge arresters shall comply with requirements of ANSI C62.1 and C62.2, as applicable, and shall be intermediate-class, gapless, meta-oxide type, suitable for mounting inside a separate metal enclosure. Arresters shall be provided with a pressure relief diaphragm.
2. Ratings: Arrester rating, kV, RMS, shall be suitable for use at nominal service voltages of 12.47 kV and 4.16 kV, three-phase, 60 Hz as indicated. Required arrester ratings are as follows:

<table>
<thead>
<tr>
<th>Nominal System Voltage-kV, RMS</th>
<th>Arrester Voltage Rating-kV, RMS</th>
<th>Arrester kV-Crest**</th>
<th>Maximum 0.5 Microsecond Discharge MCOV*</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.16</td>
<td>6</td>
<td>5.10</td>
<td>22.0</td>
</tr>
<tr>
<td>12.47</td>
<td>12</td>
<td>10.2</td>
<td>44.0</td>
</tr>
</tbody>
</table>

* Maximum continuous operating voltage.

** Equivalent of a fast front 10 kA current producing a voltage wave crested in 0.5 microsecond.

3. Arrangement:
   a. Arrester pressure relief diaphragm shall be arranged in the enclosure so that the vent ports are directed away from all adjacent apparatus. Preferably, the generated ionized gases during normal operation shall be vented to the outside of the switchgear enclosure.
   b. Arrester ground terminals shall be directly connected to the switchgear main ground bus.

4. Two sets of arresters shall be installed, one set on each side of the tie breaker bus.

F. Relays and Instruments:
   1. All relays shall be GE Multilin F650 or Basler relays, no acceptable equal.
   2. Relays: Switchgear assembly shall be furnished with protection by relays and indication. The following is a description of the required operating characteristics:
      a. *Ground fault 50G/51G
         *Instantaneous overcurrent 50
         *Time Overcurrent 51
         *Lockout relay 86
      b. The relay shall be solid-state microprocessor-based multi-functional type that operates from the secondary output of current transformers. The relay shall provide ANSI 50/51 protective functions for each of the three phases, and ANSI 50/51N or 50/51G ground fault protection functions. The relay shall be true RMS sensing of each phase and ground. Ground element shall be
capable of being utilized in residual, zero sequence, or ground source connection schemes, or deactivated.

c. Both the phase and ground protection curves shall be independently field selectable and programmable with or without load. Curves shall be selected from the following:

1) IEEE: Moderately inverse, very inverse, extremely inverse.
2) Thermal: Flat, It, I^2t, I^4t.

Thermal curves shall be similar to those on low-voltage trip units for close coordination with downstream devices. Selectable short delay pick-up and short delay time settings shall also be provided. The phase instantaneous overcurrent trip shall have field programmable pick-up points from 1 to 25 times current transformer primary rating or none.

d. The relay shall have a built-in alphanumeric display capable of displaying the following information with metering accuracy of ±1% of full-scale (In) from 0.04 I_n to 1 x I_n and ±2% of full scale (I_n) from 1 x I_n to 2 x I_n:

1) Individual phase currents.
2) Ground current.
3) Cause of trip.
4) Magnitude and phase of current causing trip.
5) Peak current demand for each phase and ground since last reset.
6) Current transformer primary rating.
7) Programmed phase and ground setpoints.

e. Relay shall have the following features:

1) Integral manual testing capability for both phase and ground.
2) Continuous self-testing of internal circuitry.
3) Unit failure alarm contact for Owner use.
4) Programmable inputs, such as current transformer ratios.
5) Access to program and test modes shall be via sealable cover for security.
6) Internal memory to store 20 event report summaries and 12 fifteen-cycle event reports.

f. Relay shall be suitable for operating temperatures from -10°C to 60°C. Relay shall be suitable for operating with humidity from 0 to 95% relative humidity.
g. Relay Alarm and/or Trip contacts shall not change state if power is lost or an undervoltage occurs. These contacts shall only cause a trip upon detection of an overcurrent or fault condition based upon programmed settings.

h. The relay shall be suitable for operating on control power with a nominal input voltage of 12 to 240 volts AC, 60 Hz. The power source will be from potential transformers. The relay shall be the dual source type. If the control voltage is lost, the unit will be capable of self-powering from the current monitored circuit. The power supply for the close and motor charge circuits shall be derived from an internal power transformer.

i. The same relay shall be used on all 15 kV and 5 kV circuit breakers. Provide local control switch to open and close each circuit breaker with two 6-volt indication lights. Control transformer (CT) ratios for the main breaker shall be as shown on the drawings. The feeder circuit breakers shall have CT ratios as shown on the drawings. All spare feeder and tie sections shall have CTs, control switches, and lights installed and wired for future use.

j. Communication Capabilities:
   1) Front RS232 communications port
   2) Rear redundant RS485 or plastic fiber optic or glass fiber optic async port
   3) Rear Ethernet 10/100 Base T sync port

3. Programmable digital AC metering:
   a. All meters shall be GE Multilin PQM II, no acceptable equal.
   b. The meter shall be True RMS, with a sampling rate of 64 samples/cycle. The meter shall measure and record the following:
      1) Amperes, Volts, Watts, VAR, VA, VARh, Wh, Power Factor, Frequency, and Unbalance per phase.
      2) Amperes, Watts, VAR, VA demand.
      3) Harmonic Analysis through 63rd Harmonic with THD and TIF.
      4) Wh, VARh, Vah, W Cost
   c. A 40-character illuminated display and keypad shall be included for programming and operation.
   d. An event recorder capable of storing 150 events shall be included.
   e. A data logger capable of storing 98,000 events shall be included.
f. A Voltage Disturbance Recorder (VDR) capable of storing 500 events shall be included.

g. Communications:
   1) COM1/COM2: RS485 2-wire half duplex, isolated.
   2) COM3: RS232, 9 pin
   3) Baud rate: 1,200-19,200 bps
   4) Protocol: ModBus RTU and DNP 3.0 level 2
   5) Functions: Read/write setpoints, Read actual values, Execute Commands.
   6) The meter shall be able to connect to a DCS or SCADA system.

h. Four analog outputs for interface to a PLC shall be provided. Output signals shall be selected from any of the measured parameters.

4. Space heaters:
   a. Space heaters with sheaths of high-temperature chrome steel shall be provided to maintain temperature in accordance with manufacturer’s tolerances inside the enclosure.
   b. There shall be a space heater in each bay.
   c. Space heaters shall be wired and controlled by thermostats. Circuiting shall not cross the tie breaker section. Independent circuiting shall be provided on each side of the switchgear.

5. Bus voltage transformers:
   a. Voltage transformers shall be molded rubber or epoxy-encapsulated, with current limiting primary fuses.
   b. Voltage transformers shall be Group 2 class for line-to-line or line-to-neutral connections as appropriate for the insulation class required. Primary voltage ratings and transformation ratios shall be as indicated. Voltage transformers shall have accuracy rating of not less than 0.3 class at the standard burden imposed by the connected devices.
   c. Cubicles shall house instrument transformers and energy meters.
   d. Fuses shall protect primary of transformers with breakers on the secondary.

G. Finish:
   1. The enclosure finish shall conform to or exceed applicable requirements of ANSI C57.12.28.
2. During fabrication, the areas of structural parts which may later become inaccessible, such as folded edges and overlapping members, shall be given an iron-oxide zinc-chromate anticorrosion primer to ensure that all surfaces are protected.

3. Full coverage at joints and blind areas shall be achieved by processing enclosures independently of components such as doors and roofs before assembly into the unitized structures.

4. To remove oils and dirt, to form a chemically and anodically neutral conversion coating to improve the finish-to-metal bond, and to retard underfilm propagation of corrosion, all surfaces shall undergo a thorough pretreatment process comprised of a fully automated system of cleaning, rinsing, phosphatizing, sealing, drying, and cooling before any protective coatings are applied. By utilizing an automated pretreatment process, the enclosure will receive a high consistent thorough treatment, eliminating fluctuations in reaction times, reaction temperature, and chemical concentrations.

5. After pretreatment, protective coatings shall be applied that shall help resist corrosion and protect the steel enclosure. To establish the capability to resist corrosion and protect the enclosure, representative test specimens coated by enclosure manufacturer’s finishing system shall satisfactory pass the following tests:
   a. 600 hours of exposure to salt-spray testing in accord with ASTM B117 with:
      1) Underfilm corrosion not to extend more than 1/32 in. from the scribe.
      2) Loss of adhesion from bare metal not to extend more than 1/8 in. from the scribe.
   b. 1000 hours of humidity testing in accord with ASTM D2247 with no blistering as evaluated in accord with ASTM D714.
   c. 500 hours of ultraviolet accelerated weathering testing in accord with ASTM G53 with no chalking as evaluated in accord with ASTM D659, and no more than a 15% reduction of paint gloss as evaluated in accord with ASTM D523.
   d. Cross-hatch adhesion testing in accord with ASTM D3359 Method B with no loss of paint.
   e. 160-in.-lb. impact adhesion testing in accord with ASTM D2794 with no paint chipping or cracking.
   f. Scab corrosion testing for 35 cycles with exposure to specific salt mist, temperature and relative humidity conditions for designated time intervals.
followed by the air blow-off adhesion test in accord with ASTM D1654 with creepage from the scribe not to extend more than 1-1/6 in. and no unusual surface failure.

g. Oil resistance testing consisting of a 72-hour immersion bath in mineral oil with no shift in color, no streaking, no blistering, and no loss of hardness.

h. 3000 cycles of abrasion testing in accord with ASTM D4060 with no penetration to the substrate.

Certified test abstracts substantiating the above capabilities shall be furnished upon request.

6. A heavy coat of insulating “no-drip” compound shall be applied to the inside surface of the roof structure to prevent condensation of moisture thereon.

7. After the enclosures are completely assembled and the components (switches, fuses, bus, etc.) are installed, the finish shall be inspected for scuffs and scratches. Blemishes shall be touched up to restore the protective integrity of the finish.

8. Touch-up materials - with complete instructions - shall be included with each shipment section of metal-enclosed switchgear for touch-up in the field.

9. The finish shall be light gray, satisfying the requirements of ANSI 61 with a final color coat of Plochere 1244.

H. Indoor features:

1. Enclosure ventilation:
   a. Ventilation openings shall be provided at the top and bottom on the front and rear of each bay.
   b. Vents shall be corrosion-resistant.
   c. Each vent shall have an inside screen, baffle, and filter to exclude insects and to protect against insertion of foreign objects.

2. Lifting eyes shall be removable. Sockets for lifting eyes shall be blind-tapped.

3. Gasketing and sealing:
   a. Door openings and opening for hinged bolted panels (and bolted panels providing access to low-voltage components) shall have resilient compression gasketing to prevent water from entering the enclosure.
   b. Gasket seals shall be provided at the top and side edges of adjoining bays to prevent water entry between the double walls.

4. Enclosure and equipment: Rated for seismic zone 4.
I. Warranty: Manufacturer shall warrant equipment to be free from defects in materials and workmanship for no less than 2 years from date of acceptance test.

PART 3 – EXECUTION

3.01 INSPECTION

A. Examine area to receive switchgear to provide adequate clearance for switchboard installation.

B. Check that concrete pads are level and free of irregularities.

C. Start work only after unsatisfactory conditions are corrected.

3.02 INSTALLATION

A. Install switchgear in accord with manufacturer’s written instructions and NEC. Install each section level and plumb and in straight horizontal alignment.

B. Anchor to pad with adequate concrete inserts and minimum of 5/8 in. stainless steel bolts and as directed by manufacturer’s written instructions to meet seismic zone 4 forces in accord with Section 1630 of the CBC and Section 16071.

3.03 ADJUSTING

A. Adjust all operating mechanisms for free mechanical movement in accord with manufacturer’s specifications.

B. Tighten bolted bus connections in accord with manufacturer’s instructions.

C. Relay settings: Set, test, and adjust protective relays associated with the equipment and its auxiliary systems. Testing shall be in accordance with Section 26 05 53. Set relays in accord with settings furnished by Owner.

3.04 FIELD QUALITY CONTROL

A. Inspect completed installation for physical damage, proper alignment, anchorage, and grounding.

B. Field testing shall be performed under provisions of NETA ATS (International Electrical Testing Associations). Refer to Section 26 05 53 for requirements.

C. Check tightness of accessible bolted bus joints using calibrated torque wrench in accord with manufacturer’s recommend torque values.

D. Physically test key interlock systems to check for proper functionality.
E. Make field test on all equipment, materials, and systems in accord with manufacturer’s recommendations, NETA, testing standards of IEEE and ANSI, upon completion of installation.

F. Conduct tests in the presence of Owner for the purpose of demonstrating equipment or systems’ compliance with specifications. Demonstrate all electrical and mechanical test to Owner that the entire installation is functioning properly and that all circuits, including power, control, instrumentation, relaying and communication will function properly and as specified.

G. Furnish, install, and maintain all tools, instruments, material, test equipment, test connections, and power. Furnish all personnel including supervision and “standby” labor required for testing, setting, and adjusting of all electrical facilities and component parts including putting the above into operation.

H. Make tests with proper regard for the protection of equipment and personnel.

I. Record all test values of equipment, giving both “as-found” and “as-left” conditions.

J. The witnessing of any test by Owner does not relieve Contractor of warranties for material, equipment, and workmanship, as specified in the General Conditions and Specifications.

K. Check control circuits for conformance with wiring diagrams.

L. Minimum tests:
   1. Perform the tests in Section 26 05 53 applicable to the equipment installed.
   2. All manufacturer’s recommended testing.

M. Equipment test values: Submit three certified copies of start-up and test data to Owner.

3.05 CLEANING

A. Touch up scratched or marred surfaces to match original finish.

END OF SECTION 26 13 23
PART 1 - GENERAL

1.01 SUMMARY
   A. This Section includes service and distribution switchboards rated 600 V and less.
   B. Related Sections include the following:
      1. Division 26 Section "Seismic Controls for Electrical Work."
      2. Division 26 Section "Electrical Power Metering."

1.02 DEFINITIONS
   A. EMI: Electromagnetic interference.
   B. GFCI: Ground-fault circuit interrupter.
   C. RFI: Radio-frequency interference.
   D. RMS: Root mean square.
   E. SPDT: Single pole, double throw.
   F. TVSS: Transient voltage surge suppressor.

1.03 SUBMITTALS
   A. Product Data: For each type of switchboard, overcurrent protective device, TVSS device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
   B. Shop Drawings: For each switchboard and related equipment.
      1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
         a. Enclosure types and details for types other than NEMA 250, Type 1.
         b. Bus configuration, current, and voltage ratings.
         c. Short-circuit current rating of switchboards and overcurrent protective devices.
         d. Descriptive documentation of optional barriers specified for electrical insulation and isolation.
e. Utility company’s metering provisions with indication of approval by utility company.

f. UL listing for series rating of installed devices.

g. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

2. Wiring Diagrams: Diagram power, signal, and control wiring and differentiate between manufacturer-installed and field-installed wiring.

C. Manufacturer Seismic Qualification Certification: Submit certification that switchboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section 16071. Include the following:

1. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. The term "withstand" means "the unit will remain in place without separation of internal and external parts during a seismic event and the unit will be fully operational after the event."

3. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

4. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Qualification Data: Submit data for testing agencies indicating that they comply with qualifications specified in "Quality Assurance" Article.

E. Field Test Reports: Submit written test reports and include the following:

1. Test procedures used.

2. Test results that comply with requirements.

3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

F. Manufacturer’s field service report.

G. Maintenance Data: For switchboards and components to include in maintenance manuals specified in Division 1. In addition to requirements specified in Division 1 Section "Contract Closeout," include the following:

1. Routine maintenance requirements for switchboards and all installed components.

2. Manufacturer’s written instructions for testing and adjusting overcurrent protective devices.
3. Time-current curves, including selectable ranges for each type of overcurrent protective device.

1.04 QUALITY ASSURANCE

A. Testing Agency Qualifications: In accordance with Section 16030.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NEMA PB 2.

D. Comply with NFPA 70.

E. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards, including clearances between switchboards, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver in sections of lengths that can be moved past obstructions in delivery path.

B. Store indoors in clean dry space with uniform temperature to prevent condensation. Protect from exposure to dirt, fumes, water, corrosive substances, and physical damage.

C. If stored in areas subjected to weather, cover switchboards to provide protection from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside switchboards; install electric heating (250-W per section) to prevent condensation in NEMA 3 or NEMA 3R enclosures.

D. Handle switchboards according to NEMA PB 2.1.

1.06 PROJECT CONDITIONS

A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.

B. Existing Utilities: Do not interrupt utilities serving facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Owner Representative not less than fourteen days in advance of proposed utility interruptions. Identify extent and duration of utility interruptions.

2. Indicate method of providing temporary utilities.
3. Proceed with utility interruptions only after receiving Owner Representative written authorizations.

C. Environmental Limitations: Rate equipment for continuous operation under the following, unless otherwise indicated:
   1. Ambient Temperature: Not exceeding 104 deg F.
   2. Altitude: Not exceeding 6600 feet.

D. Service Conditions: NEMA PB2, usual service conditions, as follows:
   1. Altitude not exceeding 6600 feet.
   2. Ambient temperatures within limits specified.

1.07 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."

1.08 EXTRA MATERIALS

A. Spares: For the following:
   1. Potential transformer fuses.
   2. Control-transformer fuses.
   3. Fuses and fusible devices for fused circuit breakers.
   4. Fuses for fused switches.
   5. Fuses for fused power-circuit devices.

B. Spare Indicating Lights: Six of each type installed.

PART 2 - PRODUCT

2.01 MANUFACTURERS
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

4. Square D Co.

2.02 MANUFACTURED UNITS

A. Front-Connected, Front-Accessible Switchboard: Panel-mounted and Fixed, individually mounted main device, panel-mounted branches, and sections rear aligned.

B. Front- and Side-Accessible Switchboard: Fixed, individually mounted main device, panel-mounted branches, and sections rear aligned.

C. Front- and Rear-Accessible Switchboard: Front and rear aligned, with features as follows:

1. Main Devices: Fixed, individually mounted.
2. Branch Devices: Individually compartmented and fixed mounted.

D. Nominal System Voltage: 480Y/277 V and/or 208 Y/120 V

E. Main-Bus Continuous: 2000 A maximum, 600 A minimum

2.03 FABRICATION AND FEATURES

A. Enclosure: Steel: NEMA 250, Type 3R (outdoors) and NEMA 250 type 1 (indoors)

B. Enclosure Finish for Outdoor Units: Factory-applied finish in manufacturer’s standard color, including undersurfaces treated with corrosion-resistant undercoating, or plated with cadmium or zinc.

C. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer’s standard light gray enamel finish over a rust-inhibiting primer on treated metal surface. Coat internal surfaces with corrosion resistant paint, or plate with cadmium or zinc.

D. Barriers: Between adjacent switchboard sections.

E. Insulation and isolation for main and vertical buses of feeder sections.

F. Insulation and isolation for main bus of main section and main and vertical buses of feeder sections.

G. Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.
1. Space-Heater Control: Thermostats to maintain temperature of each section above expected dew point.


H. Owner’s Metering and SCADA Equipment Compartment: Fabricated compartment and section complying with Owner’s requirements. If separate vertical section is required, match and align with basic switchboard.

I. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

J. Removable, Hinged Rear Doors and Compartment Covers: Secured by captive thumb screws, for access to rear interior of switchboard.

K. Hinged Front Panels: Allow access to circuit-breaker, metering, accessory, and blank compartments.

L. Pull Box on Top of Switchboard: Include the following features:
   1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.

M. Buses and Connections: Three phase, four wire, unless otherwise indicated. Include the following features:
   3. Ground Bus: 1/4-by-2-inch minimum size, drawn-temper copper of 98 percent conductivity, equipped with pressure connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
   4. Contact Surfaces of Buses: Silver plated.
   5. Main Phase Buses, Neutral Buses, and Equipment Ground Buses: Uniform capacity for entire length of switchboard’s main and distribution sections. Provide for future extensions from both ends.
7. Neutral Buses: 100 percent of the ampacity of the phase buses, unless otherwise indicated, equipped with pressure connectors for outgoing circuit neutral cables. Bus extensions for busway feeder neutral bus are braced.

N. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

2.04 OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.


3. Electronic Trip Unit Circuit Breakers: RMS sensing; field-replaceable rating plug; with the following field-adjustable settings:
   a. Instantaneous trip.
   b. Long- and short-time pickup levels.
   c. Long- and short-time time adjustments.
   d. Ground-fault pickup level, time delay, and I^2t response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.

5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.


B. Molded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.

1. Lugs: Compression style, suitable for number, size, trip ratings, and material of conductors.

2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
3. **Ground-Fault Protection:** Integrially mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

4. **Shunt Trip:** 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.

5. **Undervoltage Trip:** Set to operate at 35 to 75 percent of rated voltage without intentional time delay.

6. **Auxiliary Switch:** Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

7. **Key Interlock Kit:** Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

8. **Zone-Selective Interlocking:** Integral with electronic trip unit; for interlocking ground-fault protection function.

C. **Enclosed, Insulated-Case Circuit Breaker:** Fully rated, encased-power circuit breaker with interrupting capacity rating to meet available fault current.

1. Fixed circuit-breaker mounting.

2. Two-step, stored-energy closing.

3. Microprocessor-based trip units with interchangeable rating plug, LED trip indicators, and the following field-adjustable settings:
   a. Instantaneous trip.
   b. Long- and short-time pickup levels.
   c. Long- and short-time time adjustments with $I^2t$ response.
   d. Ground-fault pickup level, time delay, and $I^2t$ response.

4. Remote trip indication and control.

5. **Key Interlock Kit:** Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

6. **Zone-Selective Interlocking:** Integral with electronic trip unit; for interlocking ground-fault protection function.

7. **Control Voltage:** 125-V ac.

D. **Fused Switch:** NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

2.05 **INSTRUMENTATION**
A. Instrument Transformers: NEMA EI 21.1, IEEE C57.13, and the following:
   1. Potential Transformers: Secondary voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
   2. Current Transformers: Ratios shall be as indicated with accuracy class and burden suitable for connected relays, meters, and instruments.
   3. Control-Power Transformers: Dry type.
   4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondaries to ground overcurrent relays to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker ground-fault protection.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
   1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
      a. Phase Currents, Each Phase: Plus or minus 1 percent.
      b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
      c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
   2. Mounting: Display and control unit flush or semi-flush mounted in instrument compartment door.

2.06 CONTROL POWER
A. Control Circuits: 120 V, supplied through secondary disconnecting devices from control-power transformer.
B. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.
C. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.07 ACCESSORY COMPONENTS AND FEATURES
A. Accessory Set: Tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
B. Portable Test Set: To test functions of solid-state trip devices without removal from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.

D. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.

PART 3 - EXECUTION

3.01 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer’s written instructions.

3.02 EXAMINATION

A. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance.
   1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.03 INSTALLATION

A. Install switchboards and accessories according to NEMA PB 2.1.

B. Support switchboards on concrete bases, 4-inch nominal thickness.

C. Comply with mounting and anchoring requirements specified in Division 26 Section "Seismic Controls for Electrical Work."

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.

E. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures.

F. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

3.04 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section 26 05 53.

B. Switchboard Nameplates: Label each switchboard compartment with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.
3.05 CONNECTIONS

A. Install equipment grounding connections for switchboards with ground continuity to main electrical ground bus.

B. Tighten electrical connectors and terminals according to manufacturer’s published torque-tightening values. If manufacturer’s torque values are not indicated, use those specified in UL 486A and UL 486B.

3.06 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:
   1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

B. Testing: After installing switchboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
   1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Sections 7.1, 7.5, 7.6, 7.9, 7.10, 7.11, and 7.14 as appropriate. Certify compliance with test parameters.
   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

C. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front and rear panels so joints and connections are accessible to portable scanner.
   1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
   2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
   3. Record of Infrared Scanning: Prepare a certified report that identifies switchboards checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.07 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.
3.08 CLEANING

A. On completion of installation, inspect interior and exterior of switchboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish and leave touch-up paint with Owner.

END OF SECTION 26 24 13
PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes load centers and panelboards, overcurrent protective devices, and associated auxiliary equipment rated 600 V and less for the following types:
   1. Lighting and appliance branch-circuit panelboards.
   2. Distribution panelboards.
   3. Transient voltage surge suppressor panelboards.

B. Related Sections include the following:
   1. Division 26 Section "Seismic Controls for Electrical Work."

1.02 DEFINITIONS

A. EMI: Electromagnetic interference.
B. GFCI: Ground-fault circuit interrupter.
C. RMS: Root mean square.
D. SPDT: Single pole, double throw.

1.03 SUBMITTALS

A. Product Data: For each type of panelboard, overcurrent protective device, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.
   1. Dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings. Include the following:
      a. Enclosure types and details for types other than NEMA 250, Type 1.
      b. Bus configuration, current, and voltage ratings.
      c. Short-circuit current rating of panelboards and overcurrent protective devices.
      d. UL listing for series rating of installed devices.
      e. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
2. **Wiring Diagrams:** Diagram power, signal, and control wiring and differentiate between manufacturer-installed and field-installed wiring.

C. **Manufacturer Seismic Qualification Certification:** Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Seismic Controls for Electrical Work." Include the following:

1. **Basis of Certification:** Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. The term "withstand" means "the unit will remain in place without separation of internal and external parts during a seismic event and the unit will be fully operational after the event."

3. **Dimensioned Outline Drawings of Equipment Unit:** Identify center of gravity and locate and describe mounting and anchorage provisions.

4. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. **Field Test Reports:** Submit written test reports and include the following:

1. Test procedures used.

2. Test results that comply with requirements.

3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

E. **Panelboard Schedules:** For installation in panelboards. Submit final versions after load balancing.

F. **Maintenance Data:** For panelboards and components to include in maintenance manuals specified in Division 1. In addition, include the following:

1. Manufacturer’s written instructions for testing and adjusting overcurrent protective devices.

2. Time-current curves, including selectable ranges for each type of overcurrent protective device.

### 1.04 QUALITY ASSURANCE

A. **Testing Agency Qualifications:** In accordance with Section 26 05 53.

B. **Electrical Components, Devices, and Accessories:** Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to Owner, and marked for intended use.
C. Comply with NEMA PB 1.
D. Comply with NFPA 70.

1.05 COORDINATION
A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, and encumbrances to workspace clearance requirements.

1.06 EXTRA MATERIALS
A. Keys: Six spares of each type of panelboard cabinet lock, keyed alike to match the Owner standard key requirements.

PART 2 - PRODUCTS

2.01 MANUFACTURERS
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Panelboards, Overcurrent Protective Devices, Controllers, Contactors, and Accessories:
      c. Siemens Energy & Automation, Inc.
      d. Square D Co.

2.02 FABRICATION AND FEATURES
A. Enclosures: Flush- and surface-mounted cabinets. NEMA PB 1, Type 1, to meet environmental conditions at installed location.
   1. Outdoor Locations: NEMA 250, Type 3R.
   3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
   4. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7C.
B. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
C. Finish: Manufacturer's standard enamel finish over corrosion-resistant treatment or primer coat.

D. Directory Card: Typed panel circuit schedule/index with transparent protective cover, mounted inside metal frame, inside panelboard door.

E. Bus: Hard-drawn copper, 98 percent conductivity.

F. Main and Neutral Lugs: Compression type suitable for use with conductor material.

G. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors; bonded to box. When isolated grounds are required, provide ground bus insulated from box.

H. Future Devices: Mounting brackets, bus connections, and necessary appurtenances required for future installation of devices.

I. Isolated Equipment Ground Bus: Adequate for branch-circuit equipment ground conductors; insulated from box.

J. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads.

K. Split Bus: Vertical buses divided into individual vertical sections.

L. Gutter Barrier: Arrange to isolate individual panel sections.

M. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.

2.03 PANELBOARD SHORT-CIRCUIT RATING

A. UL label indicating series-connected rating with integral or remote upstream devices. Include size and type of upstream device allowable, branch devices allowable, and UL series-connected short-circuit rating.

B. Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.04 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

B. Doors: Front mounted with concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.05 DISTRIBUTION PANELBOARDS

A. Doors: Front mounted, except omit in fused-switch panelboards; secured with vault-type latch with tumbler lock; keyed alike.
B. Main Overcurrent Protective Devices: Molded Case Circuit Breaker

C. Branch overcurrent protective devices shall be one of the following:
   1. For Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.
   2. For Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.
   3. Fused switches.

2.06 OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.
   3. Electronic Trip Unit Circuit Breakers: RMS sensing; field-replaceable rating plug; with the following field-adjustable settings:
      a. Instantaneous trip.
      b. Long- and short-time pickup levels.
      c. Long- and short-time time adjustments.
      d. Ground-fault pickup level, time delay, and I^2t response.
   4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
   5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.

B. Molded-Case Circuit-Breaker Features and Accessories. Standard frame sizes, trip ratings, and number of poles.
   1. Lugs: Compression style, suitable for number, size, trip ratings, and material of conductors.
2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.


4. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system.

5. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.

6. Under-voltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.

7. Auxiliary Switch: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

8. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install panelboards and accessories according to NEMA PB 1.1.

B. Comply with mounting and anchoring requirements specified in Division 26 Section "Seismic Controls for Electrical Work."

C. Mounting Heights: Top of trim 74 inches above finished floor, unless otherwise indicated.

D. Mounting: Plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish.

E. Circuit Directory: Create a directory to indicate installed circuit loads after balancing panelboard loads. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

F. Install filler plates in unused spaces.

G. Provision for Future Circuits at Flush Panelboards: Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.

H. Wiring in Panelboard Gutters: Arrange conductors into groups and bundle and wrap with wire ties after completing load balancing.

3.02 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section 26 05 33.

B. Panelboard Nameplates: Label each panelboard with laminated-plastic nameplate mounted with corrosion-resistant screws.

3.03 CONNECTIONS

A. Install equipment grounding connections for panelboards with ground continuity to main electrical ground bus.

B. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.04 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:
1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

B. Testing: After installing panelboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

C. Balancing Loads: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes as follows:

1. Measure as directed during period of normal system loading.

2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data-processing, computing, transmitting, and receiving equipment.

3. After circuit changes, re-check loads during normal load period. Record all load readings before and after changes and submit test records.

4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

D. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove panel fronts so joints and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.

2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

3. Record of Infrared Scanning: Prepare a certified report that identifies panelboards checked and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.05 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.06 CLEANING
A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 26 24 16
PART 1 - GENERAL

1.01 SECTION INCLUDES:
   A. Single and duplex receptacles, ground-fault circuit interrupters, integral surge suppression units, and isolated-ground receptacles.
   B. Single- and double-pole snap switches and dimmer switches.
   C. Device wall plates.
   D. Pin and sleeve connectors and receptacles.
   E. Floor service outlets, poke-through assemblies, service poles, and multi-outlet assemblies.

1.02 RELATED WORK SPECIFIED ELSEWHERE:
   A. Identification: Section 26 05 53
   B. Conductors: Section 26 05 19
   C. Boxes: Section 16130

1.03 DEFINITIONS:
   A. EMI: Electromagnetic interference.
   B. GFCI: Ground-fault circuit interrupter.
   C. PVC: Polyvinyl chloride.
   D. RFI: Radio-frequency interference.
   E. TVSS: Transient voltage surge suppressor.
   F. UTP: Unshielded twisted pair.

1.04 SUBMITTALS:
   A. Product Data: For each type of product indicated.
   B. Field quality-control test reports.

1.05 QUALITY ASSURANCE
   A. Source Limitations: Obtain each type of wiring device through one source from a single manufacturer.
B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Wiring Devices:
   b. Hubbell Incorporated; Wiring Device-Kellems.
   c. Leviton Mfg. Company Inc.
   d. Pass & Seymour/Legrand; Wiring Devices Div.

2. Wiring Devices for Hazardous (Classified) Locations:
   b. EGS/Appleton Electric Company.
   c. Killark Electric Manufacturing Co./Hubbell Incorporated.

3. Multi-outlet Assemblies:
   a. Hubbell Incorporated; Wiring Device-Kellems.
   b. Wiremold Company (The).

4. Poke-Through, Floor Service Outlets and Telephone/Power Poles:
   a. Hubbell Incorporated; Wiring Device-Kellems.
   b. Pass & Seymour/Legrand; Wiring Devices Div.
   c. Square D/Groupe Schneider NA.
   d. Thomas & Betts Corporation.
   e. Wiremold Company (The).

2.02 RECEPTACLES

A. Straight-Blade-Type Receptacles: Comply with NEMA WD 1, NEMA WD 6, DSCC W-C-596G, and UL 498. “Decora or style line” type in white color.
B. Straight-Blade and Locking Receptacles: Heavy-Duty/Industrial grade.

C. Straight-Blade Receptacles: Hospital grade/Institutional grade.

D. GFCI Receptacles: Straight blade, feed-through type, Heavy-Duty/Industrial grade, with integral NEMA WD 6, Configuration 5-20R duplex receptacle; complying with UL 498 and UL 943. Design units for installation in a 2-3/4-inch deep outlet box without an adapter.

E. Isolated-Ground Receptacles: Straight blade, Heavy-Duty/Industrial grade, duplex receptacle, with equipment grounding contacts connected only to the green rounding screw terminal of the device and with inherent electrical isolation from mounting strap.
   1. Devices: Listed and labeled as isolated-ground receptacles.
   2. Isolation Method: Integral to receptacle construction and not dependent on removable parts.

F. TVSS Receptacles: Straight blade, NEMA WD 6, Configuration 5-20R, with integral TVSS in line to ground, line to neutral, and neutral to ground.
   1. TVSS Components: Multiple metal-oxide varistors; with a nominal clamp level rating of 500 volts and minimum single transient pulse energy dissipation of 140 J line to neutral, and 70 J line to ground and neutral to ground.
   2. Active TVSS Indication: Visual and audible with light visible in face of device to indicate device is "active" or "no longer in service."
   3. Receptacle Type: Hospital grade, with isolated-ground terminal.
   4. Identification: Distinctive marking on face of device to denote TVSS-type unit.

G. Industrial Heavy-Duty Pin and Sleeve Devices: Comply with IEC 309-1.

H. Hazardous (Classified) Location Receptacles: Comply with NEMA FB 11.

2.03 PENDANT CORD/CONNECTOR DEVICES

A. Description: Matching, locking-type plug and receptacle body connector, NEMA WD 6, Configurations L5-20P and L5-20R, Heavy-Duty grade.

2.04 CORD AND PLUG SETS

A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.
1. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30 percent.


2.05 SWITCHES


B. Snap Switches: Heavy-Duty grade, quiet type.

C. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on/off switches and audible frequency and EMI/RFI filters.

1. Control: Continuously adjustable slider; with single-pole or three-way switching to suit connections.

2. Incandescent Lamp Dimmers: Modular, 120 V, 60 Hz with continuously adjustable, or slider; single pole with soft tap or other quiet switch; EMI/RFI filter to eliminate interference; and 5-inch wire connecting leads.

3. Use fluorescent lamp dimmer switches below with compatible dimming-type ballasts. Coordinate with Division 16 Section "Interior Lighting." Use uniform ballast and lamp types to obtain consistent dimming characteristics.

4. Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 10 percent of full brightness and 1 percent in areas where projection equipment is utilized.

2.06 WALL PLATES

A. Single and combination types to match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.

2. Material for Finished Spaces: 0.035-inch thick, satin-finished stainless steel.


4. Material for Wet Locations: Cast aluminum with spring-loaded lift cover, with gasket between box and plate, and listed and labeled for use in “wet locations.”

2.07 FLOOR SERVICE FITTINGS

A. Type: Modular, flush-type, dual-service units suitable for wiring method used.

B. Compartments: Barrier separates power from voice and data communication cabling.
C. Service Plate: Round, die-cast aluminum with satin finish.

D. Power Receptacle: NEMA WD 6, Configuration 5-20R, gray finish, unless otherwise indicated.

E. Voice and Data Communication Outlet: Blank cover with bushed cable opening, Two modular, keyed, color-coded, RJ-45 Category 3 jacks for UTP cable or Two modular, keyed, color-coded, RJ-45 Category 5 jacks for UTP cable.

2.08 POKE-THROUGH ASSEMBLIES

A. Description: Factory-fabricated and -wired assembly of below-floor junction box with multi-channeled, through-floor raceway/firestop unit and detachable matching floor service outlet assembly.

1. Service Outlet Assembly: Pedestal type with services indicated, Flush type with two simplex receptacles and space for two RJ-45 jacks or Flush type with four simplex receptacles and space for four RJ-45 jacks.

2. Size: Selected to fit nominal 4-inch cored holes in floor and matched to floor thickness.

3. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.

4. Closure Plug: Arranged to close unused 4-inch cored openings and reestablish fire rating of floor.

5. Wiring Raceways and Compartments: For a minimum of four No. 12 AWG conductors; and a minimum of 4-pair, Category 5 voice and data communication cables.

2.09 MULTI-OUTLET

A. Components of Assemblies: Products from a single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.

B. Raceway Material: Base, cover and end plates shall be constructed of extruded aluminum #6063-T5, 0.060-inch minimum wall thickness. Finish shall be clear anodized #AA-C22A31, Class 2.

C. Wire: No. 12 AWG.

2.10 SERVICE POLES

A. Description: Factory-assembled and -wired units to extend power and voice and data communication from distribution wiring concealed in ceiling to devices or outlets in pole near floor.
1. Poles: Nominal 2.5-inch- square cross section, with height adequate to extend from floor to at least 6 inches above ceiling, and with separate channels for power wiring and voice and data communication cabling.

2. Mounting: Ceiling trim flange with concealed bracing arranged for positive connection to ceiling supports; with pole foot and carpet pad attachment.

3. Specify final finish in first subparagraph below if known.


5. Wiring: Sized for minimum of five No. 12 AWG power and ground conductors; and a minimum of four, 4-pair, Category 5 voice and data communication cables.


7. Voice and Data Communication Outlets: Four RJ-45 Category 5 jacks.

2.11 FINISHES

A. Color:

1. Wiring Devices Connected to Normal Power System: Gray as selected by the University, unless otherwise indicated or required by NFPA 70.


3. TVSS Devices: Blue.

4. Isolated-Ground Receptacles: As specified above, with orange triangle on face.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install devices and assemblies level, plumb, and square with building lines.

B. Install wall dimmers to achieve indicated rating after derating for ganging according to manufacturer's written instructions.

C. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' written instructions.

D. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical, and with grounding terminal of receptacles on top. Group adjacent switches under single, multi-gang wall plates.

E. Remove wall plates and protect devices and assemblies during painting.
F. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.02 IDENTIFICATION

A. Comply with Section 26 05 53 “Tests and Identifications”.

1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.03 CONNECTIONS

A. Ground equipment according to Division 16 Section “Grounding and Bonding.”

B. Connect wiring according to Division 16 Section “Conductors and Cables.”

C. Tighten electrical connectors and terminals according to manufacturer’s published torque-tightening values. If manufacturer’s torque values are not indicated, use those specified in UL 486A and UL 486B.

3.04 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. After installing wiring devices and after electrical circuitry has been energized, test for proper polarity, ground continuity, and compliance with requirements.

2. Test GFCI operation with both local and remote fault simulations according to manufacturer’s written instructions.

B. Remove malfunctioning units, replace with new units, and retest as specified above.

END OF SECTION   26 27 26
1.01 SUMMARY

A. Compliance with NFPA 110 shall be required. Field installation shall comply with CEC Article 702, Optional Standby Systems, except as noted. The engine generator package shall comply with UL 2200 and be UL listed.

B. The diesel engine generator package shall be synchronous brushless excitation type. The generator shall be rated 45 kW, 1-Phase, 120/240 VAC, 60 Hz.

C. This Section includes packaged diesel engine-generator set with the following features and accessories:
   1. Battery charger.
   2. Base tank.
   3. Engine-generator set.
   5. Exhaust piping external to engine-generator set.
   6. Outdoor-rated sound reduction and weatherproofing enclosure.
   7. Remote start/stop switch.
   8. Starting battery.

D. Related Sections include the following:
   1. General Requirements
   2. Division 3 - Concrete
   3. Division 1 – General Requirements
   4. Section 26 05 53 – Tests and Identification
   5. Section 16080 – Overcurrent Protection
   6. Section 16233 – Transfer Switches
   7. Section 26 05 26 – Grounding and Bonding

1.02 DEFINITIONS

A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.
B. Steady-State Voltage Modulation: The uniform cyclical variation of voltage within the operational bandwidth, expressed in Hertz or cycles per second.

1.03 SUBMITTALS

A. Product Data: Include the following:
1. Data on features, components, accessories ratings, and performance.
2. Thermal damage curve for generator.
3. Time-current characteristic curves for generator protective device.
4. Load analysis identifying SKW, SkVA, RKW, RkVA for sequential starting of loads identified in this specification.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
1. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.
2. Design Calculations: Signed and sealed by a qualified California professional engineer. Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
3. Vibration Isolation Base Details: Signed and sealed by a qualified professional engineer. Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.

C. Welding certificates.

D. Manufacturer Seismic Qualification Certification: Submit certification that day tank, engine-generator set, batteries, battery racks, accessories, and components will withstand seismic forces defined in Division 26 Section "Seismic Controls for Electrical Work." Include the following:
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Qualification Data: Provide for equipment manufacturer and installation contractor.

F. Certified summary of prototype-unit test report.

G. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.

H. Certified Summary of Performance Tests: Demonstrate compliance with specified requirement to meet performance criteria for sensitive loads.

I. Test Reports:
   1. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
   3. Report of exhaust emissions showing compliance with applicable regulations.
   4. Field quality-control test reports.

J. Certification of Torsional Vibration Compatibility: Comply with NFPA 110.

K. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals, include the following:
   1. List of tools and replacement items recommended to be stored at the Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.

L. Manufacturer’s certified letter stating that unit complies with all California State Codes, Uniform Building Code (UBC), California Electrical Code (CEC) and National Electric Manufacturer’s Association (NEMA) standards for emergency power plant.

1.04 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer’s authorized representative who is trained and approved for installation of units required for this Project.
   1. Maintenance Proximity: Not more than four hours’ normal travel time from Installer’s place of business to Project site.
   2. Engineering Responsibility: Preparation of data for vibration isolators and seismic restraints of engine skid mounts, including Shop Drawings, based on testing and engineering analysis of manufacturer’s standard units in assemblies similar to those indicated for this Project.
B. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 50 miles of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.

1. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated and that is acceptable to authorities having jurisdiction.

C. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.

D. Product Options: Drawings shall indicate size, profiles, and dimensional requirements of packaged generator sets and shall represent the specific system indicated. All drawings and data shall be marked to identify the option(s) being provided.

E. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX for welding exhaust-system piping.

F. Electrical Components, Devices, and Accessories: UL listed and labeled and marked for intended use. Where UL listing is not available labeling may be provided by a Third-Party testing agency acceptable to the College.

G. Comply with NFPA 30.

H. Comply with NFPA 37.

I. Comply with NFPA 70.

J. Comply with NFPA 110 requirements for Level 1 emergency power supply system.

K. Engine Exhaust Emissions: Comply with applicable SCAQMD requirements.

L. Noise Emission: Comply with Owner requirements and not exceed a 75dB for maximum noise level at 20 feet in any direction due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

1.05 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

1.06 WARRANTY

A. Warranty Period: Comprehensive with no additional cost to University for two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Generac
   2. Or equal

2.02 ENGINE-GENERATOR SET

A. Packaged engine-generator set shall be a coordinated assembly of compatible components.

B. Power Output Ratings: Nominal ratings as indicated on drawings, with capacity as required to operate as a unit as evidenced by records of prototype testing.

C. Output Connections: Single Phase, 3-Wire.

D. Safety Standard: Comply with ASME B15.1.

E. Nameplates: Each major system component shall be equipped with a nameplate to identify manufacturer’s name and address, and model and serial number of component.

F. Fabricate engine-generator-set mounting frame and attachment of components to resist generator-set movement during a seismic event when generator-set mounting frame is anchored to building structure.

G. Mounting Frame: Adequate strength and rigidity to maintain alignment of mounted components without depending on concrete foundation. Mounting frame shall be free from sharp edges and corners and shall have lifting attachments arranged for lifting with slings without damaging components.
   1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.

2.03 GENERATOR PERFORMANCE

A. Steady-State Voltage Operational Bandwidth: 4 percent of rated output voltage from no load to full load.

B. Steady-State Voltage Modulation Frequency: Less than 1 Hz.

C. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.

D. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
E. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.

F. Transient Frequency Performance: Less than 5 percent variation for a 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.

G. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. The telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.

H. Sustained Short-Circuit Current: For a bolted short circuit at system output terminals, the system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.

I. Start Time: Comply with NFPA 110, Type 10, system requirements.

2.04 GENERATOR PERFORMANCE FOR SENSITIVE LOADS

A. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.

1. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.

B. Steady-State Voltage Operational Bandwidth: 2 percent of rated output voltage from no load to full load.

C. Steady-State Voltage Modulation Frequency: Less than 1 Hz.

D. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.

E. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.

F. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
G. Transient Frequency Performance: Less than 2-Hz variation for a 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.

H. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. The telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.

I. Sustained Short-Circuit Current: For a bolted short circuit at system output terminals, the system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.

J. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.

K. Start Time: Comply with NFPA 110, Type 10, system requirements.

2.05 SERVICE CONDITIONS

A. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
   1. Ambient Temperature: -40 to 70 deg C.
   2. Relative Humidity: 0 to 100 percent.
   3. Altitude: Sea level to 1500 feet

2.06 ENGINE

A. Fuel: Diesel.

B. Lubrication System: The following items are mounted on engine or skid:
   1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
   2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
   3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

C. Engine Fuel System:
   1. Main Fuel Pump: Gear type, positive displacement, mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
2. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.
3. Primary fuel strainer
4. Secondary fuel filter
5. Lube-oil filter
6. Intake air filter

D. Block Heater: 1000W.

E. Governor: Electronic, Frequency regulation, isochronous.
   1. Steady state regulation +/- 0.33%

2.07 ENGINE COOLING SYSTEM

A. Description: Closed loop, liquid cooled, with radiator factory mounted on engine-generator set mounting frame and integral engine-driven coolant pump.

B. Radiator: Rated for specified coolant. Size to maintain safe engine temperature in ambient temperature of 120 deg. F. Radiator airflow restriction shall be 0.5 inches of water maximum.
   1. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
   2. Fan: Driven by multiple belts from engine shaft.

C. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.

D. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.

E. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.
   1. Rating: 50-psig maximum working pressure with coolant at 180 deg F, and non-collapsible under vacuum.
   2. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

2.08 FUEL SUPPLY SYSTEM

A. Base Tank: Comply with UL 142, freestanding, factory-fabricated fuel tank assembly, with integral, float-controlled transfer pump and the following features:
1. Containment: Integral rupture basin with a capacity of 150 percent of nominal capacity of day tank.
   a. Leak Detector: Locate in rupture basin and connect to provide audible and visual alarm in the event of day-tank leak.

2. Tank Capacity: As recommended by engine manufacturer for an uninterrupted period of 17 hours operation at 100 percent of rated power output of engine generator system without being refilled.

3. Low-Level Alarm Sensor: Liquid-level device to operate alarm contacts at 25 percent of normal fuel level.
   a. Low level sensor

4. Piping Connections: Factory-installed fuel supply and return lines from tank to engine; local fuel fill, vent line, overflow line; and tank drain line with shutoff valve, all in accordance with UL 142.

2.09 ENGINE EXHAUST SYSTEM

A. Muffler: Critical type, sized as recommended by engine manufacturer; sound level measured at a distance of 10 feet from exhaust discharge shall be 79 dBA or less.

B. Condensate Drain for Muffler: Schedule 40, black steel pipe connected to muffler drain outlet through a petcock.

C. Connection from Engine to Exhaust System: Flexible section of corrugated stainless-steel pipe.

D. Connection from Exhaust Pipe to Muffler: Stainless-steel expansion joint with liner.

E. Exhaust Piping External to Engine: ASTM A 53/A 53M, Schedule 40, welded, black steel, with welded joints and fittings.

2.10 COMBUSTION-AIR INTAKE

A. Description: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

2.11 STARTING SYSTEM

A. Description: 24V electric, with negative ground and including the following items:

1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Environmental Conditions" Paragraph in "Service Conditions" Article.

2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3. Cranking Cycle: As required by NFPA 110 for system level specified.

4. Battery: Adequate capacity within ambient temperature range specified in "Environmental Conditions" Paragraph in "Service Conditions" Article to provide specified cranking cycle at least three times without recharging.

5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.

6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in "Environmental Conditions" Paragraph in "Service Conditions" Article. Include accessories required to support and fasten batteries in place.


8. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236 and include the following features:
   a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
   b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
   c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
   e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.12 CONTROL AND MONITORING

A. Functional Description: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in a separate automatic transfer switch initiate starting and stopping of the generator set. When mode-selector switch is switched to the on position, the generator set starts. The off position of the same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down the generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down the generator set.

B. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.

1. A digital microprocessor-based control panel with two 4 line x 20 character displays shall be included.
2. System Status shall be displayed on the control panel.
3. A modem shall be included for remote communication and monitoring.
4. All connections shall be waterproof.

C. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.

D. Data Link: Internal modem for communication.

E. Remote Alarm Annunciator: Comply with NFPA 99. Labeled LED shall identify each alarm event. Common audible signal shall sound for alarm conditions. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface-mounting type to suit mounting conditions indicated.

1. Engine high-temperature shutdown.
2. Lube-oil low-pressure shutdown.
3. Overspeed shutdown.
5. Engine high-temperature pre-alarm.
6. Lube-oil low-pressure pre-alarm.
7. Fuel tank, low-fuel level.
8. Low coolant level.
11. Control switch not in auto position.

F. Remote Emergency-Stop Switch: Surface; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

2.13 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Generator Circuit Breaker: Insulated-case, electronic-trip type; 100 percent rated; complying with UL 489.
   1. Circuit Breaker Sizing as noted on plans.
   3. Trip Settings: Matched to generator thermal damage curve as closely as possible.
   4. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
   5. Mounting: Adjacent to or integrated with control and monitoring panel.

B. Generator Protector: Microprocessor-based unit that continuously monitors current level in each phase of generator output, integrates generator heating effect over time, and predicts when thermal damage of the alternator will occur. When signaled by the protector or other generator-set protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from the load circuits. Protector shall perform the following functions:
   1. Initiates a generator overload alarm when the generator has operated at an overload equivalent to 100 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms.
   2. Under single or three-phase fault conditions, regulates the generator to 300 percent of rated full-load current for up to 10 seconds.
3. As the overcurrent heating effect on the generator approaches the thermal damage point of the unit, the protector switches the excitation system off, opens the generator disconnect device, and shuts down the generator set.

4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

2.14 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1 and specified performance requirements.

B. Drive: Generator shaft shall be directly connected to engine shaft.

C. Electrical Insulation: Class F.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.

E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 100 percent of rated capacity.

F. Permanent magnet (PM) generator set shall provide the source of excitation to the exciter to increase immunity to non-linear loads and to maintain 300% of rated current for 10 seconds during short circuit conditions. Excitation shall use no slip or collector rings, or brushes, and shall be arranged to sustain generator output under short-circuit conditions as specified.

G. Digital Voltage Regulator: The microprocessor based digital voltage regulator shall maintain generator set output voltage within +/- 1% for any load between no load and full load across the entire operating temperature range. The regulator shall employ a programmable volts per Hertz regulation characteristic with adjustable slope (volts / Hertz), adjustable constant voltage corner frequency, and adjustable under voltage corner frequency. It shall be adjustable for low response to noise and high harmonic tolerance to VFDs specified in this Section. Sensing shall be three-phase true RMS. The regulator shall provide programmable over / under voltage protection, over-excitation protection, diode failure monitor, and logged fault and service codes to aid in troubleshooting. It shall incorporate an RS-232 and RS-485 and modem communications ports allowing external monitoring and control of the regulator. The regulator shall be environmentally sealed.

H. Enclosure: Drip proof.

I. Instrument Transformers: Mounted within generator enclosure.

J. Subtransient Reactance: 12 percent, maximum.
2.15 OUTDOOR GENERATOR-SET ENCLOSURE

A. Description: Prefabricated or pre-engineered enclosure with the following features:

2. Structural Design and Anchorage: Wind resistant up to 100 mph.
3. Space Heater: Thermostatically controlled and sized to prevent condensation.
4. Louvers: Equipped with bird screen and filter arranged to permit air circulation when engine is not running while excluding exterior dust, birds, and rodents.
5. Hinged Doors: With padlocking provisions
6. Ventilation: Louvers equipped with bird screen and filter arranged to permit air circulation while excluding exterior dust, birds, and rodents.
7. Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits required by engine-generator-set components.
8. Muffler Location: Within enclosure.

B. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for 2 hours with ambient temperature at top of range specified in system service conditions.

1. Louvers: Fixed-engine cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.
2. Automatic Dampers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating.

2.16 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard enamel over corrosion-resistant pretreatment and compatible standard primer.

2.17 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with NFPA 110, Level 1 energy converters in Paragraphs 3.2.1, 3.2.1.1, and 3.2.1.2.
3. Components and Accessories: Items furnished with installed unit that are not identical to those on tested prototype shall have been factory tested to demonstrate compatibility and reliability.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.

B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 CONCRETE BASES

A. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.

B. Concrete base is specified in Division 16 Section "Basic Electrical Materials and Methods," and concrete materials and installation requirements are specified in Division 3.

3.03 INSTALLATION

A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions.

B. Install packaged engine generators level on 6" raised concrete pad concrete base.

   1. Vibration Isolation: Mount packaged engine generator directly on concrete pad. Engine generator shall have Internal vibration isolation devices.

C. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

D. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.04 CONNECTIONS

A. Ground equipment according to Division 16 Section "Grounding and Bonding."

B. Connect wiring according to Division 16 Section "Conductors."
C. Tighten electrical connectors and terminals according to manufacturer’s published
torque-tightening values. If manufacturer's torque values are not indicated, use those
specified in UL 486A and UL 486B.

3.05 IDENTIFICATION

A. Identify system components according to Division 16 Section "Electrical Identification."

3.06 FIELD QUALITY CONTROL

A. Manufacturer’s Field Service: Engage a factory-authorized service representative to
inspect, test, and adjust field-assembled components and equipment installation,
including connections. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Perform each electrical test and visual and mechanical inspection stated in NETA
ATS, Sections 7.15.2.1 and 7.22.1 (except for vibration baseline test). Certify
compliance with test parameters.

2. Perform tests recommended by manufacturer.
   a. Perform load tests that represent load conditions identified in “Normal
      Conditions of Service” located in this Section.

3. Battery Tests: Equalize charging of battery cells according to manufacturer’s
   written instructions. Record individual cell voltages.
   a. Measure charging voltage and voltages between available battery terminals
      for full-charging and float-charging conditions. Check electrolyte level and
      specific gravity under both conditions.
   b. Test for contact integrity of all connectors. Perform an integrity load test and
      a capacity load test for the battery.
   c. Verify acceptance of charge for each element of the battery after discharge.
   d. Verify that measurements are within manufacturer’s specifications.

4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and
   float-charging conditions.

5. System Integrity Tests: Methodically verify proper installation, connection, and
   integrity of each element of engine-generator system before and during system
   operation. Check for air, exhaust, and fluid leaks.

6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-
inch wg. Connect to exhaust line close to engine exhaust manifold. Verify that
back pressure at full-rated load is within manufacturer's written allowable limits for the engine.

7. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.

8. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at locations 20 feet in any direction, and compare measured levels with required values.

C. Coordinate tests with tests for transfer switch and run them concurrently.

D. Test instruments shall have been calibrated within the last 12 months, traceable to standards of the National Institute for Standards and Technology, and adequate for making positive observation of test results. Make calibration records available for examination on request.

E. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

H. Remove and replace malfunctioning units, reinspect, and retest as specified above.

I. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

J. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

3.07 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.

C. Complete installation and startup checks according to manufacturer's written instructions.

3.08 DEMONSTRATION
A. Engage a factory-authorized service representative to train University maintenance personnel to adjust, operate, and maintain packaged engine generators. Minimum training time shall be four hours.

1. Coordinate this training with that for transfer switches.

END OF SECTION 26 32 13
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section Includes:
   1. Interior lighting systems, including luminaires, ballasts, lamps and emergency lighting equipment.

B. Related Work:
   1. Section 26 05 00, COMMON WORK RESULTS FOR ELECTRICAL.
   2. Section 26 05 33, RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS: Conduits, fittings, and boxes for raceway systems.
   3. Section 26 05 19, LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Low voltage power and lighting wiring.
   4. Section 26 05 26, GROUNDING AND BONDING: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
   5. Section 26 56 00, EXTERIOR LIGHTING.

1.3 SUBMITTALS

A. Submit in accordance with Division 1 requirements.

B. Shop Drawings:
   1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
   2. Include electrical ratings, dimensions, mounting, details, materials, terminations, wiring and connection diagrams, photometric data, ballasts, luminaires, lamps and controls.

1.4 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements) form a part of this specification to the extent referenced. Publications are referenced in the text by the basic designation only.

C. American National Standards Institute (ANSI).

D. Aluminum Association Inc. (AA).

E. Illuminating Engineering Society of North America (IESNA).

F. National Electrical Manufacturers Association (NEMA).

G. National Fire Protection Association (NFPA).

H. Underwriters Laboratories, Inc. (UL).

1.5 DEFINITIONS

A. Lighting terminology used herein is defined in IES

B. Exception: The term “driver” is used herein to cover both drivers and power supplies, where applicable.

C. Clarification: The term “LED light source(s)” is used herein per IES to cover LED package(s), module(s), and array(s).

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

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

2.2 LIGHTING FIXTURES (LUMINAIRES)

A. Shall be in accordance with NFPA 70, UL 1598 and shall be as shown on drawings and as specified. All luminaires shall have been certified to the California Energy Commission by its manufacturer to comply with the efficiency standards as per California Code of Regulations Title 24, Part 6, Section 111 referencing the Appliance Efficiency Regulations in Title 20. Post certification with building permit.

B. Sheet Metal:
   1. Shall be formed to prevent warping and sagging. Housing, trim and lens frame shall be true, straight (unless intentionally curved) and parallel to each other as designed.
2. Wireways and fittings shall be free of burrs and sharp edges and shall accommodate internal and branch circuit wiring without damage to the wiring.

3. When installed, any exposed fixture housing surface, trim frame, door frame and lens frame shall be free of light leaks; lens doors shall close in a light tight manner.
   a. Hinged door closure frames shall operate smoothly without binding when the fixture is in the installed position, and latches shall function easily by finger action without the use of tools.

C. Ballasts shall be serviceable while the fixture is in its normally installed position, and shall not be mounted to removable reflectors or wireway covers.

D. Recessed fixtures shall be of the type approved for the ceiling and insulation conditions and appropriate for the installation location. Insulation must be held back from the fixture to provide manufacturers' recommended clearances for proper operation. Thermal tripping shall be the installer's responsibility to correct. Where installed in fire rated ceilings, coordinate installation of fire rated enclosures around the ceiling penetrations. Fixtures shall contain the proper through wiring capacity for that which is shown on the plans.

E. Recessed fixtures shall be provided with the appropriate trims and hardware compatible with the ceiling type shown. Plaster frames are required where plaster or gypsum board ceilings are encountered.

F. Fixtures with louvers or light transmitting panels shall have hinges, latches and safety catches to facilitate safe, convenient cleaning and relamping. Vapor tight fixtures shall have pressure clamping devices in lieu of the latches.

G. Mechanical Safety: Lighting fixture closures (lens doors, trim frame, hinged housings, etc.) shall be retained in a secure manner by captive screws, chains, captive hinges or fasteners such that they cannot be accidentally dislodged during normal operation or routine maintenance.

H. Metal Finishes:
   1. The manufacturer shall apply standard finish (unless otherwise specified) over a corrosion resistant primer, after cleaning to free the metal surfaces of rust, grease, dirt and other deposits. Edges of pre-finished sheet metal exposed during forming, stamping or shearing processes shall be finished in a similar corrosion resistant manner to match the adjacent surface(s). Fixture finish shall be free of stains or evidence of rusting, blistering, or flaking.
   2. Interior light reflecting finishes shall be white with not less than 85 percent reflectances, except where otherwise specified on the drawing.
   3. Exterior finishes shall be as shown on the drawings.
I. Provide all lighting fixtures with a specific means for grounding metallic wireways and housings to an equipment grounding conductor.

J. Light Transmitting Components for Fluorescent Fixtures:
   1. Shall be 100 percent virgin acrylic plastic or water white, annealed, crystal glass.
   2. Flat lens panels shall have not less than 1/8 inch of average thickness. The average thickness shall be determined by adding the maximum thickness to the minimum unpenetrated thickness and dividing the sum by 2.
   3. Unless otherwise specified, lenses, diffusers and louvers shall be retained firmly in a metal frame by clips or clamping ring in such a manner as to allow expansion and contraction of the lens without distortion or cracking.

K. LED fixtures shall be manufactured specifically for LED lamps with ballasts or drivers integral to the fixture. Assemblies designed to retrofit fixtures are prohibited except when described in this fashion. Fixtures shall be designed for lamps as specified.

L. Provide wire lamp guard on all exposed lamp fixture/luminaires.

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

2.3 LED LUMINAIRE REQUIREMENTS

A. General Requirements:
   1. Luminaire shall have an external label per ANSI C136.15
   2. Luminaire shall have an internal label per ANSI C136.22.
   3. Luminaires shall start and operate in -20°C to +40°C ambient.
   4. LED light source(s) and driver(s) shall be RoHS compliant.

2.4 EMERGENCY LAMP POWER SUPPLY

A. Self-contained battery-operated power supply for operating LED lamp or compact fluorescent lamp for a minimum output of 90 minutes.

B. The power supply shall be installed within the luminaire ballast compartment or wireway. Provide with test switch and charge indicator installed integral to the luminaire. The test switch and charge indictor may be installed in a remote ceiling mounted flush J-box for recessed downlights which cannot accept integral components.

C. Performance: Emergency operation lumen output shall be a minimum of 1100 lumens. Unless specifically noted otherwise on the associated electrical drawings.
D. Provide access hatches, for emergency battery backup ballasts, adjacent to recessed 6-inch or less diameter downlights installed in inaccessible ceilings.

E. Manufacturers: Bodine, Iota, or approved. Emergency lamp power supplies may be provided as factory installed by the luminaire manufacturer provided the product meets the above specification criteria.

2.5 LED DRIVER

A. Driver
   1. Rated case temperature shall be suitable for operation in the luminaire operating in the ambient temperatures as indicated.
   2. Shall accept the voltage or voltage range indicated, and shall operate normally for input voltage fluctuations of plus or minus 10 percent. Consistent with NEMA SSL 1.
   3. Shall have a minimum Power Factor (PF) of 0.90 at full input power and across specified voltage range.

B. Electromagnetic interference
   1. Shall have a maximum Total Harmonic Distortion (THD) of 20% at full input power and across specified voltage range.

C. The following shall be in accordance with corresponding sections of ANSI C136.37
   1. Wiring and grounding
   2. All internal components shall be assembled and pre-wired using modular electrical connections.
   3. Mounting provisions
   4. Terminal blocks for incoming AC lines
   5. Latching and hinging
   6. Ingress protection

2.6 LAMPS

A. Provide lamps for all luminaires.

B. LED LIGHT SOURCE
   1. Minimum Color Rendering Index (CRI): 60.
   2. Correlated Color Temperature (CCT)
      a. CCT shall be as listed in Table 1 below:

<table>
<thead>
<tr>
<th>Manufacturer-Rated Allowable LM-79</th>
<th>Nominal CCT (K) Chromaticity Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1. Allowable CCT</td>
<td></td>
</tr>
</tbody>
</table>
### INTERIOR LIGHTING

<table>
<thead>
<tr>
<th>Measured CCT (K)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2700</td>
<td>2580 to 2870</td>
</tr>
<tr>
<td>3000</td>
<td>2870 to 3220</td>
</tr>
<tr>
<td>3500</td>
<td>3220 to 3710</td>
</tr>
<tr>
<td>4000</td>
<td>3710 to 4260</td>
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<tr>
<td>4500</td>
<td>4260 to 4746</td>
</tr>
<tr>
<td>5000</td>
<td>4745 to 5311</td>
</tr>
<tr>
<td>5700</td>
<td>5310 to 6020</td>
</tr>
<tr>
<td>6500</td>
<td>6020 to 7040</td>
</tr>
</tbody>
</table>

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- **A.** Installation and furnishing of lighting fixtures shall be in accordance with the CEC, manufacturer’s instructions and as shown on the drawings or specified. Fixtures damaged in transit and storage prior to completion shall be replaced at Contractor’s expense.

- **B.** Align, mount and level the lighting fixtures uniformly.

- **C.** Avoid interference with and provide clearance for equipment. Where the indicated locations for the lighting fixtures conflict with the locations for equipment, change the locations for the lighting fixtures by the minimum distances necessary as approved by the Architect. The Architectural reflected ceiling plan will take precedence over electrical plans.

- **D.** For suspended lighting fixtures, the mounting heights shall provide the clearances between the bottoms of the fixtures and the finished floors as shown on the drawings.

- **E.** Lighting Fixture Supports:
  1. Contractor shall provide support for all of the fixtures independent of suspended ceilings. Supports may be anchored to channels of the ceiling construction, to the structural slab or to structural members within a partition, or above a suspended ceiling.
  2. Shall maintain the fixture positions after cleaning and relamping.
  3. Shall support the lighting fixtures without causing the ceiling or partition to deflect.
  4. Hardware for recessed fluorescent fixtures:
  5. Fixtures shall be supported as detailed on drawings and as required by DSA standards.
  6. Installation: Fixtures shall be securely mounted on ceilings and walls with appropriate fastening devices. “Drop-in” type T-bar fixtures shall be secured with
#12 gauge safety "earthquake wires" as described by California Code of Regulations Title 24 Part 2, Chapter 47. Tech screws will be required for fastening to the T-bar system in addition to safety wire. Surface mounted fixtures shall be solidly screwed or clipped into framing above drywall with 4-#10 sheet metal screws into each fixture. Provide blocking for screw supports behind all surface mounted lighting fixtures weighing more than 15 lbs.

7. Surface mounted lighting fixtures:
   a. Fixtures shall be bolted against the ceiling independent of the outlet box at four points spaced near the corners of each unit. The bolts shall be minimum ¼-20 bolt, secured to structural ceiling. Non-turning studs may be attached to the building structure by 12 gauge safety hangers.

8. Fixtures mounted in open construction shall be secured directly to the building structure with approved bolting and clamping devices.

9. Single or double pendent mounted lighting fixtures:
   a. Each stem shall be supported by an approved outlet box, mounted swivel joint and canopy which holds the stem captive and provides spring load (or approved equivalent) dampening of fixture oscillations. Outlet box shall be supported vertically from the building structure and be allowed to swing to a 45 degree angle.

10. Outlet boxes for support of lighting fixtures (where permitted) shall be secured directly to the building structure with approved devices or supported vertically in a hung ceiling from the building structure with a nine gauge wire hanger, and be secured by an approved device to a main ceiling runner or cross runner to prevent any horizontal movement relative to the ceiling.

F. Furnish and install the specified lamps for all lighting fixtures as part of this project.

G. Coordinate between the electrical and ceiling trades to ascertain that approved lighting fixtures are furnished in the proper sizes and installed with the proper devices (hangers, clips, trim frames, flanges), to match the ceiling system being installed.

H. Bond lighting fixtures and metal accessories to the grounding system as specified in Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

I. At completion of project, relamp all fixtures which have failed/burned-out lamps. Clean all fixtures, lenses, diffusers and louvers that have accumulated dust/dirt during construction.

J. Provide unswitched leg of interior lighting branch circuit to integral emergency battery pack light fixtures, exit signs and night lights as applicable per lighting plans.

K. Wall mount fixtures in walkway areas shall not project more than 4 inches from wall when projection occurs lower than 80 inches.
SECTION 26 56 00 – EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 DESCRIPTION
   A. This section specifies the furnishing, installation, and connection of exterior luminaires, controls, poles and supports.

1.2 RELATED WORK
   A. Section 26 05 00, COMMON WORK RESULTS FOR ELECTRICAL.
   B. Section 26 05 33, RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS: Conduits, fittings, and boxes for raceway systems.
   C. Section 26 05 19, LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Low voltage power and lighting wiring.
   D. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
   E. Section 26 51 00, INTERIOR LIGHTING.
   F. Section 26 56 70, LIGHTING ACCEPTANCE TESTING.

1.3 SUBMITTALS
   A. Submit in accordance with Division 1 requirements.
   B. Shop Drawings:
      1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
      2. Include electrical ratings, dimensions, mounting, details, materials, required clearances, terminations, wiring and connection diagrams, photometric data, ballasts, poles, luminaires, effective projected area (EPA), lamps and controls.
1.4 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements) form a part of this specification to the extent referenced. Publications are referenced in the text by the basic designation only.


C. American Concrete Institute (ACI).

D. American National Standards Institute (ANSI).

E. Aluminum Association Inc. (AA).

F. Illuminating Engineering Society of North America (IESNA).

G. National Electrical Manufacturers Association (NEMA).

H. National Fire Protection Association (NFPA).

I. Underwriters Laboratories, Inc. (UL).

1.5 DELIVERY, STORAGE, AND HANDLING

A. Poles: Do not store poles on ground. Store poles so they are at least one foot above ground level. Do not remove factory-applied pole wrappings until just prior to installation of pole.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

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

2.2 POLES

A. General:
   1. Poles shall be steel as specified in fixture schedule and as shown on the drawings. Finish shall be as approved by the Architect.
   2. The pole and arm assembly shall be designed for wind loading of 100 miles per hour, with an additional 30 percent gust factor, supporting luminaire(s) having the effective projected areas indicated as per manufacturer data.
3. Poles shall anchor-bolt type designed for use with underground supply conductors. Poles shall have gasketed handhole with a minimum clear opening of 2.5” x 5”. Handhole cover shall be secured by stainless steel captive screws.
4. Provide a steel grounding stud opposite hand hole openings.

B. Provide a base cover matching the pole in material and color to conceal the mounting hardware pole-base welds and anchor bolts.

C. Hardware: All necessary hardware shall be 300 series tamperproof stainless steel.

D. Types:
1. Steel: Provide steel poles having minimum 11-gage steel with minimum yield/strength of 48,000 psi and iron-oxide primed factory finish. Base covers for steel poles shall be structural quality hot-rolled carbon steel plate having a minimum yield of 36,000 psi.

2.3 FOUNDATIONS FOR POLES

A. Foundations shall be cast-in-place concrete.

B. Foundations shall support the effective projected area of the specified pole, arm(s), luminaire(s), and all accessories specified under wind conditions as specified in this section.

C. Place concrete in spirally wrapped treated paper forms for round foundations, and construct forms for square foundations.

D. Rub-finish and round all above-grade concrete edges to approximately 1/4” radius unless otherwise detailed.

E. Concrete shall have 3000 psi minimum 28-day compressive strength.

F. Anchor bolt assemblies and reinforcing of concrete foundations shall be as shown on the drawings and meet ACI 318. Anchor bolts shall be in a welded cage or properly positioned by the tie wire to stirrups.

G. Install a copperclad ground rod, not less than 5/8” diameter by 8’ long in pullbox adjacent to each fixture. Where rock or layered rock is present, drill a hole not less than 2” in diameter and 6’ deep, backfill with tamped fine sand and drive the rod into the hole. Bond the rod to the pole with not less than number 6 AWG bare copper wires. The method of bonding shall be approved for the purpose.

H. After leveling of pole grout base solid between plate and footing with dry pack concrete for vibration reduction.
2.4 LUMINAIRES

A. UL 1598 and ANSI C136.17. Luminaries shall be weatherproof, heavy duty, outdoor types designed for efficient light utilization, adequate dissipation of lamp and ballast heat and safe cleaning and relamping.

B. Light emitting diode (LED)-based solid state lighting (SSL) products shall be factory tested in accordance to the International Engineering Society (IES) LM-79 recommendations and meet ANSI C78.377-2008 standards.

C. LED light sources shall be factory tested in accordance to IES LM-80 recommendations.

D. LED-based SSL product shall incorporate an external heat sink, integral to the luminaire.

E. IESNA HB-9 and RP-8 light distribution pattern types shall be as indicated on the drawings.

F. Incorporate associated ballasts and drivers within the luminaire housing.

G. Lenses shall be frame-mounted heat-resistant, borosilicate glass, prismatic refractors. Attach the frame to the luminaire housing by hinges or chain.

H. Pre-wire internal components to terminal strips at the factory.

I. Bracket mounted luminaries shall have leveling provisions and clamp type adjustable slip-fitters with locking screws.

J. Materials shall be rustproof. Latches and fittings shall be non-ferrous metal.

K. LED-based SSL luminaires shall be manufactured specifically for LED lamps with drivers integral to the luminaire housing.

2.5 LED-BASED SOLID-STATE DRIVERS

A. Shall be listed by either U.L. or equal listing agency and comply with IEEE C.62.41-1991, Class A operation.

B. Provide a minimum power factor of 0.9.

C. Minimum operating temperature appropriate for outdoor environments.

D. Shall operate at a frequency greater than or equal to 120Hz.
PART 3 - EXECUTION

3.1 INSTALLATION

A. Install lighting in accordance with the CEC, as shown on the drawings, and in accordance with manufacturer’s recommendations.

B. Poles:
   1. Provide pole foundations with galvanized steel anchor bolts, threaded at the top end and bent 1.57 rad 90 degrees at the bottom end. Provide galvanized nuts, washers, and ornamental covers for anchor bolts. Thoroughly compact backfill with compacting arranged to prevent pressure between conductor, jacket, or sheath and the end of conduit elbow. Adjust poles as necessary to provide a permanent vertical position with the bracket arm in proper position for luminaire location.
   2. After the poles have been installed, shimmed and plumbed, grout the spaces between the pole bases and the concrete base with non-shrink concrete grout material. Provide a plastic or copper tube, of not less than 3/8" inside diameter, through the grout tight to the top of the concrete base for moisture weeping.
   3. Attach pole base cover to pole flange with set screws.

C. Foundation Excavation: Depth shall be as required. Dig holes large enough to permit the proper use of tampers to the full depth of the hole. Place backfill in the hole in 6" maximum layers and thoroughly tamp. Place surplus earth around the pole in a conical shape and pack tightly to drain water away.

3.2 GROUNDING

A. Ground noncurrent-carrying parts of equipment including metal poles, luminaries, mounting arms, brackets, and metallic enclosures as specified in Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS. Where copper grounding conductor is connected to a metal other than copper, provide specially treated or alloyed connectors suitable and listed for this purpose.

END OF SECTION 26 56 00
Cal Poly Facilities

Electrical Work Rules for Contractors

The purpose of this document is to clarify requirements for electrical work on new and existing systems in facilities at Cal Poly. To ensure the safety of personnel working on electrical systems, it is critical that safe work practices are followed and that outages are well planned and carefully scheduled and coordinated. The following rules apply to contractors performing electrical work on the Cal Poly campus:

1. Electrical work shall not be performed on energized systems.
2. Panel covers and dead fronts shall not be removed while a panel is energized.
3. Circuit breakers shall not be cycled to switch existing loads on and off while a panel is in service.
4. All work up to the point of connection at an existing panel shall be completed without penetrating the enclosure. Once this new work is complete up to the existing panel, an outage shall be scheduled to facilitate termination at the panel.
5. Contractors shall schedule electrical outages with the responsible Project Manager. Work shall be planned and scheduled so as to minimize the number of outages required.
6. The University Electricians will de-energize systems at the point of connection on the scheduled outage day and time. Lock Out/Tag Out will be performed by both the University Electricians and the qualified contractor performing the work.
7. During an outage, the individual working on the system shall be responsible for confirming that an "electrically safe work condition" has been established per NFPA 70E procedures using appropriate PPE.
8. Once the work at the point of connection is complete an inspection shall be scheduled with the campus building inspector and/or University Electricians.
9. Upon acceptance of the inspection, the locks shall be removed and the system shall be re-energized by the University Electricians.
10. Upon re-energization, the contractor shall test all new installations to confirm they are functioning properly prior to completing work and leaving the work location.