

## **SECTION 26 00 00 - GENERAL ELECTRICAL**

### **REQUIREMENTS PART 1 - GENERAL**

#### **1.1 REFERENCE**

- A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

#### **1.2 DESCRIPTION**

- A. Intent of drawings and Specifications is to obtain complete systems tested, adjusted, and ready for operation.
- B. Except as otherwise defined in greater detail, the terms "provide", "furnish" and "install" as used in Division 26 Contract Documents shall have the following meanings:
  - 1. "Provide" or "provided" shall mean "furnish and install".
  - 2. "Furnish" or "furnished" does not include installation.
  - 3. "Install" or "installed" does not include furnishing.
- C. Include incidental details not usually shown or specified, but necessary for proper installation and operation.
- D. Check, verify and coordinate work with drawings and specifications prepared for other trades. Include modifications, relocations or adjustments necessary to complete work or to avoid interference with other trades.
- E. Included in this Contract are electrical connections to equipment provided by others. Refer to Architectural, Mechanical, Plumbing, and final shop drawings for equipment being furnished under other sections for exact locations of electrical outlets and various connections required.
- F. Information given herein and on drawings is as exact as could be secured but is not guaranteed. Do not scale drawings for dimensions.
- G. Where architectural features govern location of work, refer to Architectural Drawings.
- H. Perform work in "neat and workmanlike" manner as defined in ANSI/NECA 1, Standard Practices for Good Workmanship in Electrical Contracting.

#### **1.3 RELATED WORK**

- A. Utility Services:
  - 1. Determine utility connection requirements and include in Base Bid all costs to Owner for utility service.
  - 2. Include costs for temporary service, temporary routing of service or other requirements of a temporary nature associated with utility service.
- B. Temporary Services:
  - 1. Division 01 - Temporary Utilities.
- C. Continuity of Service:

1. No service shall be interrupted or changed without permission from Owner's Representative. Obtain written permission before work is started.
  2. When interruption of services is required, Owner's Representative, and other concerned parties shall be notified and shall determine a time.
  3. Concrete Work: Concrete shall comply with Division 03 - Concrete.
- D. Painting:
1. Furnish equipment with factory-applied finish coats or paint equipment per Division 09 – Finishes unless specified otherwise.
  2. Furnish equipment with factory applied prime finish unless otherwise specified.
  3. If factory finish on equipment furnished by Contractor is damaged in shipment or during construction, refinish equipment to satisfaction of Owner's Representative.
  4. Furnish one can of touch up paint for each final factory-applied finish coat of product.
- E. Sustainable Architecture and LEED Requirements:
1. Provide services, documentation, and product data required to meet LEED credits involving an electrical component.

#### **1.4 REQUIREMENTS OF REGULATORY AGENCIES**

- A. Rules and regulations of Federal, State and local authorities and utility companies, in force at time of execution of Contract shall become part of this specification.

#### **1.5 REFERENCE STANDARDS**

- A. Agencies or publications referenced herein refer to the following:
1. AEIC Association of Edison Illuminating Companies
  2. ANSI American National Standards Institute
  3. ASME American Society of Mechanical Engineers
  4. ASTM American Society for Testing and Materials
  5. BICSI Building Industry Consulting Services International
  6. EIA Electronic Industries Association
  7. FIPS Federal Information Processing Standards
  8. FCC Federal Communications Commission
  9. ICEA Insulated Cable Engineers Association
  10. IEEE Institute of Electrical & Electronics Engineers
  11. IESNA Illuminating Engineering Society of North America
  12. NEC National Electrical Code
  13. NECA National Electrical Contractors Association
  14. NEMA National Electrical Manufacturers Association
  15. NESC National Electrical Safety Code
  16. NETA National Electrical Testing Association
  17. NFPA National Fire Protection Association
  18. NIST National Institute of Standards & Technology
  19. OSHA Occupational Safety and Health Administration
  20. TIA Telecommunications Industries Association
  21. UL Underwriters Laboratories, Inc.

- B. Work shall be in accordance with latest edition of codes, standards or specifications unless noted otherwise.

### **1.6 LISTING**

- A. Install materials bearing UL label or UL listing, unless UL label or listing is not available for that type of material.
- B. Other nationally recognized testing agencies, acceptable to AHJ, are approved.

### **1.7 ENCLOSURES**

- A. Typical NEMA Enclosures and Usage
  1. NEMA 1 - Indoors. Falling dirt.
  2. NEMA 2 - Indoors. Falling dirt. Falling liquids. Light splashing.
  3. NEMA 3 - Outdoors. Sleet, snow, rain. Windblown dust.
  4. NEMA 3X - Same as NEMA 3 plus corrosion resistant.
  5. NEMA 3S - Same as NEMA 3 plus mechanism operable when ice covered.
  6. NEMA 3SX - Same as NEMA 3S plus corrosion resistant.
  7. NEMA 3R - Outdoors. Rain, snow, sleet.
  8. NEMA 3RX - Same as NEMA 3R plus corrosion resistant.
  9. NEMA 4 - Indoors. Falling dirt. Falling and light splashing liquids. Flying dust, lint and fibers. Hose down.
  10. NEMA 4X - Same as NEMA 4 - Indoors plus corrosion resistant.
  11. NEMA 4 - Outdoors. Rain, sleet, snow. Wind-blown dust. Hose down.
  12. NEMA 4X - Same as NEMA 4 - Outdoors plus corrosion resistant.
  13. NEMA 5 - Indoors. Falling Dirt. Falling Liquids. Settling dust, lint and fibers.
  14. NEMA 6 - Indoors. Falling dirt. Falling and light splashing liquids. Flying dust, lint and fibers. Hose down. Temporary submersion.
  15. NEMA 6P - Same as NEMA 6 - Indoors plus corrosion resistant. Prolonged submersion.
  16. NEMA 6 - Outdoors. Rain, snow, sleet. Windblown dust. Hose down. Temporary submersion.
  17. NEMA 6P - Same as NEMA 6 - Outdoors plus corrosion resistant. Prolonged Submersion.
  18. NEMA 7 - Indoors. Class I, Division 1 or 2, Groups A, B, C or D. (Flammable gas).
  19. NEMA 9 - Indoors. Class II, Division 1 or 2. Groups E, R, or G. (Combustible dust).
  20. NEMA 12 - Indoors. Falling Dirt. Falling liquids. Flying dust, lint and fibers. Oil or coolant seepage.
  21. NEMA 13 - Same as NEMA 12 plus oil or coolant spraying or splashing.

### **1.8 SUBMITTALS**

- A. Shop Drawings (Product Data):
  1. Refer to Division 01 - Submittal Procedures.
  2. Note that for satisfying submittal requirements for Division 26, "Product Data" is usually more appropriate than true "Shop Drawings" as defined in Division 01. However, the expression "Shop Drawings" is generally used throughout Specification.
  3. Submit shop drawings for equipment and systems as requested in respective specification sections. Submittals which are not requested may not be reviewed.

4. Specifically mark general catalog sheets and drawings to indicate specific items submitted and its correlation to specific designation for product in drawings.
  5. Specifically indicate proper identification of equipment by name and/or number, as indicated in specification and shown on drawings.
  6. When manufacturer's reference numbers are different from those specified, provide correct cross-reference number for each item. Clearly mark and note submittal accordingly.
  7. Submit complete record of required components when luminaires, equipment and items specified include accessories, parts and additional items under one designation.
  8. Include wiring diagrams for electrically powered or controlled equipment.
  9. Submit electrical equipment room layouts drawn to scale, including equipment, raceways, accessories and required working clearances. Submit electrical equipment room layouts concurrently with electrical distribution equipment submittals.
  10. Where submittals cover products containing non-metallic materials, include "Material Safety Data Sheet" (MSDS) from manufacturer stating physical and chemical properties of components and precautionary considerations required.
  11. Submit shop drawings or product data as soon as practicable after signing contracts. Submittals must be approved before installation of materials and equipment.
  12. Submittals that are not complete, not permanent, or not properly checked by Contractor, will be returned without review.
- B. Certificates and Inspections:
1. Obtain and pay for inspections required by authorities having jurisdiction and deliver certificates approving installations to Owner unless otherwise directed.
- C. Operation and Maintenance Manuals:
1. Refer to Division 01 - Operation and Maintenance Data.
  2. Upon completion of work but before final acceptance of system, submit to Owner's Representative for approval, 3 copies of operation and maintenance manuals in loose-leaf binders. If "one copy" is larger than 2" thick or consists of multiple volumes, submit only one set initially for review. After securing approval, submit 3 copies to Owner's Representative.
  3. Organize manuals by specification section number and furnish table of contents and tabs for each piece of equipment or system.
  4. Manuals shall include the following:
    - a. Copies of shop drawings
    - b. Manufacturer's operating and maintenance instructions. Include parts lists of items or equipment, with component exploded views and part numbers. Where manufacturer's data includes several types or models, designate applicable type or model.
    - c. CD ROM's of O&M data with exploded parts lists where available.

- d. Phone numbers and addresses of local parts suppliers and service companies
  - e. Internet/WEB page addresses where applicable
  - f. Wiring diagrams
  - g. Start up and shut down procedure
  - h. Factory and field test records
    - i. Additional information, diagrams or explanations as designated under respective equipment or systems specification section
  - 5. Instruct Owner's representative in operation and maintenance of equipment. Instruction shall include complete operating cycle on all apparatus.
  - 6. Furnish O&M manuals and instructions to Owner Representative prior to request for final payment.
- D. Record Documents:
- 1. Refer to General Conditions of Contract and Division 01 - Project Record Documents. Prepare complete set of record drawings in accordance with Division 01.
  - 2. Use designated set of prints of Contract Documents as prepared by Owner's Representative to mark-up for record drawing purposes.
  - 3. Provide approved power system in a 3-ring binder 2" max. thickness. Include the SKM power system study modeling file on a thumb drive attached to the binder.

## 1.9 JOB CONDITIONS

- A. Building Access:
- 1. Arrange for necessary openings in building to allow for admittance of all apparatus.
  - 2. Electric rooms in the custody of the University (supplying power to campus programs or entities)
    - 1) Only authorized and trained individuals may have access to electrical rooms.
    - 2) Electric rooms are to be supervised by an authorized person when the doors open and work is commencing.
    - 3) Electric rooms will not be left unattended while the door is open.
    - 4) Dust control for work will be used at all times to protect new or existing equipment.
    - 5) All provisions regarding electrical safety per NFPA 70E will be followed.
  - 3. Electrical rooms in the custody of the Contractor (not supplying power to campus programs or entities)
    - 1) Contractor is responsible for coordinating access with trades and work groups.
    - 2) All provisions regarding electrical safety per NFPA 70E will be followed.
    - 3) Dust control for work will be used at all times to protect existing or new equipment.
- B. Coordination:
- 1. Equipment provided under other Divisions of these specifications.
    - a. Motors
    - b. Electrically powered equipment
    - c. Electrically controlled equipment

- d. Starters, where specified
  - e. Variable frequency drives, where specified
  - f. Control devices, where specified
  - g. Temperature Control wiring
  2. Provide the following devices required for control of motors or electrical equipment, unless noted otherwise:
    - a. Starters
    - b. Disconnect devices
    - c. Control devices
      - 1) Pushbuttons
      - 2) Pilot lights
      - 3) Contacts
    - d. Conduit, boxes and wiring for Power wiring
    - e. Conduit, boxes and wiring for Control wiring, except for control wiring systems as defined in Section 23 09 01.
  3. Connect and wire equipment complete and ready to operate according to wiring diagrams furnished by various trades.
  4. Wire starters or other similar control devices furnished by others.
  5. This contractor's drawings and/or specifications show number and hp rating of motors furnished by others, together with their actuating devices. Should any change in size, hp rating, voltage, or means of control be made to any motor or other electrical equipment after Contracts are awarded, Contractor responsible for change shall immediately notify this Contractor. Additional costs due to these changes shall be responsibility of Contractor initiating change.
  6. Equipment and wiring shall be selected and installed for conditions in which it will be required to perform. (i.e., general purpose, weatherproof, rain tight, explosion proof, dust tight, or any other special type as required.)
  7. Comply with local utility motor starting requirements and provide starters for motors furnished by others as specified herein or under various trade sections of those specifications.
- C. Cutting and Patching:
1. Refer to General Conditions of the Contract and Division 01 - Cutting and Patching.
  2. Perform cutting and patching required for complete installation of systems, unless otherwise noted. Patch and restore work cut or damaged to original condition. This includes openings remaining from removal or relocation of existing system components.
  3. Provide materials required for patching unless otherwise noted.
  4. Do not pierce beams or columns without permission of Owner's Representative and then only as directed. If openings are required through walls or floors where no sleeve has been provided, hole shall be core drilled to avoid unnecessary damage and structural weakening.
  5. Where alterations disturb lawns, paving, walks, etc., replace, repair or refinish surfaces to condition existing prior to commencement of work. This may include areas beyond construction limits.
- D. Housekeeping and Cleanup:

1. Refer to Division 01 - Closeout Procedures.
2. As work progresses or as directed by Owner's Representative, periodically remove waste materials from building and leave area of work broom clean. Upon completion of work, remove tools, scaffolding, broken and waste materials, etc. from site.

#### **1.10 WARRANTY**

- A. Refer to Division 01 for general warranty requirements.
- B. Refer to technical sections for warranty requirement for each system.
- C. Repair, replace, or alter systems or parts of systems found defective at no extra cost to Owner.
- D. In any case, wherein fulfilling requirements of any guarantee, if this contractor disturbs any work guaranteed under another contract, this contractor shall restore such disturbed work to condition satisfactory to Owner's Representative and guarantee such restored work to same extent as it was guaranteed under such other contract.
- E. Warranty shall include labor, material, and travel time.

#### **1.11 UNIVERSITY REQUIREMENTS**

- A. Power system study, Electrical Coordination, Fault Duty Assessment, Fire Ignition and Arc Flash:
  1. Comply with NFPA 70E – Standard for Electrical Safety in the Workplace and IEEE 1584-2002 – Guide for Performing Arc Flash Calculations. Perform an Arc Flash Hazard Analysis to determine the Flash Hazard Boundary, Incident Energy, Hazard Risk Category, Shock Hazard Voltage, Required Glove Class, Limited Approach Boundary, Restricted Approach Boundary and Prohibited Approach Boundary.
  2. Submit arc flash label with above data to university representative for approval. Label will be consistent with existing labels on campus.
  3. At a minimum, the following electrical equipment will be studied: All Switchgear, Distribution Boards, Panel Boards, Equipment Disconnects, VFD Enclosures, Motor Controllers, Motor Control Centers, Medium Voltage Switchgear Enclosures, Medium Voltage Transformer Enclosures, control panels, lighting control panels and relay enclosures and any electrical enclosure with a hinged door.
  4. Arc flash calculations will be completed using the SKM software to match the rest of the campus study. Submit the arc flash report prepared by the registered professional engineers of record that performed the study. Include the SKM files and the database used to perform the study, on a CD and submit with the completed study. Install required arc flash labels on campus equipment.
  5. See 26 05 73 "Power System Study" for additional information and requirements.

## **PART 2 - PRODUCTS**

## **2.1 GENERAL**

- A. Provide all electrical distribution equipment from a single source manufacturer.

## **2.2 PRODUCT SUBSTITUTIONS**

- B. Refer to Division 01 - Product Requirements.

## **PART 3 - EXECUTION**

### **3.1 GENERAL**

- A. Verify elevations and dimensions prior to installation of materials.

### **3.2 DELIVERY, STORAGE, AND HANDLING**

- A. Deliver products to the site under provisions of Division 01.
- B. Store and protect products under provisions of Division 01.
- C. Store in clean, dry space.
- D. Maintain factory wrapping or provide cover to protect units from dirt, water, construction debris, and traffic.
- E. Handle in accordance with manufacturer's written instructions.
- F. Handle carefully to avoid damage to components, enclosure, and finish. Lift only with lugs provided for the purpose.
- G. Provide supplemental heat if required to prevent moisture contamination.

### **3.3 FLOOR, WALL, ROOF AND CEILING OPENINGS**

- A. Coordinate location of openings, chases, furred spaces, etc. with appropriate Contractors. Provide sleeves and inserts that are to be built into structure during progress of construction.
- B. Remove temporary sleeves, if used to form openings, prior to installation of permanent materials. Utilize minimum 24 ga galvanized sheet metal for permanent sleeves unless otherwise noted.
- C. Provide Schedule 40 carbon steel pipe with integral water stop for steel sleeves required below grade or to exterior.
- D. Submit to Structural Engineer for review and approval size and location of core-drilled holes prior to execution.
- E. Submit product data and installation details for penetrations of building structure. Include schedule indicating penetrating materials, (steel conduit, PVC conduit, cables, cable tray, etc.), sizes of each, opening sizes and sealant products intended for use.
- F. Where penetrations of fire-rated assemblies are involved, seal penetrations with appropriate firestopping systems as specified in Section 26 0593 - Electrical Systems Firestopping.
- G. Submit complete penetration layout drawings showing openings in building structural members including floor slabs, bearing walls, shear walls, etc. Indicate and locate, by



dimension, required openings including those sleeved, formed or core drilled. Submit drawings for approval prior to preparing openings in structural member.

- H. Provide 2" clearance around penetration openings intended for raceways and cables. Where fire resistant penetrations are required, size openings in accordance with written recommendations of firestopping systems manufacturer.
- I. Seal non fire-rated floor penetrations with non-shrink grout equal to Embeco by Master Builders, or urethane caulk, as appropriate.
- J. Seal non-rated wall openings with urethane caulk.
- K. Where penetrations occur through exterior walls into building spaces, use steel sleeves with integral water stop, similar to type "WS" wall sleeves by Thunderline Corporation. Seal annular space between sleeves and pipe with "Link-Seal" modular wall and casing seals by Thunderline Corporation, or sealing system by another manufacturer approved as equal by Owner's Representative. Sealing system shall utilize Type 316 stainless steel bolts, washers and nuts.
- L. Finish and trim penetrations as shown on details and as specified.
- M. Provide chrome or nickel-plated escutcheons where raceways pass through walls, floors or ceilings and are exposed in finished areas. Size escutcheons to fit raceways for finished appearance. Finished areas shall not include mechanical/electrical rooms, janitor's closets, storage rooms, etc., unless suspended ceilings are specified.
- N. In Bio-safety and Wash down areas,
  - 1. Exposed conduit penetrations shall be sealed as follows:
    - a. Escutcheons shall not be used when conduits are exposed in finished areas and penetrate finished surfaces.
    - b. Cut and patch penetration to within 1/4" of conduit.
    - c. Seal openings around conduit and patch work with sealants specified in Division 07
    - d. Joint Sealants. Sealant shall be installed per manufacturer's application requirements.
  - 2. Penetrations other than conduits (junction boxes, light fixtures, etc.) including wiring devices shall be sealed as follows:
    - a. Seal non-rated opening with silicone sealant.
    - b. See drawings for details.
    - c. Confirm selected sealant is compatible with paint provided by others prior to application.
    - d. Product: One-Part Mildew-Resistant Silicone Sealant: Type S; Grade NS; Class 25; Uses NT, G, A, and as applicable to nonporous joint substances indicated, O; formulated with fungicide; intended for sealing interior joints with nonporous substrates and subject to in-service exposure to conditions of high humidity and temperature extremes; subject to compliance with requirements. Provide one of the following:
      - 1) 786 Mildew Resistant Silicone Sealant; Dow Corning Corp. or equal
      - 2) Sanitary 1700 Silicone Sealant; General Electric Co. or equal
      - 3) 898 Silicone Sanitary Sealant; Pecora Corp. or equal
      - 4) Tremsil 600; Tremco Corp. or equal

- 5) OmniPlus; Sonneborn Building Products Div., Rexnord Chemical Products, Inc. or equal

### **3.4 EQUIPMENT ACCESS**

- A. Install raceways, junction and pull boxes, and accessories to permit access to equipment for maintenance. Relocate raceways or accessories to provide maintenance access at no additional cost to Owner.
- B. Install equipment with sufficient maintenance space for removal, repair or changes to equipment. Provide ready accessibility to equipment and wiring without moving other future or installed equipment.
- C. Access doors in walls, chases, or inaccessible ceilings will be provided under Division 08 - Access Doors and Frames, unless otherwise indicated. Access doors for equipment shall provide access for servicing, repairs and/or maintenance.
- D. Provide necessary coordination and information to the Trade Contractor under Division 08 - Access Doors and Frames. This information shall include required locations, sizes and rough-in dimensions.
- E. Provide access doors in walls, chases or inaccessible ceilings for equipment requiring access for servicing, repairs and maintenance, unless otherwise noted. Access frames and doors shall be as manufactured by Milcor, Incorporated, or similar, of style applicable to surface. Provide access doors used in fire-rated construction with UL label. Provide steel, prime-coated access doors in dry locations. Provide stainless steel access doors for use in ceramic tile walls, toilet rooms, locker rooms, and in areas subject to excessive moisture. Provide access doors of sufficient size to allow complete maintenance. Coordinate location of access doors with General Contractor and rough-in equipment accordingly.
- F. Locate electrical outlets and equipment to fit details, panels, decorating or finish at space. Owner's Representative reserves right to make minor position changes of outlet locations before work has been installed.
- G. Verify door swings before installing room light switch boxes. Install boxes on latch side of door unless otherwise noted
- H. Provide access to electrical equipment, raceway pullboxes and junction boxes no higher than 4' above a revocable ceiling time or access hatch.

### **3.5 EQUIPMENT SUPPORTS**

- A. Provide supporting steel not indicated on drawings as required for installation of equipment and materials including angles, channels, beams, hangers, etc.
- B. Provide steel shell with plug type concrete anchors for attaching equipment to concrete. Plastic, rawhide or anchors using lead are not allowed.
- C. Do not support equipment or luminaires from metal roof decking.

### **3.6 SUPPORT PROTECTION**

- A. In occupied areas, mechanical and electrical rooms and areas requiring normal

maintenance access, guard certain equipment to protect personnel from injury.

- B. Protect threaded rods or bolts at supporting elements as described above. Trim threaded rods or bolts such that they do not extend beyond supporting element.

### **3.7 ELECTRICAL SYSTEMS IDENTIFICATION**

- A. Refer to Section 26 0553 – Electrical Systems Identification.

### **3.8 ACCEPTANCE TESTING**

- A. Contractor shall engage testing and inspection agency to perform acceptance tests. Equipment to be tested is noted as "Testing by Testing Agency" in technical specification sections. Perform in accordance with Section 26 0812 – Power Distribution Acceptance Tests and Section 26 0813 – Power Distribution Acceptance Test Tables.
- B. When testing is to be witnessed by Owner's Representative, notify them at least 10 days prior to testing date.
- C. When equipment or systems fail to meet minimum test requirements, replace or repair defective work or materials as necessary and repeat inspection and test until equipment or systems meet test requirements. Make repairs with new materials.
- D. Contractor is responsible for certifying in writing equipment and system test results. Certification shall include identification of portion of system tested, date, time, test criteria and name and title of person signing test certification documents.
- E. Maintain copies of certified test results, including those for any failed tests, at project site. At completion of project, include copies of test records and certifications in O&M Manuals.

### **3.9 START-UP**

- A. Before energization for startup, testing, or use for energization of downstream systems, all electrical equipment must be inspected by the University IOR and/or the appropriate University Representative. All third-party testing should be complete and reports available for review at this time.
- B. Systems and equipment shall be started, tested, adjusted, and turned over to Owner ready for operation. This includes "Owner-Furnished, Contractor-Installed" (OFICI) and "Contractor-Furnished, Contractor-Installed" (CFICI) systems and equipment.
- C. Follow manufacturer's pre-start-up checkout, start-up, trouble shooting and adjustment procedures.
- D. Contractor shall provide services of technician/mechanic knowledgeable in start-up and checkout of types of systems and equipment on project.
- E. Provide start-up services by manufacturer's representative where specified or where Contractor does not have qualified personnel.
- F. Coordinate start-up with all trades.

### **3.10 CLEANING**

- A. Clean systems after installation is complete.
- B. Vacuum debris from panelboards, switchboards, motor starter and disconnect switch enclosures, junction boxes and pull boxes two weeks before energization and again prior to completion.
- C. Where louvers are provided in switchgear or transformer enclosures, vacuum louvers free of dust and dirt.
- D. Clean luminaire lenses and lamps at time of installation and clean lens exteriors just prior to final inspection.
- E. Thoroughly clean equipment of stains, paint spots, dirt and dust. Remove temporary labels not used for instruction or operation.
- F. During construction, maintain indoor air quality per general contractors IAQ plan for LEED credit.

### **3.11 CONSTRUCTION WASTE MANAGEMENT**

- A. Construction waste management shall be managed in accordance with provisions of Section 01524 Construction Waste Management. Documentation shall be submitted to satisfy the requirements of that section.

**END OF SECTION 26 00 00**

## **SECTION 26 01 26 - ACCEPTANCE TESTING OF ELECTRICAL**

### **SYSTEMS PART 1 - GENERAL**

#### **1.1 RELATED WORK**

- A. Section 26 00 00 - General Electrical Requirements

#### **1.2 REFERENCE**

- A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

#### **1.3 DESCRIPTION**

- A. Test the following systems per NETA:
  1. Power distribution monitoring, control and relay equipment
  2. Overcurrent protection device settings
  3. Starters feeding motors 40 hp or greater
  4. Motors 40 hp or greater
  5. Feeders from service point through feeders serving panelboards of 400 A or greater
  6. Emergency or standby diesel driven generators
  7. Grounding system from service point through branch panelboard feeders
  8. Circuit breakers, transformers, medium voltage cable, low voltage (600V) wire.
  9. Computer room grounding system

#### **1.4 INITIAL ACCEPTANCE TEST AND INSPECTION**

- A. Perform acceptance test per National Electrical Testing Association Standard ATS -2017 except as modified herein.
- B. Perform on-site testing after equipment installation, unless otherwise noted.
- C. Provide material, equipment, labor, and technical supervision to perform such tests and inspections.
- D. Provide test power required.
- E. Coordinate testing schedule and equipment availability with Owner's Representative.
- F. Notify Owner's Representative 1 week before testing.
- G. Prepare test results with comparison to industry and manufacturer's values and tolerances.
- H. Assure electrical equipment is operational and within industry and manufacturer's tolerances, and is installed in accordance with Contract Documents.
- I. Provide recommendations for suitability of continued energization.

#### **1.5 WORK NOT INCLUDED**

- A. Prime mover testing (turbines or engines) will be performed by others.
- B. Uninterruptible Power Systems

### **1.6 APPLICABLE CODES, STANDARDS AND REFERENCES**

- A. Perform inspections and tests in accordance with the following Codes and Standards:
  - 1. National Electrical Code - NEC
  - 2. National Electrical Manufacturer's Association - NEMA
  - 3. American Society for Testing and Materials - ASTM
  - 4. American National Standards Institute - ANSI
  - 5. Institute of Electrical and Electronic Engineers - IEEE
  - 6. National Electrical Testing Association - NETA
  - 7. State and Local Codes and Ordinances
  - 8. Insulated Cable Engineers Association - ICEA
  - 9. Association of Edison Illuminating Companies - AEIC
  - 10. OSHA - Part 1910: Subpart S - 1910.308
- B. Perform inspections and tests in accordance with the following references.
  - 1. Project Design Specifications
  - 2. Project Design Drawings
  - 3. Manufacturer's instruction manuals
  - 4. Manufacturer's shop drawings
- C. Qualifications of Testing Agency
  - 1. Member of NETA.
  - 2. Meet Federal Department of Commerce requirements for independent testing laboratory accreditation.
  - 3. Submit proof of above qualifications to Owner's Representative.

### **1.7 SUBMITTALS**

- A. Provide 5 copies of complete testing report using NETA printed forms. Test report includes the following: summary of project, description of equipment tested, description of test, test results, conclusion and recommendation, and signature of responsible test organization authority.
- B. Submit completed report to Owner's Representative no later than 30 days after completion of testing, unless directed otherwise.
- C. Acceptance test reports are required for IOR inspection before initial energization.

## **PART 2 - PRODUCTS**

### **2.1 NOT APPLICABLE TO THIS SECTION**

## **PART 3 - EXECUTION**

### **3.1 THE FOLLOWING INDICATES APPLICABLE NETA STANDARD ATS - 2017 SECTIONS FOR THIS PROJECT.**

#### **ELECTRICAL ACCEPTANCE TESTS**

- 1. GENERAL
  - 1.1 Test Instrument Calibration
  - 1.2 Test Report: acceptance test reports are required for IOR inspection before initial energization of any component

- 1.3 Safety & Precautions
2. INSPECTION AND TEST PROCEDURES:
  - 2.1 Metal Enclosed Switchgear and Switchboard Assemblies
  - 2.2 Transformers
    - 2.2.1 Transformers - Dry Type, Oil Filled Medium Voltage
    - 2.2.2 Small Transformers - Dry Type, Air Cooled (600V and Below)
  - 2.3 Cables
    - 2.3.1 Cables - Low Voltage - 600 Maximum
    - 2.3.2 Cables - Medium and High Voltage - 69 kV Maximum
  - 2.4 Switches
    - 2.4.1 Air Switches
    - 2.4.2 SF6 Sectionalizing Switches
    - 2.4.3 Transformer wire and cable
  - 2.5 Circuit Breakers
    - 2.5.1 Circuit Breakers - Low Voltage
      - Circuit Breakers - 400A and Greater (primary current injection)
      - Circuit Breakers - 100A and greater with Microprocessor trip unit.
  - 2.6 Protective Relays
    - 2.6.1 Visual and Mechanical Inspection
    - 2.6.2 Electrical Tests
  - 2.7 Instrument Transformers
    - 2.7.1 Visual and Mechanical Inspection
    - 2.7.2 Electrical Tests - Current Transformers
    - 2.7.3 Electrical Tests - Voltage Transformers
    - 2.7.4 Electrical Tests – Potential Transformers
    - 2.7.5 Test Values
  - 2.8 Metering and Instrumentation
    - 2.8.1 Visual and Mechanical Inspection
    - 2.8.2 Electrical Tests
  - 2.9 Grounding Systems
    - 2.9.1 Visual and Mechanical Inspection
    - 2.9.2 Electrical Tests
    - 2.9.3 Test Values
  - 2.10 Ground Fault System
    - 2.10.1 Visual and Mechanical Inspection
    - 2.10.2 Electrical Tests
    - 2.10.3 Test Parameters
  - 2.11 Rotating Machinery
    - 2.11.1 AC Motors (40 hp or Greater)
  - 2.12 Motor Control
    - 2.12.1 Motor Control Centers (VFD's)
  - 2.13 Surge Arrestors
    - 2.13.1 Low Voltage Surge Protection Devices
    - 2.13.2 Medium and High Voltage Surge Protection Devices
  - 2.14 Capacitors
    - 2.14.1 Visual and Mechanical Inspection
    - 2.14.2 Electrical Tests

- 2.14.3 Test Values
- 2.15 Emergency Systems
  - 2.15.1 Engine Generator
  - 2.15.2 Automatic Transfer Switches
- 3. SYSTEM FUNCTION TESTS:
- 4. THERMOGRAPHIC SURVEY
- 5. TABLES

**END OF SECTION 26 01 26**



## 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. All materials shall be new and/or never previously installed.
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 useable 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 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.
  10. Cal Poly Campus Standards for Common Work Results for Electrical
- B. Related Sections Under Other Divisions:
1. Refer to Division 27 for conduit requirements specific to low voltage cabling systems.
  2. Mechanical Wiring: Control circuit wiring, energy management controls and interlocks for mechanical equipment shall be installed by Mechanical Contractor.
  3. Painting of electrical equipment where exposed and required by the Architect to be painted as described elsewhere in the specification.
  4. 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.
  5. 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).
  6. 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).
  7. 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).
  8. Security System: Shall be installed by Owner's vendor. Contractor shall provide conduits, boxes, stubs to accessible ceilings, dedicated circuit(s) for alarm panel, access control system (key pads, electric locks), etc. as shown and/or required by the Owner's vendor.

### 1.3 SYSTEM DESCRIPTION

- A. The electrical plans indicate the general layout and arrangement; the architectural drawings and field conditions shall determine exact locations. Field verify all conditions and modify as required to satisfy design requirements as well as code minimums.

Maintain all required working clearances as described in CEC Article 110 as well as other applicable articles.

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

#### 1.4 UNIVERSITY REQUIREMENTS

Any electrical equipment operating over 250V phase to ground or above a 225A buss rating will be located in an electrical room with limited access. Electrical distribution equipment is not permitted to be installed in outdoor locations. Specific project requirements shall be reviewed with University representatives.

- A. All electrical rooms will not be designed with regard to floor plan so that access to other facilities of the building (machine rooms, telecom equipment, etc.) will have to pass through the electrical rooms.
- B. Electrical rooms will be compliant with NEC requirements regarding panic hardware and secondary exiting based on installed equipment ratings.
- C. All general building wiring conductors to be THHN/THWN
- D. All conductors regardless of size will be ordered and installed in their corresponding phase color. Phase tape is not acceptable.
- E. Color Coding: The following color code will be adhered to:
  - 1. 208/120V Systems:
    - Phase A: Black
    - Phase B: Red
    - Phase C: Blue
    - Neutral :  
Whit  
e
  - 2. 240/139V Systems
    - Phase A: Black
    - Phase B: Purple
    - Phase C: Blue

3. 480/277V Systems
    - Phase A : Brown
    - Phase B: Orange
    - Phase C: Yellow
    - Neutral: Gray
  4. 240/120V Systems
    - Phase A: Black
    - Phase B: Red
    - Neutral: White
  5. Medium Voltage Systems
    - Phase A: 1 Bands White Tape
    - Phase B: 2 Bands White Tape
    - Phase C: 3 Bands White Tape
  6. All systems:
    - Switch Leg/travelers: Pink or Purple
    - Ground: Green
  7. All systems:
    - a. 0-10V dimming pink and purple #14 AWG or smaller
  8. Fire Alarm Systems:
    - a. SLC Circuit: Twisted Black and Red
    - b. Non-resettable 24V Power: Yellow and Blue
    - c. Resettable 24V Power: Pink and Purple
    - d. NAC Circuit: Brown and Orange, Brown and Yellow, Brown and Red, and Brown and Pink
- F. Armored cable is not permitted.
- G. Equipment Disconnects and Connections:
  1. Equipment disconnects are to be rated as the "Heavy Duty" type. Provide fused disconnects as un-fused disconnects are not acceptable.
  2. Use type LFMC to connect equipment to disconnecting means.
  3. Group II equipment owned by a University Department - Equipment operating at 480V must use a hard wired disconnect or an interlocked pin and sleeve or interlocked twist lock.
- H. Enclosures:
  1. Enclosures in exterior areas are to be NEMA 3R or 4X.
  2. Conduit entry into 3R enclosures will be via the bottom whenever possible. 3R

enclosures entered from the side or the top will have "Myers Hubs" or factory hubs as appropriate.

3. Conduit entry into 4X enclosures will employ the use of "Myers Hubs" or equivalent. Sealing lock washers are not permitted.

#### 1.5 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.

#### 1.6 DELIVERY, STORAGE AND HANDLING

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

### PART 2 - PRODUCTS

#### 2.1 MATERIALS

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

#### 2.2 SUPPORTING DEVICES

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

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Professionalism and appearance of installations shall be in accordance with accepted practices of this trade. Installation methods shall conform to 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 apprised of changes or clarifications, etc.
  
- B. Employment of any person on any job in the capacity of an electrician is not permitted unless such person has qualified for and holds a valid Journeyman Electrician Pocket Card or General Journeyman Electrician Certificate issued by the State of California Division of Apprenticeship Standards 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. 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.
- F. Coordinate work with other trades as required to eliminate any delays during construction. Coordinate changes with other prime contractors to avoid construction conflicts.
- G. Engineer's Field Observation: Site visits during construction for field observations and reports will be conducted by electrical engineer when directed by the Architect. A list of items that need to be addressed will be submitted to the Architect for forwarding to the Contractor. A written response to all items shall be submitted for Owner's review once complete. When Electrical Engineering representative performs a field observation, the Electrical Contractor shall be present and available to remove equipment covers as needed.
- H. Drawings of Record: Provide a full and accurate set of field record drawings marked up in a neat and understandable manner submitted to the Owner Representative, Construction Manager, or Architect upon completion of the work and prior to issuance of a certificate of completion. The drawings shall dimension all electrical facilities including but not limited to underground conduit, vaults, boxes as well as conduit routing scaled to within 12" of actual field conditions and shall be kept up to date on a daily basis reflecting changes or deviations. Electrical facilities shall be accurately drawn on the plan to scale. Refer to the general conditions of these specifications for additional requirements. Record drawings shall be required to identify both horizontal and vertical dimensions to visible and fixed points such as concrete, asphalt, buildings, sidewalks, etc.
- I. Identification: Provide engraved laminated plastic nameplates for all switchboards, panelboards, fire alarm terminal cabinets, telephone and cable television backboards, main devices, control panels, time clocks, contactors and safety disconnect switches



accurately identifying each device. Labels shall be self-adhesive; drilling of equipment to adhere labels is not permitted. Refer to Electrical System Identification for color requirements based on system.

- J. Safety: The Electrical Contractor is responsible to maintain equipment in a safe and responsible manner. Keep dead front equipment in place while equipment is energized. Conduct construction operations in a safe manner for employees as well as other work persons or anyone visiting the job site. Provide barriers, trench plates, flags, tape, etc. The Contractor shall hold all parties harmless of negligent safety practices that may cause injury to others on or near the job site. Contractor is responsible for following all parts of NFPA 70E including work practices and PPE requirements.
- K. Guarantees: Equipment and labor shall be guaranteed and warranted free of defects, unless otherwise stated to be more restrictive, for a period of one year from the date of final acceptance by the Owner. A written warranty shall be presented to the Architect at the time of completion prior to final acceptance. Equipment deemed to be damaged, broken or failed should be repaired or replaced at no additional cost to the Owner. Materials or system requiring longer than a one- year warranty as described herein shall be separately warranted in separate letters of guarantee stating the duration of warranty.
- L. Operating and Installation Manuals: Provide two copies each of manuals, operating and installation instructions for equipment indicated in submittal packages. Instruct the Owner's representative as to the operation and location of equipment necessary to allow them to operate the facility upon final acceptance. This instruction period shall be prearranged with the Owner's representative prior to occupancy of the facility and the weeks prior to training scheduled.
- M. Lighting Acceptance Testing: Provide two copies of lighting acceptance testing results and equipment operating manuals as specified in Section 26 56 70, LIGHTING ACCEPTANCE TESTING. Instruct the Owner on operation of control systems.

END OF SECTION 26 05 00

## **SECTION 26 05 13.16 - MEDIUM-VOLTAGE SINGLE-CONDUCTOR**

### **CABLES PART 1 - GENERAL**

#### **1.1 RELATED WORK**

- A. Section 26 05 26 – Grounding and Bonding for Electrical Systems
- B. Section 26 05 43 – Underground Ducts and Raceways for Electrical Systems
- C. Section 26 05 53 – Electrical Systems Identification
- D. Section 26 08 12 – Power Distribution Acceptance Tests
- E. Section 26 12 19 - Pad-Mounted, Liquid-Filled, Medium-Voltage Transformers
- F. Section 26 13 16 – Medium Voltage Fusible Pad-Mounted Switchgear

#### **1.2 REFERENCE**

- A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 - General Requirements.

#### **1.3 DESCRIPTION**

- A. Section includes cables and related splices, terminations, and accessories for medium-voltage electrical distribution systems.
- B. 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.
- C. Cables are for use in wet or dry locations, conduit, underground duct applications.
- D. Conductors shall be rated to operate at conductor temperature of 105°C for continuous normal operation, 140°C for emergency overload conditions, and 250°C for short circuit conditions, based on 40°C maximum ambient temperature.
- E. Conductor sizes in Section are based on copper wire and only copper wire shall be used.

#### **1.4 REFERENCE STANDARDS**

- A. ASTM: B3 Soft or Annealed Copper Wire.
- B. ASTM: B8 Concentric Lay-Stranded Copper Conductor, Hard, Medium-Hard or Soft.
- C. NEMA: WC8 Ethylene-Propylene, Rubber-Insulated Wire and Cable for Transmission and Distribution of Electrical Energy.
- D. NEMA: WC26 Wire and Cable Packaging.
- E. ANSI/Insulated Cable Engineers Association (ANSI/ICEA) Standard Publication No. S-97-682.
- F. Association of Edison Illuminating Companies (AEIC) Publication No. CS-8. Specifications for Ethylene Propylene Rubber Insulated Shielded Power Cables Rated 5 Through 69 KV.
- G. NETA: Latest version of Acceptance Testing Standard.
- H. AEIC CS 8 – Specification for Extruded Dielectric Shielded Power Cables Rated 5 through

46kV.

- I. IEEE 48 – Standard Test Procedures and Requirements for Alternating-Current Cable Terminations  
2.5kV through 765kV.
- J. IEEE 386 – Standard for Separable Insulated Connector Systems for Power Distribution Systems above 600 V (ANSI).
- K. IEEE 404 – Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 – 500000 V (ANSI)
- L. IEEE 576 – Recommended Practice for Installation, Termination, and Testing of Insulated Power Cable as Used in Industrial and Commercial Applications (ANSI)
- M. ICEA S-93-639 – 5-46kV Shielded Power Cables for the Distribution and Transmission of Electrical Energy
- N. ICEA S-94-649 – 5-46kV Concentric Neutral Cables Rated 5000 to 46000 Volts
- O. ICEA S-97-682 – Utility Shielded Power Cables Rated 5000 to 46000 Volts
- P. NFPA 70 – National Electrical Code
- Q. UL 1072 – Medium-Voltage Power Cable

### 1.5 SUBMITTALS

- A. Product Data: For each type of cable indicated. Include splices and terminations for cable and cable accessories.
  - 1. Include cable drawings with the following data:
    - a. Longitudinal cutback and cross-sectional view of cable.
    - b. Identification and structure of cable components.
    - c. Dimensions of cable components in English and SI units.
  - 2. 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:
    - a. Conductor size and stranding.
    - b. Type and thickness of the semi-conducting shield.
    - c. Type and thickness of insulation.
    - d. Type and thickness of insulation shield.
    - e. Type and thickness of jacket.
    - f. Diameter of the insulated, shielded cable and variations from the average O.D. due to production.
    - g. Diameter of the single cable including the jacket.
    - h. Diameter over the insulation for single cable.
    - i. Recommended minimum bending radius, single conductor.
    - j. Manufacturer's recommendation for:
    - k. Maximum pulling tension with conductor pulling eye and cable grip.
    - l. Maximum sidewall pressure.
    - m. Cable manufacturer's name and location of plant at which cable will be produced.
    - n. Manufacturer's warranty for cable offered.
  - 3.
- B. Warranties: Cable material warranties shall be 30 years. Other warranties shall be per Division 1 requirements.
- C. Material Certificates: For each cable and accessory type, signed by manufacturer.

- D. Manufacturer Testing Certificate: For each type and voltage class of cable indicated.
- E. Certified Field Quality Control Test Reports per requirements in Section 26 0812 – Power Distribution Acceptance Tests for each type and voltage class of cable indicated. Indicate applicable standards compliance. Interpret test results and corrective action taken for compliance with specification requirements.
- F. Qualification Data: For installer and testing agency.
- G. Manufacturer’s Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation.
- H. Installation Guide: Include the following:
  - 1. Maximum allowable pulling tension (in pounds and newtons)
  - 2. Minimum allowable bending radius
  - 3. Recommended pulling compounds
  - 4. Splicing and termination instructions with diagrams, dimensions, and material lists
  - 5. Weight per 1,000 ft
  - 6. Standard “packaging” of reels (i.e., lengths, lagging, banding, etc.)
  - 7. Reactance and AC resistance (ohms to neutral) of each size and voltage class of cable, both in magnetic and non-magnetic duct, based on 3-1/C cables or 1-3/C cable in one duct.
- I. Closeout Submittals:
  - 1. Project Record Documents:
    - a. Record actual locations of cables, splices, and terminations.
  - 2. Operation and Maintenance Data:
    - a. Include manufacturer’s recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.

## 1.6 QUALITY ASSURANCE

- A. Installer:
  - 1. C10 electrical contractor’s license.
  - 2. All employees of the C10 electrical contractor will hold a valid “State Certified General Electrician” card issued by the California Department of Industrial Relations’ Division of Apprenticeship Standards.
  - 3. Person(s) performing medium voltage terminations will possess a certification indicating that they have attended formal training on splicing and terminating medium voltage cables in the types of terminations being performed. Successful completion of the course and examination will be provided to the University prior to the start of any work.
  - 4. Person(s) performing medium voltage work or installation will have at least 5 years of verifiable experience performing such work. Submit a record of employment or projects for the University to review and approve.
  - 5. 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.

- B. Regulatory Requirements:
  - 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by testing agency acceptable to authorities having jurisdiction, and marked for intended use.
  - 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.
- C. Source Limitations: Obtain cables and accessories through one source from single manufacturer.
- D. All cables shall be of a single type and configuration. Date of manufacture shall not precede contract date by more than one year.
- E. DC proof testing, labeling, and phasing after cable is installed, spliced and terminated, and before energizing in accordance with Section 26 05 53.

### 1.7 DELIVERY, STORAGE, AND HANDLING

- A. Coordinate with manufacturer to provide protective covering over cable and reel to prevent damage during shipping, storage, or handling.
- B. Store in clean, dry space. Protect from dirt, fumes, water, corrosive substances, and construction debris.

### 1.8 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:

Type of Operation		Temperature
Normal		105°C
Emergency Overload		140°C
Short Circuit		250°C (482°F)

- 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.

### **1.9 WARRANTY**

- A. Manufacturer shall provide 30 year warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

## **PART 2 - PRODUCTS**

### **2.1 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. Medium 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

### **2.2 CABLES**

- A. Cable Type: MV105
- B. Comply with UL 1072, AEIC CS 8, ICEA S-93-639, and ICEA S-97-682
- C. Conductor: Copper
- D. Conductor Stranding: Compact round, concentric lay, Class B

- E. Strand Filling: Conductor interstices are filled with impermeable compound
- F. Conductor Insulation: Ethylene-propylene-rubber
- G. Voltage Rating: 15 kV
- H. Insulation Thickness: 133 percent insulation level
- I. Shielding: Copper tape, helically applied over semiconducting insulation shield
- J. Shielding and Jacket: Corrugated copper drain wires embedded in extruded, chlorinated, polyethylene jacket
- K. Cable Jacket: Sunlight-resistant PVC. Color: black, unless otherwise designated
- L. Cables utilizing combination insulation shield and jacket are acceptable.
- M. Cable lengths shall be supplied with factory-installed, moisture-proof end seals on conductors on each end. Cable seals shall be rubber or plastic caps, and shall prevent moisture from seeping into cable ends.
- N. Each cable reel shall be tagged with the following:
  - 1. Manufacturer
  - 2. Cable Size
  - 3. Cable Type
  - 4. Voltage Class
  - 5. Manufacture Date
  - 6. Cable Length
  - 7. Tolerances
  - 8. Reel Number
  - 9. Customer Order No.
  - 10. Customer Name
- O. Surface Marking:
  - 1. Cables shall be permanently printed (or imprinted) on jacket surface at regular intervals over entire length of cable with the following:
    - a. Manufacturer's name
    - b. Conductor size
    - c. Voltage class
    - d. Insulation type
    - e. UL designation
- P. Cables shall be constructed and rated for continuous and intermittent submersion in water and shall be suitable for installation in conduit and underground duct.
- Q. Cable shield shall be capable of withstanding fault current indicated on drawings for 1/10 second.

### **2.3 SPLICE KITS**

- A. Connectors and Splice Kits: Comply with IEEE 404; type as recommended by cable or splicing kit manufacturer for application. Splicing is only permitted where shown on the construction documents. No other splicing will be permitted.
- B. Splice and termination kits shall be approved by the University. The University shall be notified 72 hours in advance so that they may observe each splice or termination being made.

- C. No below grade splicing is permitted.
- D. Splices in manholes: Provide only 15 kV 600 amp or 200 amp load-break elbows and connectors. No hand-taped splices are allowed unless specifically shown on plans.
- E. 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.
- F. Splicing Products: Where splicing is permitted per the plans and University approval it shall be completed using separable connectors. See Section 2.4 Separable Insulated Connectors.

#### **2.4 SEPARABLE INSULATED CONNECTORS**

- A. Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.
- B. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.
- C. Load-Break Cable Terminators: Elbow-type units with 15 KV class, 95 KV BIL load make/break and continuous-current rating; coordinated with insulation diameter, conductor size, and material of cable being terminated, with steel-reinforced hook-stick eye, grounding eye, and arc-quenching material. Include capacitance coupled test point on terminator body. Include cold shrinkable metallic shield adapter kit to ground metallic shielded cable. Include connection bus with parking stand for wall mounting.
- D. Dead-Break Cable Terminators: Elbow-type unit with 600A continuous-current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.
- E. Dead-Front Terminal Junctions: 15 KV class, modular bracket-mounted groups of dead-front stationary terminals that mate and match with above cable terminators. Two-, three-, or four- terminal units as indicated, with fully rated, insulated, watertight conductor connection between terminals and complete with grounding lug, manufacturer's standard accessory stands, stainless- steel mounting brackets, and attaching hardware.
  - 1. Protective Cap: Insulating, electrostatic-shielding, water-sealing cap with drain wire.
  - 2. Portable Feed-Through Accessory: Two-terminal, dead-front junction arranged for removable mounting on accessory stand of stationary terminal junction.
  - 3. Grounding Kit: Jumpered elbows, portable feed-through accessory units, protective caps, test rods suitable for concurrently grounding three phases of feeders and carrying case.
  - 4. Standoff Insulator: Portable, single dead-front terminal for removable mounting on accessory stand of stationary terminal junction. Insulators suitable for fully insulated isolation of energized cable-elbow terminator.



- F. Test-Pont Fault Indicators: Applicable current-trip ratings and arranged for installation in test points of load-break separable connectors, and complete with self-resetting indicators capable of being installed with shotgun hot stick and tested with test tool.
- G. Tool Set: Shotgun hot stick with energized terminal indicator, fault-indicator test tool, and carrying case.

## **2.5 ARC-PROOFING MATERIALS**

- A. Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent to 0.3" thick, compatible with cable jacket.
- B. Glass-Cloth Tape: Pressure-sensitive adhesive tape, 1/2" wide.

## **2.6 FAULT INDICATORS**

- A. Indicators: Automatic reset fault indicator arranged to clamp to cable sheath and provide a display after fault has occurred in cable. Instrument shall not be affected by heat, moisture, and corrosive conditions and shall be recommended by manufacturer for installation conditions.
- B. Resetting Tool: Designed for use with fault indicators, with moisture-resistant storage and carrying case.
- C. SEL Automatic reset fault indicators to be connected to campus SCADA system

## **2.7 SOURCE QUALITY CONTROL**

- A. Test and inspect cables according to Section 26 08 12 – Power Distribution Acceptance Tests and Section 26 08 13 – Power Distribution Acceptance Test Tables.

# **PART 3 - EXECUTION**

## **3.1 INSTALLATION**

- A. Install cables according to IEEE 576.
- B. Submit pull tension calculation based on the as built conditions of the conduct systems for University review and approval prior to cable installation. Pull tensions and side wall pressure must not exceed 90% of manufacturers maximum published limits.
- C. Pull Conductors: Do not exceed manufacturer's recommended minimum installation temperature, maximum pulling tensions, and sidewall pressure values.
  - 1. Where necessary, use manufacturer-approved pulling compound or lubricant that will not deteriorate conductor or insulation.
  - 2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips that will not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.
  - 3. Cut off cable damaged by cable grips or pulling make-ups so as to provide clean, undamaged cable for termination. Continuously record pulling tension during installation.
  - 4. Notify University 72 hours prior to the installation of MV cables.
  - 5. Monitor cable installation tension using direct tension measurement device on the pulling cable/rope with a device that has been calibrated within 1 year. Provide

report detailing force applied to the cable at 5' increments. Under no circumstances will cable be accepted if manufacturers pulling tension has been exceeded.

- D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.
- E. Support cables in handholes and manholes from walls on heavy-duty, non-metallic cable rack arms, at least 3" above the floor. Support cables with reinforced nylon cradles. Anchor to wall with stainless steel anchor bolts.
  - 1. Install compression connectors with hydraulic compression tool on 600V neutral/ground conductor.
- F. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by longest route from entry to exit and support cables at intervals adequate to prevent sag. Fill lowest ducts first, avoid covering or blocking duct entrances and allow space for future cable installation. Retain one of two options below.
- G. Provide at least one 360-degree loop around first and last manhole for each cable run and every third manhole in between (if applicable).
- H. Cut cable in clean, dry environment. Seal cut ends with waterproof seal immediately after cutting. Maintain a seal during and after pulling.
- I. Install terminations at ends of conductors and seal multi-conductor cable ends with standard kits. Do not install exterior terminations during inclement weather or damp atmospheric conditions.
- J. Install stress cones at cable splices and terminations, grounded per cable and connector manufacturer recommendations.
- K. Check phase rotation before connections are made to existing circuits. Clearly letter cable terminations. Identify phases with phase designations lettered on terminal boxes and other terminations throughout the system.
- L. Install separable insulated-connector components as follows:
  - 1. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected
  - 2. Portable Feed-Through Accessory: Three
  - 3. Standoff Insulator: Three
- M. Arc Proofing: Unless otherwise indicated, arc proof medium-voltage cable at locations not protected by conduit, cable tray, direct burial, or termination materials. In addition to arc-proofing tape and/or manufacturer's written instructions, apply arc proofing as follows:
  - 1. Clean cable sheath.
  - 2. Wrap metallic cable components with 10 mil pipe-wrapping tape.
  - 3. Smooth surface contours with electrical insulation putty.
  - 4. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
  - 5. Band arc-proofing tape with 1"-wide bands of half-lapped, adhesive, glass-cloth tape 2" o.c.
- N. Seal around cables passing through fire-rated elements according to Section 26 0593 – Electrical

Systems Firestopping.

- O. Install fault indicators on each phase where indicated.
- P. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware. For grounding requirements, refer to Section 26 0526 – Grounding and Bonding for Electrical Systems.
- Q. Identify cables according to Section 26 0553 – Electrical Systems Identification.

**3.2 FIELD QUALITY CONTROL**

- A. Perform cable acceptance tests on cable circuits after installing cables and before electrical circuitry has been energized. Splices and terminations required as part of this project are to be completed and acceptance tested as part of cable tests. For cables not spliced or terminated as part of project, ends should be clean, dry and long enough to eliminate leakage from conductor to ground along outer surface of cable.
- B. Perform acceptance tests and damage investigations under constant supervision of Owner's representative. Contractor shall coordinate and provide labor, material, equipment, and services necessary to test each completed cable circuit.
- C. Remove and replace defective cables and retest as required.
- D. Cable passing acceptance testing shall be placed into service not more than 72 hours after acceptance by University.
- E. Refer to Section 26 08 12 – Power Distribution Acceptance Tests for visual and mechanical inspection and electrical tests. Certify compliance with test parameters.

**3.3 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 13.16**

## **SECTION 26 05 19 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND**

### **CABLES PART 1 - GENERAL**

#### **1.1 RELATED WORK**

- A. Section 26 05 29 - Hangers and Supports for Electrical Systems
- B. Section 26 05 33 - Surface Metallic Raceway System
- C. Section 26 05 53 - Electrical Systems Identification
- D. Section 26 05 93 - Electrical Systems Firestopping
- E. Section 26 08 12 - Power Distribution Acceptance Tests
- F. Section 26 08 13 - Power Distribution Acceptance Test Tables

#### **1.2 REFERENCE**

- A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

#### **1.3 DESCRIPTION**

- A. Section includes conductors and cables rated 600 V and less, connectors, splices, and terminations rated 600 V and less, sleeves and sleeve seals for cables.
- B. Conductor and conduit sizes in these contract documents are based on copper wire, and only copper wire shall be used.

#### **1.4 REFERENCE STANDARDS**

- A. ASTM B 1 – Standard Specification for Hand-Drawn Copper Wire.
- B. ASTM B 8 – Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
- C. NEMA WC 70 – Non-Shielded Power Cable 2000 V or less for the Distribution of Electrical Energy (ICEA S-95-658).
- D. NFPA 70 – National Electrical Code.
- E. UL 44 – Thermoset-Insulated Wires and Cables.
- F. UL 83 – Thermoplastic-Insulated Wires and Cables.
- G. UL 486A-486B – Wire Connectors.
- H. UL 486C – Splicing Wire Connectors.
- I. UL 486D – Standard for Insulated Wire Connector Systems for Underground Use or in Damp or Wet Locations.
- J. UL 486E – Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors.

### 1.5 QUALITY ASSURANCE

- A. Regulatory Requirements:
  - 1. Comply with NFPA 70 for components and installation.
  - 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.
- B. Wire and cable boxes and reels shall bear the date of manufacture.
  - 1. Date of manufacture shall not precede contract date by more than one year.

### 1.6 DELIVERY, STORAGE, AND HANDLING

- A. Store in clean, dry space. Protect from dirt, fumes, water, corrosive substances, and construction debris.

### 1.7 WARRANTY

- A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1-year warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. General Cable Corporation
- B. Cerrowire
- C. Southwire Company
- D. or equal
- E. VFD Cable: Aetna Insulated Wire, Americable, General Cable, Southwire or equal

### 2.2 DESCRIPTION

- A. NEMA WC 70; single copper conductor insulated wire; 600 V rated insulation; 90°C maximum operating temperature for dry and wet or damp locations.
  - 1. Thermoplastic-insulated wires and cables: NEMA WC 5, UL 83; Type THHN, THWN .
  - 2. Thermoset-insulated wires and cables: NEMA WC 3, UL 44; Type XHHW.
- B. All conductors will be manufactured in their corresponding phase color identifiers. The use of phase tape or other means is not acceptable.
- C. All conductors #16 AWG and larger are to be stranded conductors.
- D. VFD Cable:
  - 1. Cable
    - a. 600V/2000V rated, high stranded tinned copper conductors, shielded, engineered for use with Variable Frequency Drives.
    - b. Insulation shall be rated for 90 degrees Celsius Wet/Dry operating temperature.
  - 2. Conductors

- a. Conductor shall be annealed fine wire flexible high strand count tinned copper or standard Class B stranded bare copper.
- b. Three (3) phase conductors, three (3) ground conductors. Each of the three ground conductors shall be the same size as the single ground conductor shown on the drawings.
3. Insulation
  - a. Flame-Retardant Cross-Linked Polyethylene.
  - b. Conductors shall be cabled together. Ground conductors shall be symmetrical. Fillers shall be included as necessary to make the cable round.
4. Shielding
  - a. The following are acceptable:
    - 1) Overall tinned copper braid plus aluminum/polyester tape foil, 100% coverage.
    - 2) 5mil helically applied copper tape.
    - 3) Impervious corrugated welded continuous armor.
5. Jacket
  - a. Flame-retardant Thermoplastic, suitable for 90°C use.
6. Termination Kit
  - a. Pre-sized and pre-formed specifically for VFD cable constructions. Obtain from VFD cable manufacturer.

### **2.3 REMOTE CONTROL AND SIGNAL CIRCUITS**

- A. Class 1
  1. Copper conductor, single insulated wire.
  2. Insulation type THHN-2 rated 90°C, 600 V insulation class.
  3. Type XHHW for ambient temperature less than 32°F.
  4. ASTM B 8 for stranded conductors. #16 AWG and larger to be stranded conductors.
- B. Classes 2 and 3
  1. Copper conductor, multiple twisted conductors covered with an overall non-metallic jacket unless otherwise noted.
  2. Insulation type XLEP, rated 105°C, 300 V insulation class.
  3. UL listed for use in space in which circuits will be installed.

### **2.4 CONNECTORS, SPLICES, AND TERMINALS**

- A. Manufacturers:
  1. AFC Cable Systems, Inc.
  2. Hubbell Power Systems, Inc.
  3. O-Z/Gedney; EGS Electrical Group LLC.
  4. 3M; Electrical Products Division
  5. Tyco Electronics Corp.
  6. Or equal
- B. Description: UL 486A-486B, UL 486C, UL 486D, UL 486E; factory-fabricated connectors, splices, and terminals of size, ampacity rating, material, type, and class for application and service indicated.

## **2.5 TERMINATIONS**

- A. Compression set, bolted or screw type lug, or direct to bolted or screw type terminal.
- B. Insulation piercing terminations are not permitted.
- C. "Wago" or similar type of termination devices are not permitted.

## **2.6 PLASTIC CABLE TIES**

- A. Nylon or approved; locking type; metallic ties not permitted.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION OF CONDUCTORS AND CABLES**

- A. Install conductors in a raceway system, unless otherwise specified or indicated.
- B. Install conductors only after:
  - 1. Building interior is enclosed and weather tight
  - 2. Mechanical work likely to damage conductors has been completed
  - 3. Raceway installation is complete and supported
- C. Pull conductors into raceway at same time.
- D. Neatly train and lace conductors inside boxes, equipment, and panelboards.
- E. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.
- F. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- G. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- H. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible. Protect exposed cables from damage.
- I. Support cables above accessible ceiling using plastic cable ties to support cables from structure. Do not rest cable on ceiling panels.
- J. Support cables and conductors in vertical raceways per requirements in Section 26 0529 - Hangers and Supports for Electrical Systems.
- K. Identify and color-code conductors and cables according to Section 26 0553 - Electrical Systems Identification.
- L. Wiring at Outlets: Install conductor at each outlet, with minimum 6" of slack.
- M. Limit conduit fill to a maximum of 9 current-carrying conductors provided that derating portion of the NEC is met.
- N. Install stranded conductors where conductors terminate in crimp type lugs. Do not place bare stranded conductors directly under screws.
- O. Install VFD input wiring, output wiring and control wiring in their own separate conduit systems.

### **3.2 CONDUCTOR MATERIAL APPLICATIONS**

- A. Feeders: Copper. Stranded for #16AWG and larger conductors.
- B. Branch Circuits: Copper Stranded for #16 AWG and larger conductors.
- C. Minimum conductor sizes shall be as follows:
  - 1. #12 AWG – Branch circuits of any kind.
  - 2. #14 AWG – Fire alarm system.
  - 3. #16 AWG – Remote control and signal systems.
- D. Branch wiring length limitations:
  - 1. 208Y/120 V circuits over 100' in length: Increase wire size one size for each 100' of length. Increase conduit size as required.
  - 2. 480Y/277 V circuits over 150' in length: Increase wire size one size for each 150' of length. Increase conduit size as required.

### **3.3 CONDUCTOR INSULATIONS AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS**

- A. Provide type THWN or THHN-2 wire and cable #4/0 AWG size and smaller in dry locations. Provide type THWN-2 wire and cable larger than #4/0 AWG size in wet locations. All conductor sizes shall be fully rated for the entire length of the feeder run. Conductors oversized for voltage drop may be reduced near the end of a conductor to allow termination at devices. Tap conductors from main feeder shall be reduced and allowed by the code.
- B. Motor Circuit Branch Wiring Between Motor and VFD: VFD Cable
  - 1. Terminate VFD cable using pre-sized and pre-formed termination kits supplied by cable manufacturer. Install per manufacturer's recommendations.
- C. Branch Circuits Single Conductors in Raceway: 90°C rated conductors sized at 75°C rating for connection to equipment and devices.

### **3.4 REMOTE CONTROL AND SIGNAL CIRCUITS**

- A. Sizing – #16 AWG minimum.
- B. Installation:
  - 1. Install cables in cable tray and cable rings.
  - 2. Provide protection for exposed cables where subject to damage.
  - 3. Support cables above accessible ceilings; do not rest on ceiling tiles.
  - 4. Use suitable cable fittings and connectors.

### **3.5 CONNECTORS, SPLICES, AND TERMINALS**

- A. Connectors:
  - 1. Except where equipment is furnished with bolted or screw type lug, use compression set pressure connectors with insulating covers. Use compression tools and die compatible with connectors being installed.
  - 2. Use bolt or compression-set type with application of insulating tape, pre-stretched or heat-shrinkable insulating tubing for splices and taps of #8 AWG



- conductors and larger. Install with hydraulic compression tool.
3. Use pre-insulated "twist-on" connectors with integral spring for splices and taps of #10 AWG conductors and smaller.
  4. 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-486B.
  5. Install suitable reducing connectors or mechanical connector adaptors for connecting aluminum conductors to copper conductors.
  6. Wago or other types of push in connectors are not permitted.
- B. Splices:
1. Splice wires and cable only in accessible locations such as within junction boxes.
  2. Make splices to carry full capacity of conductors with no perceptible temperature rise.
  3. Make below-grade splices in manholes and handholes watertight with pre-stretched or heat- shrinkable insulating tubing, or resin-filled insulator.
  4. Use electrical tape to build up insulation level equivalent to cable insulation and cover with not less than two half-lapped layers of plastic electrical tape, for joints, taps, and splices of #1 AWG conductors and larger.
  5. Plastic snap-on splice insulators are not allowed.
  6. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
  7. Wago or other types of push in connectors are not permitted.
- C. Terminals:
1. Insulate ends of spare conductors with electrical tape and identify spare circuit number where appropriate.
  2. Eye type crimped terminal for removable screw type terminal. Forked torque terminal when screw terminal cannot be removed.
  3. Train wires to eliminate fanning of stands, crimp with proper tool and die.
  4. Torque screw termination per manufacturer's recommended values.

### **3.6 CABLE TIES**

- A. Neatly bundle conductors and cables together for support. Size cable ties sufficiently to accommodate the multiple cables being supported.

### **3.7 FIELD QUALITY CONTROL**

- A. Test 600 volt conductors and cables per requirements in Sections 26 0812 – Power Distribution Acceptance Tests and 26 08 13 – Power Distribution Acceptance Test Tables.
- B. Interpret test results in writing and submit to Owner's Representative.
- C. Replace conductors and cables that are found defective, at no expense to Owner.

## **END OF SECTION 26 05 19**

## **SECTION 26 05 26 - GROUNDING AND BONDING FOR ELECTRICAL**

### **SYSTEMS PART 1 - GENERAL**

#### **1.1 RELATED WORK**

- A. Section 26 05 43 - Ducts and Raceways for Electrical Systems
- B. Section 26 08 12 - Power Distribution Acceptance Tests
- C. Section 26 08 13 - Power Distribution Acceptance Test Tables

#### **1.2 REFERENCE**

- A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

#### **1.3 DESCRIPTION**

- A. Section includes methods and materials for grounding systems and equipment, as required by State Codes, NFPA 70, applicable portions of other NFPA codes, as indicated herein, plus the following special applications:
  - 1. Underground distribution grounding.
  - 2. Common ground bonding with lightning protection system.
- B. Maximum resistance to ground shall be less than 5 ohms.
- C. Refer to Grounding Riser Diagram.

#### **1.4 REFERENCE STANDARDS**

- A. ASTM B 3 – Specification for Soft or Annealed Copper Wire
- B. ASTM B 8 – Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard or Soft
- C. ASTM B 33 – Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes
- D. IEEE C2 – National Electrical Safety Code (ANSI)
- E. IEEE 857 – Standard for Qualifying Permanent Connections Used in Substation Grounding
- F. NETA MTS – Maintenance Testing Specifications
- G. NFPA 70 – National Electrical Code
- H. NFPA 70B – Recommended Practice for Electrical Equipment Maintenance
- I. UL 467 – Grounding and Bonding Equipment

#### **1.5 SUBMITTALS**

- A. Product Data: For each type of product indicated.
- B. Other Informational Submittals: Plans showing dimensioned as-built locations of grounding features, including the following:
  - 1. Test wells
  - 2. Ground rods

3. Ground rings
  4. Grounding arrangements and connections for separately derived systems
  5. Grounding for sensitive electronic equipment
- C. Field Quality-Control Test Reports:
1. Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
  2. Test reports of resistance to earth. Each test report shall include:
    - a. Date of test, soil moisture content, and soil temperature
    - b. Test operator
    - c. Instrument or other test equipment used
    - d. Electrode designation or location
    - e. Ground impedance in ohms
    - f. Assumptions made - if required
- D. Closeout Submittals:
1. Operation and Maintenance Manuals: Include the following:
    - a. Instructions for periodic testing and inspection of grounding features at test wells, ground rings, grounding connections for separately derived systems based on NETA MTS.
      - 1) Instructions to perform tests to determine if ground resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if they do not.
      - 2) Include recommended testing intervals.

## 1.6 QUALITY ASSURANCE

- A. Regulatory Requirements:
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70.
  2. Comply with UL 467 for grounding and bonding materials and equipment.

## 1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store products in clean, dry space. Protect from dirt, fumes, water, corrosive substances, and construction debris.

## 1.8 WARRANTY

- A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1-year written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

## PART 2 - PRODUCTS

### 2.1 CONDUCTORS

- A. Insulated Conductors: tinned-copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction, insulation color: green.

- B. Bare Copper Conductors:
  - 1. Solid Conductors: ASTM B 3.
  - 2. Stranded Conductors: ASTM B 8.
  - 3. Tinned Conductors: ASTM B 33.
  - 4. Bonding Cable: 28 kcmil, 14 strands of #17 AWG conductor, 1/4" in diameter.
  - 5. Bonding Conductor: #4 AWG or #6 AWG, stranded conductor.
  - 6. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8" wide and 1/16" thick.
  - 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8" wide and 1/16" thick.
- C. Bare Grounding Conductor and Conductor Protector for Wood Poles:
  - 1. #4 AWG minimum, soft-drawn copper.
  - 2. Conductor Protector: Half-round PVC or wood molding. If wood, use pressure-treated fir or cypress or cedar.
- D. Grounding Bus: Horizontal rectangular bars of annealed copper, 3/8" by 4" in cross section; with insulators as indicated on drawings.

## 2.2 CONNECTORS

- A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.
- B. Bolted Connectors for Conductors and Pipes: Electro-tin plated copper or copper alloy, bolted pressure-type, with at least two bolts.
  - 1. Pipe Connectors: Clamp type, sized for pipe.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- D. Compression Connectors: Irreversible type.

## 2.3 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad steel; 3/4" in diameter by 10 ft in length.

Table 1 –TBB conductor size vs length

TBB/GE linear length m (ft)	TBB/GE size (AWG)
less than 4 (13)	6
4 – 6 (14 – 20)	4
6 – 8 (21 – 26)	3
8 – 10 (27 – 33)	2
10 – 13 (34 – 41)	1
13 – 16 (42 – 52)	1/0
16 – 20 (53 – 66)	2/0
20 – 26 (67 – 84)	3/0
26 – 32 (85 – 105)	4/0
32 – 38 (106 – 125)	250 kcmil
38 – 46 (126 – 150)	300 kcmil
46 – 53 (151 – 175)	350 kcmil
53 – 76 (176 – 250)	500 kcmil
76 – 91 (251 – 300)	600 kcmil
Greater than 91 (301)	750 kcmil

### PART 3 - EXECUTION

#### 3.1 APPLICATIONS

- A. Conductors: Stranded conductors for #16 AWG and larger, unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare tinned-copper conductor. No. #4/0 AWG] minimum.
  - 1. Bury at least 24" below grade.
- C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
- D. Grounding Bus: Install in electrical and communications rooms, in rooms housing service equipment.
  - 1. Install bus on insulated spacers 1", minimum, from wall; 6" above finished floor.
  - 2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down to specified height above floor, and connect to horizontal bus.
- E. Conductor Terminations and Connections:
  - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors
  - 2. Underground Connections: Welded connectors, except at test wells and as otherwise indicated
  - 3. Connections to Ground Rods at Test Wells: Bolted connectors
  - 4. Connections to Structural Steel: Welded connectors

### **3.2 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS**

- A. Comply with IEEE C2 grounding requirements.
- B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4" will extend above finished floor. If necessary, install ground rod before manhole is placed and provide #4/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof PVC sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2" above to 6" below concrete. Seal floor opening with waterproof, non-shrink grout.
- C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, catch basins, metallic cover frame and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with #4 AWG minimum, solid, copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits. All connections to be made by non-reversible splicing methods. All fasteners located in manholes to be 316 stainless.
- D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with transformer and switches by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than #4/0 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6" from the foundation.

### **3.3 EQUIPMENT GROUNDING**

- A. Install insulated equipment grounding conductors with feeders and branch circuits.
  - 1. Install a single insulated equipment ground conductor for each branch circuit conduit originating from panelboards.
- B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
  - 1. Feeders and branch circuits
  - 2. Lighting circuits
  - 3. Receptacle circuits
  - 4. Single-phase motor and appliance branch circuits
  - 5. Three-phase motor and appliance branch circuits
  - 6. Flexible raceway runs
  - 7. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.
- C. Air-Duct Equipment Circuits: Install a separate insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping. Ground ductwork of fans serving

flammable liquid storage rooms or fume hoods. Install continuous ground around any flexible connections in this ductwork system. Bond lower end of exhaust ducts, vent stacks, etc., which pass through roof.

- D. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
- E. Duplex receptacles of any amperage: Install separate jumper between grounding terminal on device and metallic box.
- F. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.
- G. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.
- H. Size of equipment grounding conductors for branch circuits: As indicated in NEC-70, except minimum size shall be #12 AWG.
- I. Size of branch panel feeder originating at switchboards/switchgear: As indicated in NEC-70, except in no instance smaller than #8 AWG.
- J. Signal and Communication Equipment: For alarm and other communication equipment (see Telecommunications Grounding System Installation section below for voice and data systems), install #4 AWG minimum 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" x 2" x 12" grounding bus.
  - 2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.
- K. Install grounding conductor from each standby-emergency generator to grounding electrode system. Provide flexible jumper between base and isolated generator.
- L. Install equipment grounding conductor from secondary side of each transformer to grounding electrode system as required for separately derived system.
- M. Install grounding for service entrance equipment room consisting of ground bus, ground conductors, and 5/8" x 10'-0" copperweld grounding rods arranged as indicated on drawings.
  - 1. Ground bus shall be horizontal 3/8" x 4" copper bar. Bolt to wall at 10' intervals with 1" stand- offs at each bus support.
  - 2. Install ground bus per details on drawings.
- N. Install grounding conductor to luminaires hanging from conduit swivel hangers.

- O. Metal Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch- circuit conductors to pole base. Grounding Conductor: Same size as phase conductors, but not smaller than #10 AWG.
  - 1. Install at each pole or standard a concealed driven 1/2" x 8'-0" ground rod, ground clamp and No. 3 stranded copper conductor concealed and attached to pole and base.

### 3.4 SEQUENCING, SCHEDULING

- A. Permanently attach service grounds before permanent building service is energized.
- B. Permanently attach equipment grounds prior to energizing equipment.

### 3.5 INSTALLATION

- A. Connections: Exposed and visible for inspection at all times. Do not install insulation over ground connections.
- B. Identify all grounding conductors by system and room number of termination at building grounding electrode point.
- C. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- D. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96A when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.
- E. Ground Rods: Drive rods until tops are 2" below finished floor or final grade, unless otherwise indicated.
  - 1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.
- F. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes shall be at least 12" deep, with cover.
  - 1. Test Wells: Install at least one test well for each service, unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.
- G. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
  - 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.



2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
  3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.
- H. Grounding and Bonding for Piping:
1. Metal Water Service Pipe: Install 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, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end. Water pipe, by itself, is not an adequate grounding electrode and must be supplemented by another electrode system. Bond system together.
  2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
  3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- I. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned copper bonding jumper to bond across flexible duct connections to achieve continuity.
- J. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 ft apart.
- K. Make grounding connections on surface that has been cleaned of paint, dirt, oil, etc., so that connections are bare metal to bare metal contact.
- L. Make grounding connections tight with UL listed grounding devices, fittings, bushings, etc.
- M. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column, extending around the perimeter of building.
1. Install tinned-copper conductor not less than #4/0 AWG for ground ring and for taps to building steel.
  2. Bury ground ring not less than 24" from building foundation and 30" below grade.
- N. Concrete-Encased Grounding Electrode: Fabricate according to NFPA 70, using a minimum of 20' of bare copper conductor not smaller than #4/0 AWG.
1. If concrete foundation is less than 20' long, coil excess conductor within base of foundation.
  2. 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 grounding electrode external to concrete.
- O. Equipment Grounding Conductor: Terminate in panelboard at green wire ground bus.
- P. Multiple Conductors on Single Lug: Not permitted. Terminate each grounding conductor on its own terminal lug.
- Q. Flexible Metallic Conduit, Non-Metallic Rigid Conduit, or Liquid Tight Flexible Conduit:

Install green wire grounding conductor with phase conductors in conduit.

### **3.6 BONDING AND GROUNDING SYSTEM INSTALLATION**

- A. Provide required elements and miscellaneous hardware necessary to establish Bonding and Grounding infrastructure as specified.
- B. Install products in accordance with manufacturer's instructions. Install Compression Connectors with compression, tool-and-die system, as recommended by manufacturer of connectors.
- C. Electrical Bonding Conductor, Electrical Bonding Backbone (TBB), and Grounding Equalizer (GE): Exothermic type connections.
- D. Locate TGBs and TMGB per drawings.
- E. Telecommunications Bonding Backbone (TBB) shall be continuous and not interrupted by Telecommunications Grounding Busbars (TGB).
  - 1. TGBs shall be bonded to TBB via tap off of TBB. Exception: "last" TGB on TBB (e.g., furthest from TMGB).
  - 2. Grounding Equalizer(s) (GE) shall connect to TGBs to be interconnected.
- F. Insulate busbars from their support.
- G. All below grade grounding connections shall be made with exothermic welds.

### **3.7 FIELD QUALITY CONTROL**

- A. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
  - 1. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal , at ground test wells , and at individual ground rods. Make tests at ground rods before any conductors are connected.
- B. Test grounding systems per requirements in Section 26 08 12 – Power Distribution Acceptance Tests and 26 08 13 – Power Distribution Acceptance Test Tables.
- C. Interpret test results in writing and submit to Engineer.
- D. Inspect completed system by commissioning authority, prior to backfilling.

**END OF SECTION 26 05 26**

## **SECTION 26 05 29 - HANGERS AND SUPPORTS FOR ELECTRICAL**

### **SYSTEMS PART 1 - GENERAL**

#### **1.1 RELATED WORK**

- A. Section 26 0533 – Raceway and Boxes for Electrical Systems
- B. Section 26 0548 – Vibration and Seismic Controls for Electrical Systems
- C. Section 26 1213 – Liquid-Filled, Medium-Voltage Transformers
- D. Section 26 1219 – Pad-Mounted, Liquid-Filled, Medium-Voltage Transformers
- E. Section 26 1316 – Medium-Voltage Fusible Interrupter Switchgear
- F. Section 26 1319 – Medium-Voltage Vacuum Interrupter Switchgear
- G. Section 26 2200 – Low-Voltage Transformers
- H. Section 26 2300 – Low-Voltage Switchgear
- I. Section 26 2413 – Switchboards
- J. Section 26 2416.13 – Lighting and Appliance Panelboards
- K. Section 26 2416.16 – Distribution Panelboards
- L. Section 26 2816 – Enclosed Switches and Circuit Breakers
- M. Section 26 2913 – Enclosed Controllers
- N. Section 26 3213 – Engine Generators
- O. Section 26 3623 – Automatic Transfer Switches
- P. Section 26 5000 – Lighting

#### **1.2 REFERENCE**

- A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions and sections under Division 01 General Requirements.

#### **1.3 DESCRIPTION**

- A. Section includes the following:
  - 1. Manufactured hangers and supports for individual raceways and cables, slotted channel and angle systems for multiple conduit runs, and most electrical equipment that is not floor mounted.
  - 2. Construction requirements for concrete housekeeping pads for floor-mounted electrical equipment.
  - 3. Conduit hangers for acoustical noise and vibration control.
  - 4. Heavy equipment support pads for acoustical noise and vibration control.
  - 5. Equipment mounts for acoustical noise and vibration control.

#### **1.4 REFERENCE STANDARDS**

- A. AWS D1.1/D1.1M – Structural Welding Code-Steel.
- B. ASTM A 36/A 36M – Carbon Structural Steel.

- C. ASTM A 325 – Structural Bolts, Steel, Heat Treated, 827/724 MPa(120/105 ksi) Minimum Tensile Strength.
- D. ASTM A 780 – Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
- E. MSS SP-58 – Pipe Hangers and Supports - Materials, Design and Manufacture.
- F. MSS SP-69 – Pipe Hangers and Supports - Selection and Application.
- G. MFMA-4 – Metal Framing Standards Publication.
- H. NECA 1 – Standard Practices for Good Workmanship in Electrical Construction.
- I. NECA 101 – Standard for Installing Steel Conduits (Rigid, IMC, EMT).
- J. NFPA 70 – National Electrical Code.
- K. SSPC-PA 1 – Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel.
- L. ETL PVC-001 – PVC Coated Conduit

### **1.5 QUALITY ASSURANCE**

- A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, “Structural Welding Code – Steel.”
- B. Comply with NFPA 70.
- C. Certification
  - 1. Installer of PVC-coated hangers and supports shall be certified by a PVC conduit manufacturer.

## **PART 2 - PRODUCTS**

### **2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS**

- A. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of **[5] [ ]** times the applied force.
- B. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
  - 1. Finishes
    - a. Metallic Coatings:
      - 1) Factory standard primed, galvanized or electroplated finish and applied according to MFMA-4, for indoor applications.
      - 2) Hot-dip galvanized after fabrication and applied according to MFMA-4, for outdoor applications.
    - b. Nonmetallic Coatings: Manufacturer’s standard PVC, polyurethane, or polyester coating applied according to MFMA-4, for corrosive environments.

- c. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA- 4.
  2. Channel Dimensions: Selected for applicable load criteria.
  3. Manufacturers:
    - a. Allied Support Systems; Power-Strut Unit.
    - b. Cooper B-Line, Inc.; A division of Cooper Industries.
    - c. ERICO International Corporation.
    - d. GS Metals Corporation.
    - e. Thomas & Betts Corporation.
    - f. Unistrut; Tyco International, Ltd.
    - g. Wesanco, Inc.
    - h. National Pipe Hanger Corporation.
    - i. Michigan Hanger Co., Inc.; O-Strut Division.
    - j. or equal.
- C. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
- D. Raceway and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- E. PVC Raceway Support Devices: ANSI C80.1, UL6, ETL PVC-001.
- F. Support for Conductors in Vertical Raceway: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.
- G. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- H. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
  1. Concrete Anchors
    - a. Anchors shall be selected, sized, and detailed by Contractor's structural engineer registered in project's jurisdiction, based on project conditions and in accordance with project building code. Calculations and drawings shall be submitted.
    - b. Anchors shall meet ICC Acceptance Criteria, and ICC-ES Evaluation Reports (ESRs) shall specifically list the current applicable codes.
    - c. Anchors installed in hardened concrete for purpose of transmitting structural loads from one connected element to another, or for safety related elements such as sprinkler pipes, heavy suspended pipes, and barrier rails shall have ICC-ES report demonstrating anchors have met requirements of AC 193 for mechanical anchors in concrete elements.
    - d. Post-installed expansion anchors and undercut anchors installed in hardened concrete shall be qualified for strength design and tested according to ACI 355.2. Designs shall be per the requirements of ACI 318, Appendix D.
    - e. Anchors for seismic load application shall be approved by ICC-ES Evaluation Reports to resist seismic loads and selected to meet project seismic design requirements. Refer to Section 20 0549 – Seismic Anchorage and Restraints

- and Structural drawings.
- f. Anchors shall be zinc plated in accordance with ASTM B633.
  - g. Select anchors with load ratings based on cracked concrete conditions.
  - h. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
    - 1) Manufacturers:
      - a) Hilti Inc.
      - b) ITW Ramset/Red Head; A division of Illinois Tool Works, Inc.
      - c) MKT Fastening, LLC.
      - d) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit
      - e) Or equal
  - i. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
    - 1) Manufacturers:
      - a) Cooper B-Line, Inc.; A division of Cooper Industries
      - b) Empire Tool and Manufacturing Co., Inc.
      - c) Hilti Inc.
      - d) ITW Ramset/Red Head; A division of Illinois Tool Works, Inc.
      - e) MKT Fastening, LLC.
      - f) Or equal
    - 2. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
    - 3. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
  - I. Beam Clamps: C-clamps are allowed 3/8" or smaller and only for static loading such conduits. Provide locknut for hanging rod at clamp. C-clamps are not allowed for open web steel joist applications nor seismic applications.
  - J. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
  - K. Toggle Bolts: All-steel springhead type.
  - L. Hanger Rods:
    - 1. MSS SP-58; threaded steel, with adjusting and lock nuts; electroplated zinc finish.
    - 2. MSS SP-58; nonmetallic, with adjusting and lock nuts.

## **2.2 FABRICATED METAL FRAMING EQUIPMENT SUPPORT ASSEMBLIES**

- A. Description: Welded or bolted, structural steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates; not be lighter than 12 ga.
- C. Finish: Electro-galvanized
- D. Manufacturers: Same as in paragraph 2.1.B.3 above.

### **2.3 CONTINUOUS INSERT CHANNELS**

- A. Length and support capabilities to be suitable for application.
- B. Brackets, inserts and accessories suitable for channel insert selected.
- C. Manufacturers:
  - 1. Unistrut; Tyco International, Ltd.
  - 2. Cooper B-Line, Inc.; A division of Cooper Industries
  - 3. Michigan Hanger Co., O-Strut Division
  - 4. Anvil International, Inc.
  - 5. Or equal

### **2.4 CONDUIT HANGERS FOR ACOUSTICAL NOISE AND VIBRATION CONTROL**

- A. Manufacturers:
  - 1. Mason Industries, Inc. (Hauppauge, NY), Type HD.
  - 2. Amber/Booth Co. (Houston, TX), Type BRD-A.
  - 3. Kinetics Noise Control, Inc. (Dublin, OH), Type RH or FH.
  - 4. Vibration Eliminator Co., Inc. (Long Island City, NY), Type 3C.
  - 5. Vibration Mountings & Controls, Inc. (Butler, NJ), Type RHD.
  - 6. Or equal
- B. HN (hanger neoprene) isolators shall consist of a neoprene-in-shear element contained within a steel housing. A neoprene neck bushing shall be provided where the hanger rod passes through the hanger housing to prevent the rod from contacting the hanger housing. A pre-compressed glass fiber element may be substituted for the neoprene element.
- C. HN isolators shall be selected to achieve 1/10" minimum static deflection under load.

### **2.5 HEAVY EQUIPMENT SUPPORT PADS FOR ACOUSTICAL NOISE AND VIBRATION CONTROL**

- A. Manufacturers:
  - 1. Mason Industries, Inc. (Hauppauge, NY), Type WSW or Super W.
  - 2. Amber/Booth Co. (Houston, TX), Type NR.
  - 3. Kinetics Noise Control, Inc. (Dublin, OH), Type NPS.
  - 4. Vibration Eliminator Co., Inc. (Long Island City, NY), Type 200N (Multilayers).
  - 5. Vibration Mountings & Controls, Inc. (Butler, NJ), Series Maxi-Flex.
  - 6. Or equal
- B. DNP (double neoprene pad) isolators shall be formed by layers of 1/4" to 3/8" thick (3/4" total thickness) ribbed or waffled neoprene. These layers shall be permanently adhered together. The pads shall have a galvanized steel load bearing plate on top to distribute the load over the entire surface of each pad. The pads shall be sized so that they will be loaded within the manufacturer's recommended range.

### **2.6 EQUIPMENT MOUNTS FOR ACOUSTICAL NOISE AND VIBRATION CONTROL**

- A. Manufacturers:
  - 1. Mason Industries, Inc. (Hauppauge, NY), Type ND.
  - 2. Amber/Booth Co. (Houston, TX), Type RVD.
  - 3. Kinetics Noise Control, Inc. (Dublin, OH), Type RD.
  - 4. Vibration Eliminator Co., Inc. (Long Island City, NY), Type D44.
  - 5. Vibration Mountings & Controls, Inc. (Butler, NJ), Series RD.
  - 6. Or equal

- B. FN (floor neoprene) isolators shall be neoprene-in-shear type with steel reinforced top and base. All metal surfaces shall be covered with neoprene. The top and bottom surfaces shall be ribbed. Bolt holes shall be provided in the base and the top shall have a threaded fastener. The mounts shall include leveling bolts that may be rigidly connected to the equipment.
- C. FN isolators shall be selected to achieve 1/10" minimum static deflection under load.

### **PART 3 - EXECUTION**

#### **3.1 APPLICATION**

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.
- B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70.
- C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25% in future without exceeding specified design load limits.
  - 1. Secure raceways and cables to these supports with 2-bolt conduit clamps.
- D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 3/4" and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.
- E. Install PVC-coated hangers and supports in areas with corrosive atmosphere.

#### **3.2 SUPPORT INSTALLATION**

- A. Comply with NECA 1 and NECA 101 for installation requirements, except as specified in paragraphs below.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT and RMC may be supported by openings through structure members, as permitted in NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor application size and placement shall be reviewed and approved by Structural Engineer prior to installation. Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
  - 1. To Wood: Fasten with lag screws or through bolts.
  - 2. To New Concrete: Bolt to concrete inserts.
  - 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
  - 4. To Existing Concrete: Expansion anchor fasteners.
  - 5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4" thick or greater. Do not use for anchorage to lightweight-aggregate concrete or



- for slabs less than 4" thick.
6. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.
  7. To Light Steel: Sheet metal screws.
  8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic- restraint strength and anchorage requirements.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.
  - F. Do not support raceway by other raceway.
  - G. Do not support equipment or raceway from metal roof decking or floor decking.
  - H. Do not impose weight of electrical equipment, raceways, or lighting fixtures on support provided for other trades or systems.
  - I. Top or bottom chords of open web steel joists may be used to support loads provided total load within panel does not exceed 100 lbs and load is placed concentric to joist (panel is length of chord between two adjacent diagonal web members at point of connection to chord).
    1. C-clamps are not permitted for use in open web steel joist applications.
  - J. Suspend hangers by means of hanger rods. Perforated band iron and flat wire (strap iron) are not allowed.
  - K. Use conduit-mounting pedestals for piping on roof. Install bottom of pedestal flat on roof deck and insulate exterior of pedestal, flush and counter flush.
  - L. Minimize use of concrete anchors and inserts after concrete pour.
  - M. Punching, drilling, welding of building structural steel or welding attachment to building structural steel is not allowed, unless approved by structural engineer.
  - N. Use tools approved for use with PVC-coated conduits and fittings.

### **3.3 INSTALLATION OF FABRICATED METAL SUPPORTS**

- A. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site- fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.

### **3.4 CONCRETE HOUSEKEEPING PADS**

- A. Construct concrete housekeeping pads for all floor-mounted electrical equipment.
- B. Dimensions: 4" high and not less than 4" larger in both directions than supported equipment, so anchors will be a minimum of 10 bolt diameters from edge of the base.
- C. Use 3000 psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section "Cast-in-Place Concrete."

- D. Anchor equipment to concrete housekeeping pad.
  - 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
  - 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
- E. Coordinate with Owner's Representative installation of housekeeping pads on roof.

### **3.5 PAINTING**

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC- PA 1 requirements for touching up field-painted surfaces.
  - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Touchup: Comply with requirements in Division 09 Section "Painting" for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing- repair paint to comply with ASTM A 780.

### **END OF SECTION 26 05 29**

## **SECTION 26 05 33 - RACEWAY AND BOXES FOR ELECTRICAL**

### **SYSTEMS PART 1 - GENERAL**

#### **1.1 RELATED WORK**

- A. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables
- B. Section 26 05 26 – Grounding and Bonding for Electrical Systems
- C. Section 26 05 29 – Hangers and Supports for Electrical Systems
- D. Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems
- E. Section 26 05 53 – Electrical Systems Identification
- F. Section 26 27 26 – Wiring Devices

#### **1.2 REFERENCE**

- A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

#### **1.3 DESCRIPTION**

- A. Section includes raceways, fittings, wireways, wall ducts, indoor service poles, outlet boxes, pull and junction boxes, floor boxes, tap boxes and raceway seals.

#### **1.4 REFERENCE STANDARDS**

- A. ANSI/NECA 1 – Standard Practices for Good Workmanship in Electrical Contracting
- B. ANSI C80-1 – Rigid Steel Conduit-Zinc Coated (GRS)
- C. ANSI C80-3 – Electrical Metallic Tubing-Zinc Coated (EMT)
- D. ANSI C80-5 – Aluminum Rigid Conduit-Zinc Coated (ARC)
- E. ANSI C80-6 – Intermediate Metal Conduit-Zinc Coated (IMC)
- F. ASTM A 53/A 53M – Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
- G. BICSI TDMM – Telecommunications Distribution Methods Manual, Latest Edition
- H. ETL PVC-001 – PVC-Coated Conduit
- I. NEMA 250 – Enclosures for Electrical Equipment (1000 V Maximum)
- J. NEMA FB 1 – Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable
- K. NEMA OS 1 – Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports
- L. NEMA OS 2 – Nonmetallic Outlet Boxes, Device Boxes, Covers, and Box Supports
- M. NEMA RN 1 – Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
- N. NEMA TC 2 – Electrical Polyvinyl Chloride (PVC) Conduit

- O. NEMA TC 3 – PVC Fittings for Use with Rigid PVC Conduit and Tubing
- P. NFPA 70 – National Electrical Code
- Q. TIA-569-B – Commercial Building Standard for Telecommunications Pathways and Spaces
- R. UL 1 – Flexible Metal Conduit
- S. UL 6 – Electrical Rigid Metallic Conduit-Steel
- T. UL 6A – Electrical Rigid Metallic Conduit-Aluminum and Stainless Steel
- U. UL 360 – Liquid-Tight Flexible Steel Conduit
- V. UL 514A – Metallic Outlet Boxes
- W. UL 514B – Conduit, Tubing, and Cable Fittings
- X. UL 514C – Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
- Y. UL 651 – Schedule 40 and 80 Rigid PVC Conduit and Fittings
- Z. UL 797 – Electrical Metallic Tubing-Steel
- AA. UL 870 – Wireways, Auxiliary Gutters, and Associated Fittings
- BB. UL 1242 – Electrical Intermediate Metal Conduit-Steel
- CC. UL 2024 – Optical Fiber and Communication Cable Raceway

### 1.5 SUBMITTALS

- A. Product Data:
  - 1. Floor boxes
- B. Manufacturer's Installation Instructions:
  - 1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation and installation of product.
- C. Closeout Submittals:
  - 1. Project Record Documents:
    - a. Record actual routing of raceways larger than 2".
    - b. Record actual location and mounting heights of wireways, wall ducts, indoor service poles, floor boxes, tap boxes, outlet, pull and junction boxes.
  - 2. Operation and Maintenance Data:
    - a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
    - b. Include spare parts data listing, source, and current prices of replacement parts and supplies.

### 1.6 QUALITY ASSURANCE

- A. Regulatory Requirements:
  - 1. Comply with NFPA 70.
  - 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.
- B. Certification:
  - 1. Installer of PVC-coated conduits and fitting shall be certified by a PVC conduit

manufacturer.

### **1.7 DELIVERY, STORAGE, AND HANDLING**

- A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris, and traffic.
- B. Protect PVC conduit from sunlight.
- C. Comply with manufacturer's written instructions.

### **1.8 WARRANTY**

- A. Refer to Division 01 and Section 26 00 00 – General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1-year written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

### **1.9 UNIVERSITY STANDARDS**

- A. Raceway methods and selections that meet campus standards:
  - 1. All fittings used in the assembly of raceways are to be of the "steel type". Die cast fittings are not acceptable.
  - 2. Die Cast condulets are not acceptable. Provide Form 7 Cast Iron or Form 7 Aluminum condulets where condulets are required. Condulets must be installed in accessible locations.
  - 3. The use of "factory fittings" for EMT, IMC and Rigid pipe is not acceptable. All conduits will be field bent and cut to fit using field tools and equipment. PVC factory elbows and fittings are acceptable were PVC has been determined to be an acceptable raceway.

## **PART 2 - PRODUCTS**

### **2.1 RIGID METAL CONDUIT (RMC)**

- A. Rigid Steel Conduit (RSC): ANSI C80.1, UL 6; heavy wall galvanized steel
- B. Rigid Aluminum Conduit (RAC): ANSI C80.5; heavy wall aluminum
- C. PVC coated rigid steel conduit: NEMA RN 1, ANSI C80.1, UL 6, ETL PVC-001; plastic cap protector caps
- D. Fittings (couplings, conduit bodies, connectors and bushings): NEMA FB 1, UL 514B; steel; threaded; connectors with double locknuts and steel insulating bushings, thermoplastic insulating bushings for conduits 2" and smaller; conduit bodies cover: steel, with stainless steel screws and neoprene gaskets; PVC coated to match conduit.
- E. No die cast bodies are acceptable.
- F. Fittings Manufacturers: Cooper Crouse-Hinds; Carlon Electric Products/Prime Conduit Inc.; O- Z/Gedney; Appleton; Hubbell or equal;
- G. All condulets shall be cast iron. The use of die cast fittings is not acceptable.

## **2.2 ELECTRICAL METALLIC TUBING (EMT)**

- A. ANSI C80.3, UL 797; galvanized steel tubing
- B. Fittings (couplings, conduit bodies, and connectors): NEMA FB I, UL 514B; steel, watertight gland compression type connectors with double locknuts and insulated throat; conduit bodies cover: steel, with stainless steel screws and neoprene gaskets. Indentor, drive-on, die-cast or pressure cast fittings not permitted.
- C. Fittings Manufacturers: Same as manufacturers listed in 2.1.F.

## **2.3 FLEXIBLE METAL CONDUIT (FMC)**

- A. UL 1; interlocked steel
- B. Fittings: NEMA FB I, UL 514B; steel

## **2.4 LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC)**

- A. UL 360; interlocked steel, with PVC jacket
- B. Fittings: NEMA FB 1, UL 514B; steel

## **2.5 RIGID NONMETALLIC CONDUIT (RNC)**

- A. NEMA TC 2, UL 651; Schedule 40 PVC
- B. Fittings: NEMA TC 3, UL 651

## **2.6 OUTLET BOXES**

- A. Sheet Metal Outlet Boxes: NEMA OS 1, UL 514A; galvanized steel with stamped knockouts.
  - 1. Luminaire and Equipment Supporting Boxes: Rated for weight of equipment supported; 1/2" male fixture studs, where required.
  - 2. Concrete Ceiling Boxes: Concrete type
- B. Cast-Metal Outlet Boxes: NEMA FB 1, Type FD, with gasketed cover
  - 1. For applications requiring more than 2 gang boxes, provide stainless steel custom fabricated welded boxes with threaded hubs and coverplate. For applications including terminations and splicing of power conductors, a standard UL Listed box shall be used inside of the custom fabricated box.]
- C. Nonmetallic Outlet Boxes: NEMA OS 2
- D. Gangable type boxes are not allowed.
- E. Manufacturers: O-Z/Gedney; Raco; Cooper Crouse-Hinds or equal;

## **2.7 PULL AND JUNCTION BOXES**

- A. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1; galvanized steel
- B. Cast-Metal, Pull, and Junction Boxes: NEMA FB 1; galvanized, cast iron with ground flange, gasketed cover and stainless-steel cover screws
- C. Minimum size: 4" square by 2-1/8" deep for use with 1" conduit and smaller; 4-11/16" square by 2- 1/8" deep for use with 1-1/4" conduit and larger
- D. Sheet Metal Boxes Larger Than 12" in any direction: Hinged cover or a chain installed

between box and cover

- E. Field-fabricated boxes not allowed without prior approval of local authority having jurisdiction.
- F. Manufacturers: O-Z/Gedney; Raco; Cooper Crouse-Hinds or equal;

## **2.8 POKE-THROUGH FITTINGS**

- A. Poke-Through Fittings: Assembly comprising service fitting, poke-through component, fire stops and smoke barriers, and junction box for conduit termination.
  - 1. Fire Rating: 3h
  - 2. Service Fitting Type: Flush
  - 3. Manufacturers: Hubbell, Legrand/Wiremold, FSR or equal;

## **2.9 FLOOR BOXES**

- A. Metal Floor Boxes: NEMA OS1; cast metal and sheet metal; fully adjustable; rectangular; Moisture- proof, with forged brass blank cover with each box and close up covers and/or carpet flanges as required for finished floor.

## **2.10 MULTISERVICE FLOOR BOXES**

- A. Above Grade: Stamped steel, watertight design approved for use on above-grade concrete floor applications, with four independent wiring compartments and capacity for up to four duplex receptacles and/or communication services. The box: fully adjustable providing pre-pour and after- pour adjustment, tunnel compartment, and two receptacle brackets. Conduit knockouts per drawing requirements. Comply with UL 514A and UL 514C scrub water exclusion test for tile, terrazzo, carpet and wood floors.
- B. On Grade: Cast iron or steel pour box, watertight design approved for use in on-grade and above- grade concrete floor applications, with four independent wiring compartments and capacity for up to four duplex receptacles and/or communication devices. The box: fully adjustable providing pre- pour and after-pour adjustment, tunnel compartment, and two receptacle brackets. Conduit knockouts per drawing requirements. Comply with UL 514A and UL 514C scrub water exclusion test for tile, terrazzo, carpet and wood floors.
- C. Covers: Activation Covers – Die-cast aluminum with textured aluminum finish, and black or brass powder-coated paint finishes as selected by the Owner’s Representative. Cover: flanged or flangeless, as required, with options for tile or carpet inserts, blank covers, or covers with one or two 1” liquid tight conduit openings for furniture feed applications.
- D. Communication Modules Mounting Accessories: Complete line of faceplates and bezels provided by floor box manufacturer to facilitate mounting of fiber optic, coaxial, high-performance twisted- pair cabling, and communication devices. Cabling type and faceplate configurations per requirements in Section 27 1500 – Communications Horizontal Cabling. The box shall accommodate workstation connectivity outlets and modular inserts and other system devices.
- E. Manufacturers:
  - 1. Hubbell - HBLCFB Series
  - 2. Spider - AFB/CFB Series
  - 3. Legrand/Wiremold - Evolution Series
  - 4. Or equal

### **2.11 TAP BOXES**

- A. Multi-tap connectors as indicated on drawings.
- B. Manufacturers: IlSCO;

### **2.12 EXPANSION FITTINGS**

- A. Malleable iron, hot dip galvanized allowing 4" ( $\pm 2$ ") raceway movement.
- B. Manufacturers: OZ/Gedney AX Series; or equivalent by manufacturer listed in 2.1.F.

### **2.13 RACEWAY PENETRATION SEALS**

- A. Thruwall and Floor Seals.
- B. Manufacturers: New construction – OZ/Gedney FSK Series; existing construction – OZ/Gedney CSM Series; or equivalent by manufacturer listed in 2.1.F.

### **2.14 RACEWAY SEALING FITTINGS**

- A. For one through four conductors: Manufacturers: OZ/Gedney CSB Series;
- B. For greater than four conductors: Manufacturers: OZ/Gedney EYA Series with sealing compound;
- C. Low-temperature or hazardous locations: Manufacturers: OZ/Gedney EYA Series with sealing compound;

### **2.15 CABLE SUPPORTS**

- A. Manufacturers: OZ/Gedney Type S; or equivalent by manufacturer listed in 2.1.F.

### **2.16 SLEEVES FOR RACEWAYS**

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends, with integral water stop.
- B. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052" or 0.138" thickness and of length to suit application.
- C. Integral Water Stop: Manufacturer: Thunderline Corporation;
  - 1. Steel. Type WS engineered sleeve.

### **2.17 SLEEVE SEALS**

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
  - 1. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
  - 2. Pressure Plates: Plastic. Include two for each sealing element.
  - 3. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

## **PART 3 - EXECUTION**



### 3.1 COORDINATION

- A. Coordinate with Owner's Representative size and location of required built-in openings in building structure, including those sleeved, formed or core drilled.
- B. Coordinate with Owner's Representative cutting, removing, or piercing general or mechanical insulation, fire-rated walls, ceilings or steelwork.
- C. Verify with Owner's Representative all surface raceway installations except in mechanical, electrical, and communications rooms.
- D. Coordinate with Owner's Representative exact locations of floor boxes, where shown on drawings, prior to rough-in.
- E. Coordinate routing of through-roof conduits.
- F. Coordinate sleeve selection and application with selection and application of firestopping specified in Section 26 0593 – Electrical Systems Firestopping.
- G. Verify that exterior wall or wet location boxes are gasketed type cast boxes with matching cover.
- H. Verify with manufacturer that "touch-up" paint kit and PVC-coating kit are available for use.

### 3.2 EXAMINATION

- A. Examine surfaces to receive raceways and boxes for compliance with installation tolerances and other conditions affecting performance of raceway's installation. Do not proceed with installation until unsatisfactory conditions have been corrected.

### 3.3 INSTALLATION – For additional information See Section 3.4 Application

- A. Raceways:
  - 1. Comply with ANSI/NECA 1 and NFPA 70 for installation requirements applicable to products specified in Part 2 except where requirements on drawings or in this Section are stricter.
  - 2. Arrange raceways to maintain headroom and present neat appearance.
  - 3. Raceway routing is shown in approximate locations, unless dimensioned. Route to complete raceway installation before starting conductor installation.
  - 4. Keep raceways at least 12" away from parallel runs of fuels, steam, hot-water pipes or ductwork. Install horizontal raceway runs above water and steam piping. Install raceways level and square and at proper elevations: 6'-6" minimum headroom, except in exit pathways 7'-0" minimum headroom. Do not block access to junction boxes, mechanical equipment or prevent removal of ceiling panels, etc.
  - 5. Run raceways concealed in construction to avoid adverse conditions such as heat and moisture, to permit drainage, and to avoid materials and equipment of other trades, except where noted otherwise.
  - 6. Avoid exposed raceway runs. Run raceways exposed where impractical or impossible to conceal or where specific approval is obtained. Run exposed raceways grouped and parallel or perpendicular to construction. Do not route exposed raceways over boilers or other high- temperature machinery or in contact with such equipment. Offset exposed raceways at boxes.
  - 7. Route raceways installed above accessible ceilings parallel or perpendicular to construction.

8. Do not install raceways in structural or topping floor slabs, except where noted on the plans. Install raceway in structural or topping floor slabs, where noted on plans, as follows:
  - a. Center raceways in structural slabs clear of reinforcing steel, except where crossing same, and spaced on centers equal or exceeding 3 times the raceway diameter. Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement. Space raceways laterally to prevent voids in concrete.
  - b. Outside diameter of raceway shall not exceed 12".
  - c. Obtain approval from Owner's Representative for each run of raceway 1" or larger.
  - d. Do not install raceways in topping slabs of 2" or less.
  - e. Locate raceways to avoid conflict with equipment, door bucks, partitions and other equipment bolted to floor.
  - f. Arrange stub-ups so curved portions of bends are not visible above finished slab. Install with an adjustable top or coupling threaded inside for plugs set flush with finished floor. Extend conductors to equipment with rigid steel conduit; use flexible metal conduit 6" above the floor. Install threaded plugs flush with floor for future equipment connections.
  - g. Change from nonmetallic raceway to RMC before rising above floor, with a minimum of 6" of RMC embedded in concrete.
9. Cut raceways square using saw or pipe cutter.
10. Use hydraulic one-shot raceway bender or factory elbows for bends in raceway larger than 2", unless sweep elbows required. Bend raceways according to manufacturer's recommendations. Factory fittings are only permitted for PVC and RMC only.
11. Use raceway fittings compatible with raceways and suitable for use and environment.
12. Provide bushings on all raceways.
13. Raceways minimum sizes:
  - a. Minimum raceway size 3/4", except as noted on drawings.
  - b. Minimum home run size: 3/4", except as noted on drawings.
  - c. Minimum size for flexible metal conduit is 1/2".
  - d. Minimum size for liquid tight flexible metal conduit is 1/2"
14. Install empty raceways 2-1/2" and larger with 2500# pull tape; install 200 lb nylon pull cord in raceways smaller than 2-1/2"; leave at least 12" of slack at each end of pull wire. Cap raceways at both ends.
15. Feed devices on same wall vertically from above or junction box in suspended ceiling.
  - a. Do not install horizontal bends in conduit around corners.
  - b. Feed devices in exterior or load-bearing walls by horizontal conduit runs.
16. Raceways Supports:
  - a. Independently support or attach raceway system to structural parts of construction. Suspended ceiling systems shall not be considered as structural parts of construction for raceway support. Do not attach raceways to piping system.
  - b. Raceway supports for horizontal or vertical single runs:
    - 1) Hot dipped galvanized heavy-duty sheet steel straps, mineralac clamps or steel slotted support channel system with appropriate components.

- 2) Spring steel type pressure clamps for raceways 3/4" and smaller.
  - c. Raceway supports for horizontal and vertical multiple runs:
    - 1) Trapeze-type supports fabricated with steel slotted channel systems with appropriate components.
    - 2) Support horizontal runs with appropriately sized rods.
    - 3) Anchor vertical runs to structure.
    - 4) Spring-steel type pressure clamps for raceways 3/4" and smaller.
  - d. Vertical raceway runs 1-1/4" and larger passing through floors: Support at each floor with pipe riser clamps.
  - e. Do not support raceways with wire, perforated pipe straps or plastic tie-wrap. Remove wires used for temporary support.
  - f. Secure raceways in metal stud walls to prevent rattling.
  - g. Arrange raceway supports to prevent misalignment during wiring installation.
  - h. Do not fasten raceways to corrugated metal roof deck.
  - i. For fasteners and supports, including steel slotted support systems, support devices, support spacing, support of conductors in vertical raceways, and hanger rod size, refer to Section 26 0529 – Hangers and Supports for Electrical Systems and NFPA 70.
17. Raceways Seismic Restraints:
    - a. Avoid raceway runs crossing building seismic joints. Use flexible connections where crossings cannot be avoided.
    - b. Install rigid bracing and lateral restraints for suspended raceway runs per requirements in Section 26 0548 – Vibration and Seismic Controls for Electrical Systems.
  18. Identify raceways per requirements in Section 26 05 53 – Electrical Systems Identification.
  19. Ground raceways per requirements in Section 26 05 26 – Grounding and Bonding for Electrical Systems.
  20. Flexible Conduit Connections: Use maximum of 72" of flexible conduit for recessed and semi- recessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for motors.
    - a. Use LFMC in damp or wet locations
  21. Install PVC-coated raceways in areas with corrosive atmosphere as noted on plans.
  22. Use tools approved for use with PVC coated conduits and fittings.
  23. Install stainless steel raceway clamps, mounting hardware, supports, hangers, etc., when located in "wet" or "wash-down" areas.
  24. Communications Raceways:
    - a. Minimum communications raceway size: 1", unless otherwise noted on drawings.
    - b. Install one raceway from each communications outlet box. Horizontal raceway runs between wall outlet boxes are not allowed.
    - c. Install insulated bushings on end of each raceway.
    - d. Use UL listed metallic grounding clamps, when terminating raceway on cable tray.
    - e. Install flush two-gang box with two-gang trim ring for each communications outlet or as noted on drawings.
    - f. Install with no more than 180-degrees of bends between pull or junction boxes or

- terminations at distribution frames or cabinets where necessary to comply with these requirements.
- g. Conduit bend radii (minimum) shall be:
    - 1) Six (6) times internal conduit diameter for conduit 2" or less internal diameter.
    - 2) Ten (10) times internal conduit diameter for conduit greater than 2" internal diameter.
  - h. Conduit bends shall be smooth, even, and free of kinks or other discontinuities that may have detrimental effects on pulling tension or cable integrity during or after installation.
  - i. Do not install 90-degree condulets. Install continuous radius sweeps of 45-degree minimum for 90-degree bends.
  - j. Do not install continuous sections longer than 100 ft.
  - k. Install nylon pull cord in empty raceways. Leave at least 12" of slack at each end of pull wire. Cap raceways at both ends.
25. Power and low-voltage raceways: Minimum 12" separation when run parallel, cross perpendicular.
- B. Boxes:
- 1. Install boxes to accommodate device indicated by symbol, in conformance with code requirements, number and size of conductors and splices and consistent with type of construction.
  - 2. Install the appropriate cover on surface-mounted boxes:
    - a. Raised device covers on 4" square and 4-11/16" boxes and handy box covers on handy boxes, etc.
    - b. Device covers that are square drawn or square cut on boxes in block.
    - c. Tile covers on boxes in tile.
    - d. Round drawn device covers on boxes in lath and plaster walls or dry wall only.
    - e. Set front edge of device boxes flush with finished wall surfaces except on walls of non-combustible materials where boxes may have maximum set back of 1/4". Secure flush-mounted box to interior wall and partition studs. Accurately position to allow for surface finish thickness.
  - 3. Set outlet boxes parallel to construction and independently attached to same.
  - 4. Do not install back-to-back and through-the-wall boxes. Install with minimum 6" horizontal separation between closest edges of the boxes. Install with minimum 24" separation in acoustic-rated walls and fire-rated walls.
  - 5. Install multi-ganged boxes where 2 or more devices are in same location, unless otherwise noted.
  - 6. Box Support:
    - a. Mount boxes straight.
    - b. Install horizontal bracing at top or bottom of box for 3 or more gang device boxes in stud walls.
    - c. Install stud support one side, with short piece of stud, for up to 2 gang device boxes.
    - d. Do not support boxes with tie-wire.
    - e. For one and two gang box support, manufactured bracket supports shall be accepted alternate.
    - f. Support boxes independently of raceways.

- g. Install adjustable steel channel fasteners for hung ceiling outlet box.
  - h. Install stamped steel bridges to fasten flush-mounted outlet box between studs.
  - i. Do not install boxes to ceiling support wires or piping systems.
7. Install partitions in multi-ganged boxes where different types of devices are installed, or devices installed operate at different voltages.
  8. Mount boxes in block walls at block joint nearest to indicated height.
  9. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.
  10. When boxes are installed in fire-resistive walls and partitions, provide 24" horizontal separation between boxes on opposite sides of a wall. In addition, limit penetrations to 16 sq in per penetration and not to exceed a total of 100 sq in per 100 sq ft of wall area. Apply fire stop putty pads acceptable to the fire marshal.
  11. Pull and junction boxes: Install as shown, or as necessary to facilitate pulling of wire and to limit number of bends within code requirements. Install above accessible ceilings and in unfinished areas.
  12. Install boxes to be permanently accessible.
  13. Do not intermix conductors from more than one system in same junction box or pull box, unless shown or specifically authorized otherwise.
  14. Adjust box location up to 10' prior to rough-in to accommodate intended purpose.
  15. Orient boxes to accommodate wiring devices oriented as specified in Section 26 2726 – Wiring Devices.
  16. Inaccessible Ceiling Areas: Install outlet and junction boxes no more than 6" from ceiling access panel or from removable recessed luminaire.
  17. The drawings do not necessarily show every outlet, pull or junction box required. Add all required boxes as necessary.
- C. Floor Boxes:
1. Set metal floor boxes level and flush with finished floor surface.
  2. Use cast floor boxes for installations in slab on grade.
  3. Install floor boxes and fittings to preserve fire-resistant rating of slabs and other elements, using materials and methods specified in Section 26 0593 – Electrical Systems Firestopping.
  4. Power and IT or AV conduits require a minimum 12" separation where routed parallel including entry into floor boxes.
- D. Expansion Fittings:
1. Install raceway expansion and deflection fittings in all raceway runs embedded in or penetrating concrete where movement perpendicular to axis of the raceway may be encountered.
  2. Install raceway expansion fittings complete with bonding jumpers in raceway runs that cross- expansion joints in structure and raceway runs mechanically attached to 2 separate structures.
  3. Use couplings and flexible connection made up of 24" length of flexible metal conduit, where EMT runs across expansion joints in ceiling spaces.
  4. Install fitting(s) that provide expansion and contraction for at least 0.0004" per ft of length of straight run per °F of temperature change.

5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation.
- E. Raceway Penetration Seals:
1. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.
  2. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint. Refer to Division 07 Section "Maintenance of Joint Protection" for materials and installation.
  3. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway penetrations. Install sleeves and seal with firestop materials. Comply with Section 26 0593 – Electrical Systems Firestopping.
  4. Roof-Penetration Sleeves: Seal penetration of individual raceways with flexible, boot-type flashing units applied in coordination with roofing work.
  5. Conduits may be directly cast into above grade concrete walls and slabs.
  6. Aboveground, Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1" annual clear space between pipe and sleeve for installing mechanical sleeve seals.
  7. Underground, Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1" annual clear space between raceway and sleeve for installing mechanical sleeve seals.
  8. Sleeve-Seal Installation: Use type and number of sealing elements recommended by manufacturer for raceway material and size. Position raceway in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
  9. Provide chrome- or nickel-plated escutcheons where raceways pass through walls, floors or ceilings and are exposed in finished areas. Size escutcheons to fit raceways for finished appearance. Finished areas shall not include mechanical/electrical rooms, janitor's closets, storage rooms, etc., unless suspended ceilings are specified.
  10. Remove temporary sleeves, if used for form wall openings, prior to installation of permanent materials.
- F. Raceway Sealing Fittings:
1. Install listed watertight seals to prevent the passage of moisture and water vapor through raceway, where raceway passes from interior to exterior of the building, where raceway passes between areas of different temperatures such as into or out of cold rooms or freezers, where raceway enters room which at any time is subject to low or high temperatures and where raceway enters a room which at any time is subject to internal air pressures above or below normal.
  2. Install watertight seals in interior of all raceways passing through building roof, ground floor slab (when the raceway does not extend beyond building footprint), or through outside walls of building above or below grade. Seal on the end inside building, using raceway sealing fittings manufactured for the purpose. Locate fittings

- at suitable accessible locations. For concealed raceways install each fitting in flush steel box with blank coverplate to matchfinish of adjacent plates or surfaces.
3. Seal raceways entering or passing through "hazardous (classified) areas" as defined in NFPA 70.
- G. Sleeve Installation for Electrical Penetrations:
1. Coordinate sleeve selection and application with selection and application of firestopping specified in Section 26 0593 – Electrical Systems Firestopping.
  2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
  3. Rectangular Sleeve Minimum Metal Thickness:
    - a. For sleeve cross-section rectangle perimeter less than 50" and no side greater than 16", thickness shall be 0.052".
    - b. For sleeve cross-section rectangle perimeter equal to, or greater than, 50" and 1 or more sides equal to, or greater than, 16", thickness shall be 0.138".
  4. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies, unless openings compatible with firestop system used are fabricated during construction of floor or wall.
  5. Cut sleeves to length for mounting flush with both surfaces of walls.
  6. Extend sleeves installed in floors 2" above finished floor level.
  7. Size pipe sleeves to provide 1/2" annular clear space between sleeve and raceway, unless sleeve seal is to be installed or unless seismic criteria require different clearance.

### 3.4 APPLICATION

- A. Raceway uses permitted and not permitted per NFPA 70 requirements, Cal Poly Standards, and as described below. Raceways and cables not listed in this section are not permitted for use on campus.
- B. RNC Raceways:
1. Above and below grade concrete encasements.
  2. Below grade native or sand encasements.
  3. In exposed corrosive areas (Schedule 80) with approval from the owner.
  4. Not exposed or concealed above grade.
- C. Rigid Metal Conduit (RMC) permitted to be installed as follows:
1. Installations below grade and in or under concrete slabs with corrosion protection tape
  2. All transitions for below grade to above grade with 6" minimum embedment.
  3. Pump HVAC and building equipment rooms.
  4. Concealed in concrete or block encasements
  5. Above grade in exposed locations
  6. All locations except corrosive atmospheres
  7. Hazardous locations
  8. Locations requiring mechanical protection
- D. Aluminum RMC
1. Food service areas.
  2. Other areas approved or indicated on the drawings.
- E. Electrical Metallic Tubing (EMT) permitted to be installed as follows:

1. Interior partitions
  2. Above suspended ceilings
  3. Exposed in telecom and electric rooms.
  4. In labs and warehouses where installed above 10' AFF.
  5. Not used in outdoor, wet or damp locations.
- F. Flexible Metal Conduit (FMC) permitted to be installed as follows:
1. Areas where a building finish will conceal this installation (wall, ceiling tile). Not exposed when building finishes are complete.
  2. In lengths not to exceed 20' between accessible junction or pull boxes.
  3. No flexible metal conduit length restriction when using "Manufactured Wiring Systems."
- G. Liquid Tight Flexible Metal Conduit (LFMC) permitted to be installed as follows:
1. Areas where will not be concealed by a building finish.
  2. Concrete encasements.
  3. Use liquid tight flexible conduit, 2 ft to 4 ft in length, for final connections to:
    - a. Vibrating equipment (including transformers and hydraulic, pneumatic, electric solenoid, or motor-driven equipment) in wet locations.
    - b. Instruments and control devices
    - c. Kitchen equipment
- H. Stainless Steel Conduit
1. Use exposed stainless-steel conduit as directed on drawings.
- I. One-half inch raceway permitted:
1. Between controller and its control or pilot device
  2. Between lighting switch and nearest outlet for luminaire
  3. Control wiring where mounted on equipment where conduit must follow contour of equipment
  4. Protective and signal systems where noted.
  5. Where shown on plans

### 3.5 RACEWAY WIRING METHODS

- A. Underground:
1. Install rigid steel conduit or RNC with appropriate corrosion protection.
  2. RNC – Schedule 40 PVC
  3. Install concrete or polycast boxes of appropriate size.
- B. In or Under Slab on Grade:
1. Install rigid steel conduit RMC with appropriate corrosion protection.
  2. Install RNC and transition to RMC with 6" of embedment for above slab.
  3. Cast metal floor boxes, plastic floor boxes with metal finish hardware to finish floor.
- C. Outdoor Locations, Above Grade:
1. Install rigid steel conduit RMC
  2. Install LFMC as required for equipment connections.
  3. Install cast metal or nonmetallic outlet, pull, and junction boxes. Install flush mounting outlet boxes in finished areas.



- D. Wet and Damp Locations:
  - 1. Install rigid steel conduit RMC
  - 2. Install cast metal or nonmetallic outlet, junction, and pull boxes. Install flush mounting outlet boxes in finished areas.
  - 3. Install LEMC as required for equipment connections
- E. Concealed Dry Locations:
  - 1. Install electrical metallic tubing; install sheet metal boxes; install flush mounting outlet boxes in finished areas; install hinged enclosure for large pull boxes (above 24X24).
  - 2. Install FMC where lengths between accessible pulling points does not exceed 20 feet.
- F. Exposed Dry Locations (Classrooms, Laboratories, Offices, Hallways, Kitchens, Dorm Rooms, Restrooms, Gyms, Stairwell, Utility Rooms, etc.):
  - 1. Make every effort to conceal electrical infrastructure.
  - 2. Use "Surface Raceway" 26 05 33.13 for areas where concealment is not possible.
  - 3. LFMC for equipment connections that are hardwired.
- G. Exposed Dry Locations (Workshops, Warehouses, Store Rooms, etc.):
  - 1. EMT at location 10" AFF.
  - 2. RMC at locations below 10' AFF.
  - 3. LFMC for equipment connections that are hardwired.
- H. Mechanical/ Electrical Rooms:
  - 1. RMC for mechanical rooms that have water piping in the same space.
  - 2. EMT for electrical rooms or mechanical rooms with no water piping.
  - 3. LFMC for equipment connections that are hardwired.
- I. Corrosive Environments:
  - 1. Refer to University for direction.
- J. Foodservice Areas:
  - 1. Refer to University for direction.
- K. Exposed Subject to Damage:
  - 1. Install rigid steel conduit.
- L. Hazardous Locations:
  - 1. Install rigid steel conduit; install cast metal boxes.

### 3.6 FIELD QUALITY CONTROL

- A. Inspect raceway, boxes, indoor service poles, and wireways for physical damage, proper alignment, supports and seismic restraints, where applicable.
- B. Replace any damaged component of the raceway system, or install new raceway system.
- C. Inspect components, wiring, connections and grounding.

### 3.7 REPAINTING

- A. Repair damage to galvanized finishes with manufacturer-supplied zinc-rich paint kit. Leave remaining paint with Owner's Representative.
- B. Repair damage to PVC or paint finishes with manufacturer-supplied touch-up coating. Leave remaining coating with Owner's Representative.
- C. Wireways, indoor service poles: Remove paint splatters and other marks from surface; touch-up chips, scratches, or marred finished to match original finish using manufacturer-supplied paint kit. Leave remaining paint with Owner's Representative.

### **3.8 ADJUSTING**

- A. Adjust flush-mounted boxes pre-pour and after-pour to be flush with finished materials.
- B. Install knockout closures in unused openings in boxes.
- C. Align adjacent wall-mounted outlet boxes for switches and similar devices.
- D. Adjust outlet boxes to allow luminaires to be positioned as indicated on reflected ceiling plan.

### **3.9 CLEANING**

- A. Clean interior and exterior of boxes, wireways, and indoor poles to remove dust, debris and other material.

**END OF SECTION 26 05 33**

## **SECTION 26 05 33.13 - SURFACE RACEWAY**

### **SYSTEM PART 1 - GENERAL**

#### **1.1 RELATED WORK**

- A. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables
- B. Section 26 05 26 – Grounding and Bonding for Electrical Systems
- C. Section 26 05 53 – Electrical Systems Identification
- D. Section 26 27 26 – Wiring Devices
- E. Section 27 05 53 – Communications Systems Identification
- F. Section 27 15 00 – Communications Horizontal Cabling

#### **1.2 REFERENCE**

- A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

#### **1.3 DESCRIPTION**

- A. Section includes surface metallic] raceway system for branch circuits, and low-voltage wiring.
- B. Surface raceway system shall consist of raceway bases, appropriate fittings, and device mounting plates necessary for a complete installation.
- C. The lengths of the raceways shown on drawings are illustrative and diagrammatic only and are not accurate. Raceways shall be provided completely installed to match lengths of cabinets and shelving as indicated on (laboratory) casework shop drawings. Receptacle circuits shall be pre-wired.

#### **1.4 REFERENCE STANDARDS**

- A. ANSI/NECA 1 – Standard Practices for Good Workmanship in Electrical Contracting
- B. NFPA 70 – National Electrical Code
- C. UL 5 - Surface Metal Raceways and Fittings
- D. UL 5A - Nonmetallic Surface Raceways and Fittings
- E. UL 94 – Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

#### **1.5 SUBMITTALS**

- A. Product Data: Catalog cuts of components.
- B. Shop Drawings:
  - 1. Complete layout, with locations of raceway components.
  - 2. Grounding, branch circuiting, and wiring including locations of service entrances.
  - 3. Receptacle types, manufacturers, and spacing.
  - 4. Receptacle labeling with proper voltage, phase, circuit and panelboard designations, as indicated on drawings.

5. Communication faceplate types, manufacturers and labeling.

C. Manufacturer's Installation Instructions:

1. Indicate application conditions and limitations of use. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

D. Closeout Submittals:

1. Project Record Documents

a. Record actual locations of surface raceways with receptacle types, locations and circuits identified.

2. Operation and Maintenance Data:

a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.

b. Include spare parts data listing, source, and current prices of replacement parts and supplies.

## 1.6 QUALITY ASSURANCE

A. Obtain surface raceways from one source and by single manufacturer.

B. Regulatory Requirements:

1. Comply with NFPA 70 for components and installation.

2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

## 1.7 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory unopened packaging until ready for installation.

B. Comply with manufacturer's written instructions.

## 1.8 WARRANTY

A. Refer to Division 01 and Section 26 00 00 – General Electrical Requirements for general warranty requirements.

B. Manufacturer shall provide standard 1-year written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

A. Metallic Raceways:

1. Hubbell
2. Legrand/Wiremold
3. Mono-Systems
4. Or equal

### 2.2 FABRICATION

- A. UL 5, UL 5A, as applicable
- B. Fabrication:
  - 1. Aluminum
  - 2. Suitable for use in dry interior locations only.
  - 3. Two-piece with base and snap-on cover
  - 4. Two or Three-compartment raceway with separate cover for each compartment.
  - 5. Size as indicated on plans Two compartments - same size as Wiremold 4000 Series.
  - 6. Covers with cutouts for device plates as shown on drawings.
  - 7. 6" and 12" long device plates with flange to overlap joint of adjacent cover.
- C. Prewired Raceways:
  - 1. Wiring devices factory installed, wired, and covers labeled with panel number and circuit number, voltage, phase, and amperes, as identified on drawings, per requirements in Sections 26 0519 – Low-Voltage Electrical Power Conductors and Cables and 26 2726 – Wiring Devices.
  - 2. Raceway sections with 12" pigtails at feed locations, in 2 ft minimum length and customized to match length shown on drawings.
  - 3. Equivalent distance between receptacles; number of receptacles per length of raceway as shown on drawings.
  - 4. Factory installed, NFPA 70 sized, grounding conductors, per requirements in Section 26 0526 – Grounding and Bonding for Electrical Systems.
  - 5. Raceway covers with hole-cut provisions for communication outlets.
  - 6. Wiring devices on top and communication outlets on bottom.
- D. Material:
  - 1. Aluminum Raceways: Alloy 6063-T5 extruded aluminum, minimum thickness 0.060"
  - 2. Fittings: Same material and metal thickness as linear raceway components.
  - 3. Add steel raceways to spec such as Wiremold Series 4000, 3000, 2000, 700, and 500.
- E. Finish:
  - 1. Aluminum Raceways:
    - a. Electrostatically painted, refer to Architectural specifications for color.
  - 2. Fittings: Color to match linear raceway components.
  - 3. Add steel raceway to spec such as Wiremold Series 4000, 3000, 2000, 700 and 500.
- F. Accessories:
  - 1. Fittings: Available as standard accessories, including external corner units, internal corner units, flat units, blank end units, internal and external elbows, coupling for joining raceway sections, and device mounting brackets and plates.
  - 2. Wire Clips: One for every 2 linear ft of indicated raceway configuration.
  - 3. Corner elbows and tee fittings, to maintain 2" cable bend radius that meets requirements for communications pathways and specifications for fiber optic, coaxial, and high-performance twisted-pair cabling.
  - 4. Device Mounting Brackets and Plates: Plastic device mounting brackets and trim plates allowing installation of indicated wiring devices, and communications outlets horizontally in raceways; trim cover sized to overlap device cut-out in raceway,

concealing seams; finished to match linear raceway components; plastic compatible with UL 94; brackets and plates, to match raceway width, and with device mounting holes.

- G. Communications Outlets and Accessories:
  - 1. Cabling Type: Per requirements in Section 27 1000 – Structured Cabling and Section 27 1500 – Communications Horizontal Cabling.
  - 2. Mounting faceplates and bezels: Faceplates configuration per requirements in Section 27 1000 Structured Cabling and Section 27 1500 – Communications Horizontal Cabling.

### **PART 3 - EXECUTION**

#### **3.1 COORDINATION**

- A. Coordinate cover plate openings with the wiring devices contained within.
- B. Coordinate cover plate openings with the communications outlets contained within, to provide for one opening for each communication symbol shown on drawings in Division 27. Coordinate device plate sizes (single-gang or two-gang) to accept communication faceplate types specified in Section 27 1000 – Structured Cabling and Section 27 1500 – Communications Horizontal Cabling.
- C. Verify with manufacturer that 'touch-up' paint kit is available for repainting.
- D. Coordinate surface raceways installation with (laboratory) casework shop drawings to match lengths of cabinets and shelving.
- E. Verify location of raceways with architectural interior elevation drawings.

#### **3.2 EXAMINATION**

- A. Do not begin installation until substrates have been properly prepared.
- B. If substrate preparation is the responsibility of another installer, notify Architect/Engineer of unsatisfactory preparation before proceeding.

#### **3.3 INSTALLATION**

- A. Install in accordance with ANSI/NECA 1 and manufacturer's instructions.
- B. Install flathead screws, clips and straps to fasten surface raceways to substrates, ensuring they are permanently and mechanically anchored. Double-sided adhesive is not acceptable. Mount plumb and level. Use suitable insulating bushings and inserts at connections to outlets and corner fittings.
- C. Install wiring devices and communications outlets of type, quantity and spacing as indicated on drawings.
- D. Mount raceways on wall and casework parallel to or at right angles to structure and casework.
- E. Feed raceways mounted on walls casework from a backbox through a wall box connector. Determine point of feed in field and complete wiring connections.
- F. Install a chase nipple extension between outlet box on wall and raceway when raceway

mounted to support channel for modular casework.

- G. Maintain ground continuity throughout entire raceway length per requirements in Section 26 0526 – Grounding and Bonding for Electrical Systems.
- H. Do not field cut prewired raceways.
- I. Install appropriate backbox extension rings where raceway is mounted to steel slotted channel or by some other method, stood off from wall.
- J. Raceway receptacle faceplates shall be labeled with adhesive labels with 1/4" high lettering, per requirements in Section 26 0553 – Electrical Systems Identification, indicating receptacle voltage, phase, and amperage (i.e., 120V, 1-phase, 20A) at top of receptacle, and panel and circuit designation (i.e., NLP-D2-2/12) at bottom of receptacle, in accordance with requirements in Section 26 0553 – Electrical Systems Identification, for 15A, 20A and 30A receptacles.
- K. Reinforce each cover section for every 30A receptacle in raceway with two 4-40 Phillips counter-sunk steel screws attached to enclosure near top and bottom of receptacle.
- L. Identify communication outlets per requirements in Section 27 0553 – Communications Systems Identification.
- M. Raceway base shall be secured using screws. Securing with double-sided adhesive is not acceptable.

### **3.4 FIELD QUALITY CONTROL**

- A. Inspect surface raceways for physical damage and proper alignment.
- B. Inspect components, wiring, connections, installation, and grounding.

### **3.5 REPAINTING**

- A. Remove paint splatters and other marks from surface of equipment.
- B. Touch-up chips, scratches, or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint with Owner Representative.

### **3.6 CLEANING**

- A. Vacuum dirt and construction debris from interior and exterior of equipment; do not use compressed air to assist in cleaning.

### **END OF SECTION 26 05 33.13**

## **SECTION 26 05 39 - UNDERFLOOR RACEWAYS FOR ELECTRICAL**

### **SYSTEMS PART 1 - GENERAL**

#### **1.1 RELATED WORK**

- A. Section 03 30 00 - Cast-In-Place Concrete
- B. Section 05 31 00 - Steel Decking
- C. Section 26 00 00 - General Electrical Requirements
- D. Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables
- E. Section 26 05 26 - Grounding and Bonding for Electrical Systems
- F. Section 26 05 33 - Raceway and Boxes for Electrical Systems
- G. Section 26 05 53 - Electrical Systems Identification
- H. Section 26 05 93 - Electrical Systems Firestopping
- I. Section 26 27 26 - Wiring Devices
- J. Section 27 05 53 - Communications Systems Identification
- K. Section 27 15 00 - Communications Horizontal Cabling

#### **1.2 REFERENCE**

- A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

#### **1.3 DESCRIPTION**

- A. Provide underfloor raceway systems including materials, accessories, and wiring, except cellular floor will be furnished and installed by others.
- B. Provide complete underfloor duct - Trench duct raceway system, including materials, accessories and wiring, in locations as indicated on drawings.
- C. Provide Trench duct in locations, widths, and barriered into power and communications compartments as indicated on drawings.
- D. Underfloor system shall provide underfloor distribution for electrical and communications services.

#### **1.4 REFERENCE STANDARDS**

- A. UL209 – UL Standard for Safety for Cellular Metal Floor Electrical Raceways and Fittings
- B. UL 884 - Underfloor Raceways and Fittings

#### **1.5 SUBMITTALS**

- A. Product Data: catalog cuts of components.
- B. Shop Drawings:
  - 1. Complete layout, with locations of raceway components.



2. Grounding, branch circuiting, and wiring including locations of service entrances.
  3. Receptacle types, manufacturers, and spacing.
  4. Receptacle labeling with proper voltage, phase, circuit and panelboard designations, as indicated on drawings.
- C. Communication faceplate types, manufacturers and labeling
- D. Manufacturer's Installation Instructions:
1. Indicate application conditions and limitations of use. Include instructions for storage, handling, protection, examination, preparation, installation, and start-up of product.
- E. Closeout Submittals:
1. Project Record Documents
    - a. Record actual locations of raceways with service types, locations and circuits identified.
  2. Operation and Maintenance Data:
    - a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
    - b. Include spare parts data listing, source, and current prices of replacement parts and supplies.

## **1.6 QUALITY ASSURANCE**

- A. Obtain surface raceways from one source and by single manufacturer.
- B. Regulatory Requirements:
1. Comply with NFPA 70 for components and installation.
  2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

## **1.7 DELIVERY, STORAGE, AND HANDLING**

- A. Store in clean, dry space. Maintain factory unopened packaging until ready for installation.
- B. Comply with manufacturer's written instructions.

## **1.8 WARRANTY**

- A. Refer to Division 01 and Section 26 00 00 – General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1-year written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

## **PART 2 - PRODUCTS**

## 2.1 MANUFACTURERS

- A. Trench Duct Raceway Systems for use in classroom applications
  - 1. Wiremold
  - 2. Square D
  - 3. Dennis Filges
  - 4. Mono-Systems, Inc.
  - 5. Or equal
- B. Cellular Metal Underfloor Raceway Systems
  - 1. H. H. Robertson
  - 2. Walker Systems, Inc. [CorDeck]
  - 3. Wiremold
  - 4. Or equal

## 2.2 TRENCH-DUCT UNDERFLOOR RACEWAY SYSTEM

- A. Trench: Steel and fabricated to sizes indicated.
  - 1. Provide barrier strips of matching height.
    - a. Triple compartment
  - 2. Completely accessible from top.
  - 3. Provide extruded rubber gasket integral to side rail system meeting UL mop-tight requirements.
  - 4. Provide access holes at each intersection between trench duct and each cell when used in a metal cellular floor application identified in section 2.5.
- B. Cover Plates:
  - 1. Removable steel plates 1/4" thick.
  - 2. Fabricate to receive floor finish material.
  - 3. Provide in 2 ft lengths.
  - 4. Secure by mechanical devices without fasteners protruding above finished floor surface.
  - 5. Provide extruded rubber gasket integral to side rail system meeting UL mop-tight requirements.
  - 6. Construct of steel and list for application.
- C. Trim Strip to accommodate floor finish material.
- D. Supports: Adjustable for height.
- E. Preset Inserts:
  - 1. Factory-installed,
    - a. Access openings: rectangular.
    - b. Gang as indicated on drawings.
  - 2. Spacing shall be as indicated on drawings.
- F. Accessories:
  - 1. Fittings: Standard accessories, including flat horizontal elbows, flat tees, vertical wall elbows, vertical transitions, reducers blank end units, cabinet couplers, duct couplers joining raceway sections, expansion couplings, duct offsets and device mounting brackets and plates.
  - 2. Elbows transitions and tee fittings, to maintain 2" cable bend radius that meets requirements for communications pathways and specifications for fiber optic, coaxial, and high-performance twisted-pair cabling.

### 2.3 CELLULAR METAL UNDERFLOOR RACEWAY SYSTEM

- A. System shall consist of Service Raceway, Trench Duct, Preset Inserts and Activation kits.
  - 1. Service Raceway shall consist of hollow spaces formed when a steel sheet, cold formed into a fluted panel, is joined by spot welding to a flat metal bottom sheet and is provided as factory assembled structural steel floor deck system. One Service Raceway shall be a cell that encloses a single space with a longitudinal axis parallel to that of the steel deck unit.
  - 2. Trench Duct shall be a transverse wire raceway that provides access to predetermined Service Raceways (cells) of a cellular metal floor system by the premises wiring system.
- B. Service Raceway formed by the cellular metal decking system shall be provided under Division 05
  - 1. Material and Fabrication: Steel, factory assembled:
    - a. Cells shall be contiguous and maintain complete isolation from adjacent cells.
  - 2. Provide factory punched holes into each cell wall, of size and arrangement required for preset insert location spacing required and Trench Duct or Junction Box locations.
- C. Trench Duct assembly shall consist of vertical elbows, risers, cabinet connectors, cover plates end enclosures, leveling supports and partitions required to connect with cellular Service Raceway integral to steel deck system.
  - 1. Three-compartment preassembled rectangular raceway with blank, flat-top, multichannel dividers and fitted to connect with Service Raceway at right angles to Trench Duct raceway.
    - a. Provide capability for Service Raceways to be run in both directions from intersection with Trench Duct raceway.
    - b. Provide means of stabilizing conductor bending radius to 2" minimum where cable transitions from Trench Duct to Service Raceway.
    - c. Conform to requirements identified in section 2.4 Trench Duct Underfloor Raceway System.
- D. Junction Box:
  - 1. Three-compartment junction box connecting conduit raceway systems, Trench Duct, or other rectangular cross section raceways with cellular floor Service Raceways.
    - a. Locate as indicated on drawings.
    - b. Provide 22" diameter removable cover.
    - c. Use raceway areas of same or greater cross section area as Service Raceways.
    - d. Provide capability allowing service raceways to be run in both directions from junction box location.
    - e. Provide with adjustment and leveling screws.
- E. Preset Inserts: Rectangular-shaped metal housing assemblies arranged to provide electrical system outlet access to each cell designated for service raceway use. Inserts provided throughout the entire length of each such raceway.
  - 1. List for application.
  - 2. Spacing as indicated on drawings.
  - 3. Housing and connecting provisions:
    - a. recessed
    - b. Triple-system service fitting.

4. Include mounting and connecting provisions for surface, single- or multiple-system service fitting.
  5. Include connecting provisions for wiring-extension service fitting to feed wall outlets.
  6. Each insert shall be equipped with a disposable cover plate arranged for installation with top 1/8" below surface of concrete. Arrange insert to receive flush-, recessed-, or wiring-extension service fitting to replace disposable top.
- F. After-Set Inserts: Assemblies to tap raceways and floor cells through holes core-drilled in floor shall not be utilized for new construction.
- G. Service Fittings and Activations:
1. Provide activations as indicated on plans.
    - a. Recessed with flange
    - b. Recessed without flange
    - c. Flush partition with flange
    - d. Recessed partition without flange
  2. Activation kits shall provide triple service access and shall be UL Listed and Classified.
  3. Activation kits shall allow 2 separate receptacle boxes and faceplates to accommodate duplex receptacles and communication device mounting brackets.
  4. Activation to include metal covers.
    - a. Supporting wire egress shall be provided with center located, gasketed opening.
    - b. Flangeless for under carpet and tile applications.
    - c. Include flange for mounting to floor.
    - d. Blank or provide area for flooring insert.
    - e. Cover for feeding furniture partition shall be provided two 1" factory punched holes.
    - f. Provide an adjustment range spanning 3/4".
  5. Floor Mounted
    - a. Modular type with brushed-aluminum finish
  6. Recessed:
    - a. Modular fittings that include covers, provisions for receptacles and outlets, and associated device plates for indicated services
    - b. Flush handhole covers with brushed-aluminum trim, recessed to suit floor finish material

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

- A. Metal raceway shall be electrically continuous and bonded for proper grounding.
- B. Raceway Support: Support at intervals not exceeding 5 ft or in accordance with manufacturer's installation sheets.
- C. Accessories: Provide accessories as required for complete installation, including insulated bushings and inserts where required by manufacturer.
- D. Unused Openings: Close unused raceway openings using manufacturers recommended accessories.
- E. Coordinate architectural and electrical drawings for dimensions prior to installation. If conflicts exist between drawings, consult the Owner's Representative
- F. Install distribution raceway system and accessories in accordance with manufacturer's

installation instructions, and as specified.

- G. Align installations parallel to, or at right angles with building walls and level to finished floor.
- H. Trench Duct: Coordinate duct support heights with floor depth and concrete topping depth. Minimum topping depth shall be 1" unless otherwise noted.
- I. Cellular metal floor systems: Coordinate cellular metal floor systems construction and installation with structural.
- J. Cellular metal floor systems: Inspect cellular raceway steel deck and verify units are level and are placed in straight lines through the entire length of the cells. Provide metal cover over abutting joints between steel deck units exceeding 1/2". Repair all sharp edges, burrs, or protrusions or replace steel deck unit.
- K. Cellular metal floor systems: Apply self-adhesive tape to abutting end joints at cellular floor units immediately after they have been secured in place. Seal ends of cellular metal unit to prevent ingress of dirt water or concrete. Seal raceways, cells, and inserts to prevent water, concrete, or foreign matter from entering raceways before and during pouring slab or placing fill
- L. Cellular metal floor system: Provide bonding lug on steel deck and bond to Header Duct sections with #4 bare copper ground wire between. Bond all steel decks with active cells to premises grounding system
- M. Underfloor duct and header duct shall be set in place, leveled, and adequately supported before concrete pour.
- N. Marker screw caps shall be used at locations including: adjacent to junction boxes, on each side of permanent walls, at each end run of duct, and on both sides of change of direction of duct.
- O. After concrete has hardened, trench duct shall be swabbed out and dried where moisture occurs.
- P. Openings shall be covered during construction.
- Q. Vacuum duct free of dirt, mortar, concrete, and other debris.
- R. Cap or plug boxes, openings, and open raceway ends.
- S. Open Trench Duct to each usable cellular floor cell
  - 1. Openings shall be 3" diameter with polyethylene grommet.
- T. Open Header Ducts to underfloor ducts.
  - 1. Openings shall have polyethylene grommet.
- U. Inserts shall be factory capped.
- V. Each run shall be marked at each end with marking screws.

### **3.2 CLEANING AND PROTECTION**

- A. Clean exposed surfaces using non-abrasive materials and methods recommended by manufacturer.
- B. Protect raceways and boxes until acceptance.

### **END OF SECTION 26 05 39**

## **SECTION 26 05 43 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL**

### **SYSTEMS PART 1 - GENERAL**

#### **1.1 RELATED WORK**

- A. Section 03 30 00 - Cast-In-Place Concrete
- B. Section 26 05 26 - Grounding and Bonding for Electrical Systems
- C. Section 26 05 33 - Raceway and Boxes for Electrical Systems
- D. Section 26 05 43.13 - Excavation and Backfill
- E. Section 26 05 43.19 - Manholes and Hardware
- F. Section 26 05 53 - Electrical Systems Identification

#### **1.2 REFERENCE**

- A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

#### **1.3 DESCRIPTION**

- A. Section includes conduits, ducts, and duct accessories for concrete encased for underground distribution for electrical power and communications.
- B. The terms duct and duct bank, as used in this Section, are defined as follows:
  - 1. Duct: A single underground conduit, encased in concrete or direct buried.
  - 2. Duct Bank: Two or more ducts run together.

#### **1.4 REFERENCE STANDARDS**

- A. ANSI C2 – National Electrical Safety Code
- B. ANSI C80.1 – Rigid Steel Conduit-Zinc Coated (GRC)
- C. ASTM F512 – Specification for Smooth-Wall Poly (Vinyl Chloride) (PVC) Conduits and Fittings for Underground Installation
- D. ETL PVC-001 – PVC Coated Conduit
- E. NEMA RN 1 – Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
- F. NEMA TC2 – Electrical Polyvinylchloride (PVC) Conduit
- G. NEMA TC3 – PVC Fittings for Use with Rigid PVC Conduit and Tubing
- H. NEMA TC6&8 – PVC Plastic Utilities Duct for Underground Installation
- I. NEMA TC9 – Fittings for PVC Plastic Utility Duct for Underground Installation
- J. NFPA 70 – National Electrical Code
- K. UL 651 – Schedule 40 and 80 Rigid PVC Conduit
- L. UL 651A – Type EB and A Rigid PVC Conduit and HDPE Conduit
- M. UL E53373 – Underground Fiber Reinforced Epoxy Conduit (FRE)

N. ULG – Electrical Rigid Metallic Conduit-Steel

**1.5 SUBMITTALS**

- A. Product data for the following:
  - 1. Duct bank materials, including spacers and miscellaneous components
  - 2. Ducts and conduits and their accessories, including elbows, end bells, bushings, seals, bends, fittings, plugs, pull tape, and solvent cement
  - 3. Warning tape
  - 4. Warning plank
- B. Manufacturer's Installation Instructions:
  - 1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- C. Closeout Submittals:
  - 1. Project Record Documents:
    - a. Record actual routing of conduits and duct banks.
  - 2. Operation and Maintenance Data:
    - a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
    - b. Include spare parts data listing, source, and current prices of replacement parts and supplies.

**1.6 QUALITY ASSURANCE**

- A. Regulatory Requirements:
  - 1. Comply with NFPA 70
  - 2. Comply with ANSI C2
  - 3. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.
- B. Certification:
  - 1. Installer of PVC coated conduits and fitting shall be certified by a PVC conduit manufacturer.

**1.7 DELIVERY, STORAGE, AND HANDLING**

- A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris, and traffic.
- B. Deliver ducts to project site with end capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.

**1.8 WARRANTY**

- A. Refer to Division 01 and Section 26 00 00 – General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1-year written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall

begin on date of substantial completion.

## **PART 2 - PRODUCTS**

### **2.1 CONDUITS**

- A. Rigid Steel Conduit (RSC): ANSI C80.1, UL 6, heavy wall, hot dipped, galvanized steel with ETL PVC-001 certified PVC coating.
- B. Rigid Nonmetallic Conduit (RNC): NEMA TC 2 Type EPC-40-PVC, UL 651, with matching fittings by same manufacturer, complying with NEMA TC 3 and UL 651, listed for underground use, concrete encased.
- C. Size:
  - 1. As indicated on drawings

### **2.2 DUCT ACCESSORIES**

- A. Duct Spacers:
  - 1. Rigid PVC interlocking spacers.
  - 2. Factory-fabricated, sized for type and sizes of ducts with which used, and selected to provide minimum duct spacings indicated while supporting ducts during concreting or backfilling. Horizontal and vertical locking separation of 3" between ducts.
- B. Elbows: Material to match conduit; minimum bend radius of 60".
- C. Bell Ends: Manufactured bell ends of appropriate sizes at each end of conduit; pre-manufactured system for PVC with conduit seals, provisions for roughing into the concrete pour and waste stops, when entering a new building or a new manhole.
- D. Bushings: Groundable steel bushings of appropriate sizes on all metal conduits where bell ends are not used; pre-manufactured system for PVC with conduit seals, provisions for roughing into concrete pour and water stops, when entering a new or existing building or a new or existing manhole.
- E. Seals: Mechanical interlocking assembly seal of modular synthetic rubber links properly sized to fit the pipe and tightened in place, in accordance with manufacturer's instructions, when entering an existing building or manhole below grade and concrete shall be core drilled for the appropriate size conduit and seal.
- F. Plugs: Closure plugs or caps of same material as conduit at ends of unused sections.
- G. Pull Tape: Nylon pull tape with measurement markings in uniform lengths in each empty duct.
- H. Grounding:
  - 1. Steel grounding bushings, where bell ends are not used.
  - 2. Bonding fitting with bonding strap on steel conduit with end bells.
- I. Warning Tape: Underground line warning tape specified in Section 26 0553 - Electrical Systems Identification.
- J. Concrete Warning Plank: Nominal 12" x 24" x 3" in size, manufactured from 6000 psi concrete.
  - 1. Color: Red dye for electrical duct bank and orange dye for communications duct bank added to concrete during batching.
  - 2. Label: 2" high, 3/8" deep letters with word "ELECTRIC" or "COMMUNICATIONS"



marked on plank.

- K. Solvent Cement: Recommended by conduit manufacturer.

### **PART 3 - EXECUTION**

#### **3.1 COORDINATION**

- A. Coordinate layout and installation of ducts with final arrangement of other utilities, site grading, and surface features as determined in the field.
- B. Coordinate elevations of ducts and duct bank entrances into manholes, pad-mounted switchgear, pad-mounted transformer, and generator with final locations and profiles of ducts and duct banks as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations from those indicated as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by Owner's Representative. For manholes and handholes construction, refer to Section 26 0543.19 – Manholes and Hardware.
- C. Adjust the depth of electrical utilities to avoid existing utilities with no change to contract price.
- D. Utility Coordination: When duct lines are being constructed for use by a utility serving the project, consult with them for duct size and quantity, minimum bending radii, maximum distance between pulling points, grounding details, termination arrangement, and other criteria.
- E. Duct Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.
  - 1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
  - 2. Drawings shall be signed and sealed by a qualified professional engineer.

#### **3.2 EXISTING UTILITIES**

- A. The existing utilities shown on contract drawings have been plotted from available records. No guarantee is made as to accuracy of locations indicated, and is shown for the benefit of Contractor.
- B. Contact all serving utility companies and have them locate their lines prior to commencing work. Telephone "Call Before You Dig" at 1-800-424-5555, 48 hours prior to commencing work. Coordinate with Owner's Representative all existing utility lines prior to commencing work.
- C. Protect shown, visible and located utilities from damage. Promptly repair all active shown, visible and located utilities damaged by construction. This repair shall be made solely at the expense of the Contractor.
- D. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies to shut off services if lines are active.

#### **3.3 PROJECT CONDITIONS**

- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
  - 1. Notify Owner's Representative no fewer than 10 days in advance of proposed interruption of electrical service.
  - 2. Do not proceed with interruption of electrical service without Owner's Representative's written permission.

### **3.4 DUCT INSTALLATION**

- A. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes to drain in both directions.
- B. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends, both horizontally and vertically, at other locations, unless otherwise indicated. All 90-degree sweeps with radius 10 ft or less shall be rigid steel conduit.
- C. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane. Do not use conduit that requires the use of couplings for straight runs. Use acceptable PVC terminal adapters when joining PVC conduit to metallic fittings or rigid metal conduit.
- D. Duct Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10" o.c. for 5" ducts, and vary proportionately for other duct sizes.
  - 1. Begin change from regular spacing to end-bell spacing 10 ft from the end bell without reducing duct line slope and without forming a trap in the line.
  - 2. Direct Buried Duct Banks: Install an expansion and deflection fitting in each conduit in area of disturbed earth adjacent to manhole or handhole.
  - 3. Concrete Enclosed Duct Banks: Install watertight expansion fitting in each conduit, with internal bonding jumper to allow for 3/4" movement in any direction.
  - 4. Grout end bells into structure walls from both sides to provide watertight entrances.
  - 5. Fill annular space between walls and sleeves with cement mortar.
- E. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least 5 ft outside the building wall without reducing duct line slope away from the building, and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition. Install conduit penetrations of building walls as specified in Section 26 0533 - Raceway and Boxes for Electrical Systems.
- F. Expansion Fittings: Provide suitable expansion fittings or other suitable means to compensate for expansion and contraction for raceways crossing expansion joints in structures or concrete slabs between two adjacent structures and between a duct bank and structure. Provide for the high rate of thermal expansion and contraction of PVC conduit by providing PVC expansion joints as recommended by manufacturer and as required. Refer to structural drawings for location of expansion joints in structures.

- G. Sealing: Provide temporary closure at termination of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand minimum of 15 psig hydrostatic pressure. Provide watertight entrance sealing device where an underground conduit enters a structure through a concrete roof or membrane waterproofed wall or floor.
- H. Fire Stops: Provide fire stop openings around electrical penetrations to maintain fire-resistance rating, where underground raceways penetrate fire-rated walls or floors.
- I. Pulling Cord: Install 2500# pull tape in all ducts including spares. Identify with tags at each end and at any intermediate pull point the origin and destination of each spare duct. Where a duct has been identified with a name and numbers in the Raceway identification table, use that name on the tag in lieu of origin and destination. Provide a removable permanent cap over each end of each spare duct.
- J. Concrete Encased Ducts: Support ducts on duct spacers.
  - 1. Spacer Installation:
    - a. Provide spacers close enough to prevent sagging and deforming of ducts, with not less than 5 spacers per 20 ft of duct. Secure spacers to earth and to ducts to prevent floating during concreting. Stagger spacers approximately 6" between tiers. Tie entire assembly together using tie wires and reinforcing steel. Install base and intermediate spacers at every coupling point of each duct line for a separation horizontally and vertically per NEC.
  - 2. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
    - a. Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written recommendations, or use other specific measures to prevent expansion-contraction damage.
    - b. Terminate each pour in a vertical plane if more than one pour is necessary, and install 3/4" reinforcing rod dowels extending 18" into concrete on both sides of joint near corners of envelope. Obtain Owner's Representative's approval for the number and location of dowels.
  - 3. Pouring Concrete: Space concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct bank application.
  - 4. Reinforcement: Reinforce concrete-encased duct banks where they cross disturbed earth and where indicated. Arrange reinforcing bars and ties without forming conductive or magnetic loops around ducts or duct groups. Size reinforcing bars and wire ties as indicated on drawings. Provide rebars with minimum of 2" of concrete on sides, top and bottom. Reinforcing bars shown in sections are required throughout.

5. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms of materials and in a manner acceptable to Owner's Representative.
  6. Minimum Space between Ducts: 3" between ducts and exterior envelope wall, 2" between ducts for like services, and 4" between power and signal ducts.
  7. Depth: Install top of duct bank at least 24" below finished grade in areas not subject to deliberate traffic, and at least 30" below finished grade in deliberate traffic paths for vehicles, unless otherwise indicated.
  8. Maintain a grade of at least 4" per 100 ft, either from one manhole or pull box to the next, or from a high point between them, depending on surface contour.
  9. Warning Tape: Bury warning tape approximately 12" above all concrete-encased ducts and duct banks. Align tape parallel to and within 3" of the centerline of duct bank. Provide an additional warning tape for each 12" increment of duct bank width over a nominal 18". Space additional tapes 12" apart, horizontally.
  10. Place duct banks on an undisturbed soil base if possible. Where concrete encased duct bank is installed over an extensive area of disturbed earth such that within the periphery of a building, provide a separate concrete base under the duct bank to ensure stability of raceways during installation. Allow this base to set before duct bank is installed.
  11. Provide bare 4/0 ground conductor in concrete duct bank.
- K. Stub-Ups:
1. Use manufactured PVC duct elbows for stub-ups at poles and equipment and at building entrances through floor, unless otherwise indicated. Extend concrete encasement throughout length of the elbow. Concrete encasement applies to concreted encased ducts.
  2. Use manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.
    - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase couplings with 3" of concrete. Concrete encasement applies to concrete encased ducts.
    - b. Stub-Ups to Equipment: For equipment mounted on outdoor concrete pads, extend steel conduit horizontally a minimum of 5 ft from edge of equipment pad or foundation. Encase in concrete for concrete encased ducts. Install insulated grounding bushings on terminations at equipment.
- L. Arrangement and Routing:
1. Arrange multiple duct runs substantially in accordance with details shown on drawings. Locate underground ducts where indicated on drawings and grade to the elevations shown on civil drawings.
  2. Make minor changes in location or cross-section as necessary to avoid obstructions or conflicts. Where duct runs cannot be installed substantially as shown because of conditions not discoverable prior to digging of trenches, refer the condition to the Owner's Representative for written instructions before further work is done.

3. Maintain a 12" minimum vertical separation between ducts and other systems at crossings where other utility piping systems are encountered or being installed along a raceway route. Maintain a 12" minimum separation between ducts and other systems in parallel runs. Do not place ducts over valves or couplings in other piping systems. Refer conflicts with these requirements to the Owner's Representative for written instructions before further work is done.
  4. Provide markers at grade to indicate direction of underground conduits provided under this contract. Provide markers consisting of double-ended arrows, straight for straight runs and bent at locations where runs change direction. Provide markers at all bends and at intervals not exceeding 100 ft in straight runs. Use markers made of sheet bronze not less than 1/4" thick embedded in and secured to the top of concrete posts. User markers not less than 10" long and 3/4" wide and marked ELECTRIC CABLES in letters 1/4" high incised into the bronze to a depth of 3/32".
  5. Enter manholes and structures with ducts at right angles.
- M. PVC Coated Conduits: Use tools approved for use with PVC coated conduits and fittings.

### **3.5 UNDERGROUND DUCT APPLICATION**

- A. Ducts for Electrical Cables Over 600V: RNC, FRE – Standard Wall, in concrete encased duct bank, unless otherwise indicated.
- B. Ducts for Electrical Feeders 600V and Less: RNC, NEMA Type EPC-40-PVC, in concrete encased duct bank, unless otherwise indicated.
- C. Ducts for Electrical Branch Circuits: RNC, NEMA Type EPC-80-PVC, in direct buried duct bank, unless otherwise indicated.
- D. Underground Ducts for Telephone, Communications, or Data Utility Service Cables: RNC, NEMA Type EPC-40-PVC, in concrete encased duct bank, unless otherwise indicated.

### **3.6 EARTHWORK**

- A. Excavation and Backfill: Comply with Section 26 0543.13 - Excavation and Backfill, do not use heavy-duty, hydraulic-operated compaction equipment.

### **3.7 CONCRETE**

- A. Concrete: 3000 psi, 28-day strength, complying with Division 03 – Concrete, where concrete encased.
- B. Coordinate color based on system. Medium and High Voltage Duct Banks are to be encased in Red Concrete only.
- C. Communication conduits to be encased in gray concrete.

### **3.8 GROUNDING**

- A. Ground underground ducts according to Section 26 0526 - Grounding and Bonding for Electrical Systems.

### **3.9 FIELD QUALITY CONTROL**

- A. Perform the following tests and inspections:
  - 1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts.
  - 2. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80% fill of duct. If obstructions are indicated, remove obstructions and retest.
- B. Preparation for pulling in conductors:
  - 1. Do not install crushed or deformed raceways. Avoid traps in raceways where possible. Take care to prevent the lodging of plaster, concrete, dirt, or trash in raceways, boxes, fittings, and equipment during the course of construction. Make raceways entirely free of obstructions or replace them. Ream all raceways, remove burrs, and clean raceway interior before introducing conductors or pull wires.
  - 2. Immediately after installation, plug or cap all raceway ends with watertight and dust-tight seals until the time for pulling in conductors.
- C. Do not backfill underground direct buried and concrete encased ducts until the Owner's Representative has inspected them. Notify Owner's Representative 24 h in advance of duct concrete pour, or backfill of direct buried ducts.

### **3.10 CLEANING**

- A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

**END OF SECTION 26 05 43**

Note: Requires project specific editing at Brackets [ ]

## **SECTION 26 05 48 - VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS**

### **PART 1 - GENERAL**

#### **1.1 RELATED WORK**

- A. Section 26 05 29 – Hangers and Supports for Electrical Systems
- B. Section 26 05 33 – Raceway and Boxes for Electrical Systems
- C. Section 26 12 19 – Pad-Mounted, Liquid-Filled, Medium-Voltage Transformers
- D. Section 26 22 00 – Low-Voltage Transformers
- E. Section 26 23 00 – Low-Voltage Switchgear
- F. Section 26 24 13 – Switchboards
- G. Section 26 24 16.13 – Lighting and Appliance Panelboards
- H. Section 26 24 16.16 – Distribution Panelboards
- I. Section 26 28 16 – Enclosed Switches and Circuit Breakers
- J. Section 26 29 13 – Enclosed Controllers
- K. Section 26 32 13 – Engine Generators
- L. Section 26 36 23 – Automatic Transfer Switches
- M. Section 26 51 00 – Interior Lighting

#### **1.2 REFERENCE**

- A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions and sections under Division 01 General Requirements.

#### **1.3 DESCRIPTION**

- A. Section includes requirements for seismic restraints, vibration control and anchorage to building structure of electrical systems, including equipment specified in paragraph "Related Work", raceways, cable trays, and lighting fixtures:
  - 1. Seismic restraints, vibration control and anchorage to building structure shall meet ratings applicable to seismic Design Category.
- B. Obtain services of Engineer registered and licensed in the State of California to design seismic restraints, vibration control and methods of anchorage of electrical systems to building structure.
- C. Seismic anchorage and restraints shall be designed and installed in accordance with codes and standards as enforced by Authorities Having Jurisdiction in the State of California. Authorities shall include Owner's insurance company.

#### **1.4 REFERENCE STANDARDS**

- A. ASTM A 492 – Specification for Stainless Steel Rope Wire

- B. ASTM A 603 – Specification for Zinc-Coated Steel Structural Wire Rope
- C. ASTM E 488 – Specification for Test Methods for Strength of Anchors in Concrete and Masonry Elements
- D. AWS D1.1/D1.1M – Structural Welding Code – Steel
- E. IBC – International Building Code
- F. ICC-ES – International Code Council Evaluation Service
- G. MFMA-3 – Metal Framing Standards Publication
- H. NFPA 70 – National Electrical Code
- I. NFPA 5000 – Building Construction and Safety Code
- J. SEI/ASCE 7-05 – Structural Engineering Institute/American Society of Civil Engineers - Minimum Design Loads for Buildings and Other Structures

### 1.5 PERFORMANCE REQUIREMENTS

- A. Governing Codes:
  - 1. 2006 IBC, Section 1613, which references and modifies SEI/ASCE 7-05, Chapter 13
  - 2. Currently adopted version of the California Building Code (CBC)
- B. In Sections for equipment and components in structures with an Importance Factor greater than 1.0 in IBC Seismic Design Category C, D, E, or F, a “Manufacturer Seismic Qualification Certification” is required in Part 1 “Submittals” Article that certifies that equipment will withstand seismic forces derived from criteria specified in this Section, and that equipment will remain internally intact to be operable with little or no delay.
- C. In Sections for equipment and components other than those noted above, a “Manufacturer Seismic Qualification Certification” is required in Part 1 “Submittals” Article that certifies that equipment will remain physically intact when subjected to seismic forces derived from criteria specified in this Section.
- D. Seismic-Restraint Loading:
  - 1. Building Seismic Design Category as defined in the UBC: [A] [B] [C] [D] [E] [F]
  - 2. Site Class as Defined in the IBC: [A] [B] [C] [D] [E] [F]
  - 3. Assigned Occupancy Category as Defined in the IBC: [I] [II] [III] [IV]
  - 4. Component Importance Factor: [1.0] [1.5] [ ]
    - a. Non-hazardous and non-life safety systems shall have component importance factor ( $I_p$ ) of 1.0.
    - b. Life safety systems shall have component importance factor ( $I_p$ ) of 1.5, and following system shall be classified as life safety systems:
      - 1) Emergency systems per NEC Article 700.
      - 2) Life safety branch of emergency systems per NEC Article 517.
  - 5. Component Response Modification Factor: [1.5] [2.5] [3.5] [5.0] [ ]
  - 6. Component Amplification Factor: [1.0] [2.5] [ ]
  - 7. Design Spectral Response Acceleration at Short Periods (0.2 Second): [ ]%
  - 8. Design Spectral Response Acceleration at 1.0-Second Period: [ ]%
- E. Lateral bracing forces shall be determined using equations listed in SEI/ASCE, Chapter 13.



## 1.6 SUBMITTALS

- A. Product Data: For the following:
  - 1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
  - 2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used:
    - a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to Authorities Having Jurisdiction.
    - b. Annotate to indicate application of each product submitted and compliance with requirements.
  - 3. Restrained-Isolation Devices: Include ratings for horizontal, vertical, and combined loads.
- B. Shop Drawings:
  - 1. Submit vibration isolation and seismic-restraint details:
    - a. Indicate fabrication and arrangement.
    - b. Detail attachments of restraints to the restrained items and to the structure.
    - c. Show attachment locations, methods, and spacings.
    - d. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events.
    - e. Indicate association with vibration isolation devices.
  - 2. Submit design calculations. Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators and seismic restraints:
  - 3. Coordinate design calculations with wind-load calculations required for equipment mounted outdoors. Comply with requirements in other Division 26 Sections for equipment mounted outdoors.
  - 4. Submit design analysis to support selection and arrangement of vibration isolation and seismic restraints. Include calculations of combined tensile and shear loads.
  - 5. Submit welding certificate.
  - 6. Submit field quality control test reports.
  - 7. Shop drawings, including calculations, shall be signed and sealed by a Structural Engineer registered and licensed in the State of California.
- C. Submit manufacturer Seismic Qualification Certification of Compliance for review by Authority Having Jurisdiction, per SEI/ASCE.
- D. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.

## 1.7 QUALITY ASSURANCE

- A. Comply with seismic-restraint requirements in IBC unless requirements in this Section are more stringent.
- B. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M.

- C. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to Authorities Having Jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred.
- D. Comply with NFPA 70.

## **PART 2 - PRODUCTS**

### **2.1 VIBRATION ISOLATORS**

- A. Manufacturers:
  - 1. Ace Mountings Co., Inc.
  - 2. Amber/Booth Company, Inc.
  - 3. California Dynamics Corporation
  - 4. Isolation Technology, Inc.
  - 5. Kinetics Noise Control
  - 6. Mason Industries
  - 7. Vibration Eliminator Co., Inc.
  - 8. Vibration Isolation
  - 9. Vibration Mountings & Controls, Inc.
- B. Pads: Arrange in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment:
  - 1. Resilient Material: Oil- and water-resistant [neoprene] [rubber] [hermetically sealed compressed fiberglass].
- C. Spring Isolators: Freestanding, laterally stable, open-spring isolators.
  - 1. Outside Spring Diameter: Not less than 80% of the compressed height of the spring at rated load.
  - 2. Minimum Additional Travel: 50% of the required deflection at rated load.
  - 3. Lateral Stiffness: More than 80% of rated vertical stiffness.
  - 4. Overload Capacity: Support 200% of rated load, fully compressed, without deformation or failure.
  - 5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4" thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.
  - 6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
- D. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.
  - 1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4" thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable

- equipment mounting and leveling bolt that acts as blocking during installation.
2. Restraint: Seismic or limit-stop as required for equipment and Authorities Having Jurisdiction.
  3. Outside Spring Diameter: Not less than 80% of the compressed height of the spring at rated load.
  4. Minimum Additional Travel: 50% of the required deflection at rated load.
  5. Lateral Stiffness: More than 80% of rated vertical stiffness.
  6. Overload Capacity: Support 200% of rated load, fully compressed, without deformation or failure.

## 2.2 SEISMIC-RESTRAINT DEVICES

- A. Manufacturers:
  1. Amber/Booth Company, Inc.
  2. California Dynamics Corporation
  3. Cooper B-Line, Inc.; a division of Cooper Industries
  4. Hilti Inc.
  5. Loos & Co.; Seismic Earthquake Division
  6. Mason Industries
  7. TOLCO Incorporated; a brand of NIBCO INC.
  8. Unistrut; Tyco International, Ltd.
- B. General Requirements for Restraint Components: Rated strengths, features, and application requirements shall be as defined in reports by an agency acceptable to Authorities Having Jurisdiction.
  1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least **[4] [XXX]** times the maximum seismic forces to which they will be subjected.
- C. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.
- D. Restraint Cables: **[ASTM A 603 galvanized] [ASTM A 492 stainless]**-steel cables with end connections made of steel assemblies with thimbles, brackets, swivels, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.
- E. Hanger Rod Stiffener: **[Steel tube or steel slotted-support-system sleeve with internally bolted connections] [Reinforcing steel angle clamped]** to hanger rod. Do not weld stiffeners to rods.
- F. Bushings for Floor-Mounted Equipment Anchor: Neoprene bushings designed for rigid equipment mountings and matched to type and size of anchors and studs.
- G. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices.
- H. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

- I. Mechanical Anchor: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchors with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.
- J. Adhesive Anchor: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

### **2.3 FACTORY FINISHES**

- A. Finish: Manufacturer's standard prime-coat finish ready for field painting.
- B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
  1. Powder coating on springs and housings.
  2. Hardware shall be galvanized. Hot-dip galvanized metal components for exterior use.
  3. Baked enamel or powder coat for metal components on isolators for interior use.
  4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation after unsatisfactory conditions have been corrected.

### **3.2 APPLICATION**

- A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an agency acceptable to Authorities Having Jurisdiction.
- B. Hanger Rod Stiffeners: Install hanger rod stiffeners where required to prevent buckling of hanger rods due to seismic forces.
- C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

### **3.3 SEISMIC-RESTRAINT DEVICE INSTALLATION**

- A. Equipment and Hanger Restraints:
  1. Install restrained isolators on electrical equipment.

2. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125".
  3. Install seismic-restraint devices using methods approved by an agency acceptable to Authorities Having Jurisdiction providing required submittals for component.
- B. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- C. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
- D. Restraint cables: Provide slack with maximums recommended by manufacturer.
- E. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
- F. Drilled-in Anchors:
1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
  2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
  3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
  4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
  5. Set anchors to manufacturer's recommended torque, using a torque wrench.
  6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

### **3.4 METHODS AND MATERIALS**

- A. Vibration control and seismic restraint methods and materials shall be supplementary to supporting devices and together shall serve as equipment support criteria. Provide hangers and supports in accordance with Section 26 0529 – Hangers and Supports for Electrical Systems.

### **3.5 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION**

- A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where they terminate with connection to equipment

that is anchored to a different structural element from the one supporting them as they approach equipment.

### **3.6 [FIELD QUALITY CONTROL**

- A. Testing Agency: [Owner will engage] [Engage] a qualified testing agency to perform tests and inspections and prepare test reports.
- B. Perform tests and inspections.
- C. Tests and Inspections:
  - 1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to Authorities Having Jurisdiction.
  - 2. Schedule test with Owner, through Owner's Representative, before connecting anchorage device to restrained component (unless post-connection testing has been approved), and with at least 7 days advance notice.
  - 3. Obtain Owner's Representative' approval before transmitting test loads to structure. Provide temporary load-spreading members.
  - 4. Test at least [4] [XXX] of each type and size of installed anchors and fasteners selected by Owner's Representative.
  - 5. Test to 90% of rated proof load of device.
  - 6. Measure isolator restraint clearance.
  - 7. Measure isolator deflection.
  - 8. Verify snubber minimum clearances.
  - 9. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Prepare test and inspection reports.]

### **3.7 ADJUSTING**

- A. Adjust isolators after isolated equipment is at operating weight.
- B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
- C. Adjust active height of spring isolators.
- D. Adjust restraints to permit free movement of equipment within normal mode of operation.

**END OF SECTION 26 05 48**

## **SECTION 26 05 53 - ELECTRICAL SYSTEMS**

### **IDENTIFICATION PART 1 - GENERAL**

#### **1.1 RELATED WORK**

- A. Section 26 05 13.16 – Medium-Voltage Cable
- B. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables
- C. Section 26 05 33 – Raceways and Boxes for Electrical Systems
- D. Section 26 05 43 – Underground Ducts and Raceways for Electrical Systems
- E. Section 26 05 73 – Power System Studies
- F. Section 26 09 23 – Lighting Control Devices
- G. Section 26 12 19 – Pad-Mounted, Liquid-Filled, Medium-Voltage Transformers
- H. Section 26 13 16 – Medium-Voltage Fusible Interrupter Switchgear
- I. Section 26 22 00 – Low-Voltage Transformers
- J. Section 26 23 00 – Low-Voltage Switchgear
- K. Section 26 24 13 – Switchboards
- L. Section 26 24 16.13 – Lighting and Appliance Panelboards
- M. Section 26 24 16.16 – Distribution Panelboards
- N. Section 26 27 13 – Electrical Metering
- O. Section 26 27 26 – Wiring Devices
- P. Section 26 28 16 – Enclosed Switches and Circuit Breakers
- Q. Section 26 29 13 – Enclosed Controllers
- R. Section 26 32 13 – Engine Generators
- S. Section 26 36 23 – Automatic Transfer Switches
- T. Section 26 43 00 – Surge Protection Devices
- U. Section 28 31 16 – Multiplexed Fire Detection and Alarm Systems

#### **1.2 REFERENCE**

- A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 - General Requirements.

#### **1.3 DESCRIPTION**

- A. Section includes the following:
  - 1. Identification for raceway and metal-clad cable
  - 2. Identification for conductors and communication and control cable
  - 3. Underground-line warning tape
  - 4. Warning labels and signs
  - 5. Instruction signs and posted drawings
  - 6. Equipment identification nameplates
  - 7. Wiring devices identification

8. Miscellaneous identification products

- B. Refer to the respective Division 26 Sections, and Sections in other Divisions that specify electrical components, for additional electrical identification requirements.

**1.4 REFERENCE STANDARDS**

- A. ANSI A13.1 – Scheme for the Identification of Piping Systems
- B. ANSI C2 – National Electrical Safety Code
- C. ANSI Z535.4 – National Standards for Product Safety Signs and Labels
- D. 29 CFR – Labor, Part 1910 – Occupational Safety and Health Standards, Section 1910.145 – Specifications for Accident Prevention Signs and Tags
- E. NFPA 70 – National Electrical Code

**1.5 SUBMITTALS**

- A. Product Data: For each electrical identification product indicated.
- B. Nameplate Schedule: Prior to making nameplates, submit a complete schedule to Architect for approval indicating nameplate size, lettering size, color and actual nameplate information.
- C. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.
- D. See subsection "University Standards" below.

**1.6 QUALITY ASSURANCE**

- A. Comply with ANSI A13.1 and ANSI C2.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.145.

**1.7 COORDINATION**

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout project.
- B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- C. Coordinate installation of identifying devices with location of access panels and doors.
- D. Install identifying devices before installing acoustical ceilings and similar concealment.

**1.8 UNIVERSITY STANDARDS**

- A. Submittals:
  - 1. Provide a sample of all label type for the particular project to the University for approval prior to the execution of any label or identification placement.
  - 2. Identification of power receptacles, equipment disconnects and other utilization devices and equipment.



3. Provide a thermoplastic engraved legend, white background with black letters that denotes the panel designation and circuit designation per below example:  
1LA 2,4,6  
Where "1LA" is the panel designation and "2,4,6" is the circuit designation.
  4. Minimum size for power receptacles is .5" high by 1.5" wide with .25" letters.
  5. Affix to the device using 30 year silicone adhesive.
- B. Labels for Panel boards, Distribution Boards and Switchgear
1. Panel boards are to be named using the following scheme: #XY  
Where # denotes the floor number where the equipment is located Where X denotes the voltage:  
L = 208/120V 3 Phase or 240/120V 1 Phase  
M = 240V 3 Phase  
H = 480/277V 3 Phase or 480V  
Where Y denotes the panel designation on that floor. A, B, C and so forth
  2. Sub panels will be labeled as follows: #XY-\$  
Where \$ is the number 1, 2, 3 etc. of the sub panel feed from the panel board
  3. Distribution boards will be named using the following scheme:  
#DBXY Where # denotes the floor number where the equipment is located Where X denotes the voltage:  
L = 208/120V 3 Phase or 240/120V 1 Phase  
M = 240V 3 Phase  
H = 480/277V 3 Phase or 480V  
Where Y denotes the Distribution Board designation on that floor. A, B, C and so forth
  4. Main Switchgear will be named as follows: #-MDB-\$  
Where # is the building number and \$ is the switchgear number if there is more than one. See University Representative if further clarification is needed. Use 30 year silicon adhesive to attach legend to panel enclosure.
- C. Labels for Medium Voltage Conductors and Equipment
1. Provide a waterproof tag (laminated plastic or similar) on each end of termination and in each manhole or pull box indicating the Feeder # from the drawings, the from location, the to location and the approximate feet at the location of the label. Color scheme is as follows:
    - a. Normal circuits: black nameplate with white letters
    - b. Emergency circuits: red nameplate with white letters
    - c. Standby circuits: yellow nameplate with black letters
    - d. Fire alarm circuits: red nameplate with yellow letters
    - e. Communication circuits: orange nameplate with white letters
  2. Provide thermoplastic engraved legends with white letters on a black background indicating the asset identification number as shown on the drawings. Labels are to be a minimum of 1" high by 3" long with .5" letters. Use 30 year silicon adhesive to

attach legend to the enclosure.

D. Labels for Junction and Pull Boxes

1. Exposed locations: Provide a thermoplastic engraved legend with white letters on a black background indicating the contents, panel numbers and circuit numbers of conductors and equipment in the box. Use 30 year silicon adhesive to attach legend to the box.
2. Concealed locations: Write legibly from a distance of 15 feet on the box with an indelible ink marker as the contents, panel numbers and circuit numbers of the conductors and equipment in the box.

E. Circuit Directories

1. Circuit Directories are to be installed in a permanent enclosure on the inside of the door of the equipment that they are in reference to.
2. Circuit Directories are to be neatly typed and include the panel designation, date and the source of electricity for the panel.
3. Circuit directories are to provide enough description of each load or circuit such that an operator can distinguish a particular load in questions from all other loads in the panel without the use of a circuit tracer or similar tools. Provide a map or diagram with directory if appropriate.

F. Wire Identification

1. All wires are to be installed in their corresponding phase colors. See above in section 26 05 00.
2. Panel connections will have circuit number tape on the ungrounded phase conductors to indicate their specific circuit number.
3. Panel connections will have circuit number tape on the grounded conductors (neutrals) to indicate their specific circuit numbers.

G. Other Electrical Identification

1. All VFD, Lighting Controllers, Relay Cabinets and thermoplastic engraved legend with white letters on black background indicating the equipment designation. Use 30 year silicon adhesive to attach legend.
2. All power outlets, power disconnects and lighting switches will have an engraved plastic legend indicating their feed panel and circuit number. Glue engraved legend in place with silicone.

## **PART 2 - PRODUCTS**

### **2.1 RACEWAY IDENTIFICATION MATERIALS**

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
- B. Manufacturers: Brady USA, Ideal, Marking Services, Inc. (MSI), Seton, or approved equal.

- C. Color for Printed Legend:
  - 1. Power Circuits: Black letters on an orange field.
  - 2. Legend: Indicate system or service and voltage, if applicable.
- D. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical- resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- E. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action when placed in position.
- F. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2" long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action when placed in position.

## **2.2 CONDUCTOR AND COMMUNICATION- AND CONTROL-CABLE IDENTIFICATION MATERIALS**

- A. Comply with ANSI A13.1 for minimum size of letters for legend.
- B. Manufacturers: Brady USA, Ideal, Marking Services, Inc. (MRI), Seton, or equal.
- C. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
- D. Aluminum Wraparound Marker Labels: Cut from 0.014" thick aluminum sheet, with stamped, embossed, or scribed legend, and fitted with tabs and matching slots for permanently securing around wire or cable jacket or around groups of conductors.
- E. Metal Tags: Brass or aluminum, 2" x 2" x 0.05", with stamped legend, punched for use with self- locking nylon tie fastener.
- F. Write-On Tags: Polyester tag, 0.015" thick, with corrosion-resistant grommet and polyester or nylon tie for attachment to conductor or cable.
  - 1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
- G. Plasticized Card-Stock Tags: Vinyl cloth with preprinted and field-printed legends. Orange background, unless otherwise indicated, with eyelet for fastener.

## **2.3 UNDERGROUND-LINE WARNING TAPE**

- A. Manufacturers: Ideal, Marking Services, Inc. (MRI), Seton, or approved equal.
- B. Description: Permanent, bright-colored, continuous-printed, polyethylene tape.
  - 1. Not less than 6" wide by 4 mils thick.
  - 2. Compounded for permanent direct-burial service.
  - 3. Embedded continuous metallic strip.
  - 4. Printed legend shall indicate type of underground line.
  - 5. Red tape for electrical and orange tape for communications installations.

## **2.4 WARNING LABELS AND SIGNS**

- A. Comply with NFPA 70 and 29 CFR 1910.145.
- B. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive

- labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.
- C. Self-Adhesive Arc Flash Warning Labels: Industrial grade, made of durable polyester with over-laminate to withstand harsh environments (UV rays, scratches and most chemicals).
    - 1. Manufacturer: Seton or approved equal
  - D. Engraved Plastic Signs: Engraving stock, melamine plastic laminate, minimum 1/16" thick for signs up to 20 sq in and 1/8" thick for larger sizes.
    - 1. Engraved legend with black letters on white face.
    - 2. No punched or drilled mechanical fasteners are permitted
    - 3. Color schemes is as follows:
      - a. Normal: black background with white letters
      - b. Emergency: red background with white letters
      - c. Standby: yellow background with black letters
      - d. Fire alarm: red background with yellow letters
      - e. Communication: orange background with white letters
  - E. Baked-Enamel Warning Signs for Interior Use: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. 1/4" grommets in corners for mounting. Nominal size, 7" x 10".
  - F. Metal-Backed, Butyrate Warning Signs for Exterior Use: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396" galvanized-steel backing; and with colors, legend, and size required for application. 1/4" grommets in corners for mounting. Nominal size, 10" x 14".
  - G. Warning label and sign shall include, but are not limited to, the following legends:
    - 1. Multiple Power Source Warning: "DANGER – ELECTRICAL SHOCK HAZARD – EQUIPMENT HAS MULTIPLE POWER SOURCES."
    - 2. Workspace Clearance Warning: "WARNING – OSHA REGULATION – AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."
    - 3. Arc Flash Labels: Per ANSI Z535.4, the signal word WARNING appearing in black letters on an orange background, with second line below (Arc Flash and Shock Hazard) in black letters on white background and third line below (Appropriate PPE Required) in black letters on white background. Include the following information on the label:
      - a. Equipment name
      - b. Available bolted current
      - c. Flash protection boundary distance
      - d. Incident energy level at 18" expressed in cal/cm<sup>2</sup>
      - e. Personnel protective equipment (PPE) class
      - f. Voltage shock hazard
      - g. Limited shock approach boundary
      - h. Restricted shock approach boundary
      - i. Prohibited shock approach boundary

## 2.5 INSTRUCTION SIGNS AND POSTED DRAWINGS

- A. Instruction Signs: Engraved, laminated acrylic or melamine plastic, minimum 1/16" thick for signs up to 20 sq in and 1/8" thick for larger sizes.
  - 1. Engraved legend with black letters on white face.
  - 2. Punched or drilled for mechanical fasteners.
  - 3. Mounting Frames: Extruded aluminum, 4-point screw mount with 1/8" clear plexiglass cover.
- B. Posted Drawings: Print electrical riser diagrams on 20 lb bond paper. (Blueprint paper is not acceptable.) Reduce drawings to approximately 1/2 size using Xerox reduction process. Contact Engineer to obtain updated original plans for printing.

## 2.6 EQUIPMENT IDENTIFICATION NAMEPLATES

- A. Engraved, Three-layer, Laminated Acrylic or Melamine Nameplate: Punched or drilled for screw mounting. Minimum letter height shall be 3/8" unless noted otherwise.
- B. Color schemes to be as follows:
  - i. Typical u.n.o. below: black background with white letters
  - ii. Emergency: red background with white letters
  - iii. Standby: yellow background with black letters
  - iv. Fire alarm: red background with yellow letters
  - v. Communication: orange background with white letters

## 2.7 WIRING DEVICES IDENTIFICATION

- A. Refer to Section 26 27 26 – Wiring Devices for requirements.

## 2.8 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, type 6/6 nylon cable ties.
  - 1. Minimum Width: 3/16"
  - 2. Tensile Strength: 50 lb minimum
  - 3. Temperature Range: -40°F to 185°F
  - 4. Color: Black, except where used for color-coding
- B. Paint: Paint materials and application requirements are specified in Division 09 – Finishes painting Sections.
- C. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws  
with nuts and flat and lock washers.

## PART 3 - EXECUTION

### 3.1 APPLICATION

- A. Raceway and Ductbanks More Than 600 V Concealed within Buildings: 4" wide black stripes on 10" centers over orange background that extends full length of raceway or duct and is 12" wide. Stencil legend "DANGER CONCEALED HIGH-VOLTAGE WIRING" with 3" high black letters on 20" centers. Stop stripes at legends. Apply to the following finished surfaces:
  - 1. Floor surface directly above conduits running beneath and within 12" of a floor

- that is in contact with earth or is framed above unexcavated space.
- 2. Wall surfaces directly external to raceways concealed within wall.
- 3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.
- B. Accessible Raceways More Than 600 V: Identify raceways by painting with red paint the entire length of raceways. Stencil the legend "DANGER – HIGH VOLTAGE [XXX] VOLTS" in black letters at least 2" high. Repeat legend at 10 ft maximum intervals.
  - 1. Identify covers of exposed junction and pull boxes with red paint. Stencil the legend "DANGER – HIGH VOLTAGE [XXX] VOLTS" in black letters 1/2" high.
- C. Accessible Raceways, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30A: Identify with orange [self-adhesive vinyl labels].
  - 1. Identify 4" round, 4" square and 4-11/16" junction boxes concealed above ceiling or exposed with neat lettering on cover with permanent black marking pen. Identify source, circuit number, phase, and control circuit number.
- D. Accessible Raceways and Cables of Auxiliary Electrical Systems: Identify the following systems with color-coded, self-adhesive vinyl tape applied in bands, and as required per code:
  - 1. Fire Alarm System (including covers of pull and junction boxes): Red
  - 2. Fire-Suppression Supervisory and Control System: Red and yellow
  - 3. Combined Fire Alarm and Security System: Red and blue
  - 4. Security System: Blue and yellow
  - 5. Mechanical and Electrical Supervisory System: Green and blue
  - 6. Telecommunication System: Green and yellow
- E. Conductors to Be Extended in the Future and Spare Conductors: Attach write-on tags to conductors and list source and circuit number.
- F. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, signal, sound, intercommunications, voice, and data connections.
  - 1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
  - 2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
  - 3. Coordinate identification with project drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual.
- G. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable. Install underground-line warning tape for both direct-buried cables and cables in raceway.
- H. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply self-adhesive warning labels. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access to equipment.

1. Equipment with Multiple Power or Control Sources: Apply to door or cover of equipment including, but not limited to, the following:
  - a. Power transfer switches
  - b. Controls with external control power connections
2. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.
3. Arc Flash Warning Labels: install per NFPA 70 for each switchgear, switchboard, panelboard, motor control center, industrial control panel (every enclosure that may contain energized conductors or components). Locate labels so they are visible to the personnel before examination, adjustment, servicing, or maintenance of the equipment.
4. Available Fault Current Labels: install per NFPA 70 for each piece of service entrance equipment. Locate labels so they are visible to the personnel before examination, adjustment, servicing or maintenance of the equipment.
- I. Instruction Signs and Posted Drawings:
  1. Operating Instructions: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend printed in all capital letters of 12 pt size minimum where instructions are needed for system or equipment operation.
  2. Emergency Operating Instructions: Install instruction signs with white legend on a red background with minimum 3/8" high letters for emergency instructions at equipment used for power transfer.
- J. Emergency Electrical System Junction and Pull Boxes:
  1. Identify with spray-painted covers as follows:
    - a. 480/277 V circuits: Red/Brown
    - b. 120/208 V circuits: Red/White
  2. Confirm with University for boxes located in concealed areas.
- K. Equipment Identification Nameplates: On each unit of equipment, install unique designation nameplate that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply nameplates to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
  1. Nameplate Instructions:
    - a. Indoor Equipment: Engraved, laminated acrylic or melamine nameplate. Unless otherwise indicated, provide a single line of text with 1/2" high letters (1/4" where space is limited) on 1-1/2" high nameplate; where 2 lines of text are required, use nameplates sized 2" high.
    - b. Outdoor Equipment: Engraved, laminated acrylic or melamine nameplates sized similar to indoor equipment nameplates
    - c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
  2. Install nameplates for equipment including, but not limited to, the following:

- a. Panelboards, electrical cabinets, and enclosures
  - b. Access doors and panels for concealed electrical items
  - c. Electrical switchgear, switchboards, and distribution panelboards including each feeder device within the equipment enclosures.
  - d. Transformers
  - e. Electrical substations
  - f. Emergency system boxes and enclosures
  - g. Motor-control centers, including each device
  - h. Disconnect switches
  - i. Enclosed circuit breakers
  - j. Motor controllers
  - k. Pushbutton stations
  - l. Power transfer equipment
  - m. Contactors
  - n. Remote-controlled switches, dimmer modules, and control devices
  - o. Battery inverter units
  - p. Battery racks
  - q. Power-generating units
  - r. Voice and data cable terminal equipment
  - s. Master clock and program equipment
  - t. Intercommunication and call system master and staff stations
  - u. Television/audio components, racks, and controls
  - v. Fire alarm control panel and annunciators
  - w. Security and intrusion-detection control stations, control panels, terminal cabinets, and racks
  - x. Monitoring and control equipment
  - y. Uninterruptible power supply equipment
  - z. Terminals, racks, and patch panels for voice and data communication and for signal and control functions
  - aa. Non-concealed junction box covers of auxiliary electrical systems
3. Provide the following information on each nameplate:
- a. Equipment name/tag:
    - 1) Matching the designation from the contract documents, or identifying the load controlled or function of the equipment where no specific tag is shown on the contract documents.
    - 2) For disconnect switches, use the prefix "SW-" followed by the name of the equipment served, example: "SW-PMP-201."
  - b. Equipment operating voltage, phase, wiring configuration, and ampacity:
    - 1) Example: "208V/3PH/4W/225A"
  - c. Source of power supply, including circuit number:
    - 1) Example: "FED FROM LP-2/45"
- L. For service entrance equipment, provide a nameplate identifying the maximum available fault current and "as of" effective date.
  1. Example: "MAXIMUM AVAILABLE FAULT CURRENT 33,500A AS OF 2017/06/15."
- M. Access Panel Identification: Furnish typewritten charts with identification and location of access panels serving equipment and incorporate in O&M Manuals.



### 3.2 INSTALLATION

- A. Verify identity of each item before installing identification products.
- B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- C. Apply identification devices to surfaces that require finish after completing finish work.
- D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- E. Install non-adhesive signs and plastic nameplates parallel to equipment lines; attach with screws and auxiliary hardware appropriate to the location and substrate. Secure to inside surface of door or panelboard that is recessed in finished locations.
- F. Posted Drawings and Operating Instructions: Mount drawings and operating procedures on the wall immediately adjacent to the piece of equipment for which the instructions apply. If sufficient wall space is available, mount directly to one of the sheet metal panels of the equipment.
- G. Warning Signs: Install warning signs where there is hazardous exposure or danger associated with access to or operation of electrical facilities. Provide text of sufficient clarity and lettering of sufficient size to convey adequate information at each location; mount permanently in an appropriate and effective location. Comply with ANSI A13.1 standard color and design.
  - 1. Operational Tags: Where needed for proper and adequate information on operation and maintenance of electrical systems, provide tags of plasticized card stock, either preprinted or hand printed to convey the message; example: "DO NOT OPEN THIS SWITCH WHEN BREAKER IS CLOSED."
- H. System Identification Color Banding for Raceways and Cables: Each color band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50 ft maximum intervals in straight runs, and at 25 ft maximum intervals in congested areas.
- I. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder, and branch-circuit conductors.
  - 1. Colors for 208/120 V Circuits:
    - a. Phase A (left bus in panelboard): Black
    - b. Phase B (center bus in panelboard): Red
    - c. Phase C (right bus in panelboard): Blue
    - d. Neutral: White
      - 1) Dedicated neutral, Phase A: white with black tracer
      - 2) Dedicated neutral, Phase B: white with red tracer
      - 3) Dedicated neutral, Phase C: white with blue tracer
    - e. Equipment Ground: Green
  - 2. Colors for a 240V 3 Phase System:
    - a. Phase A: Black
    - b. Phase B: Purple
    - c. Phase C: Blue
  - 3. Colors for a 240/120V Single Phase Systems:

- a. Phase A: Black
- b. Phase B: Red
- c. Neutral: White
4. Colors for 480/277 V Circuits:
  - a. Phase A (left bus in panelboard): Brown
  - b. Phase B (center bus in panelboard): Orange
  - c. Phase C (right bus in panelboard): Yellow
  - d. Neutral: Gray
    - 1) Dedicated neutral, Phase A; gray with brown tracer
    - 2) Dedicated neutral, Phase B; gray with orange tracer
    - 3) Dedicated neutral, Phase C; gray with yellow tracer
  - e. Equipment Ground: Green
5. Where dedicated neutrals are required or are shown on the drawings, neutral insulation color shall be either white or gray with colored tracer to match color of phase conductor to which neutral is dedicated.
6. All conductors will be manufactured in their corresponding phase color identifiers. The use of phase tape or other means is not acceptable.
- J. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6" to 8" below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16" overall.
- K. Painted Identification: Prepare surface and apply paint according to Division 09 – Finishes painting Sections.

**END OF SECTION 26 05 53**

## **SECTION 26 05 73 - POWER SYSTEM STUDIES**

### **PART 1 - GENERAL**

#### **1.1 RELATED WORK**

- A. Section 26 05 53 – Electrical Systems Identification
- B. Section 26 08 12 – Power Distribution Acceptance Tests
- C. Section 26 08 13 – Power Distribution Acceptance Test Tables
- D. Section 26 13 16 – Medium-Voltage Fusible Interrupter Switchgear
- E. Section 26 22 00 – Low-Voltage Transformers
- F. Section 26 23 00 – Low-Voltage Switchgear
- G. Section 26 24 13 – Switchboards
- H. Section 26 24 16.13 – Lighting and Appliance Panelboards
- I. Section 26 24 16.16 – Distribution Panelboards
- J. Section 26 28 13 – Fuses
- K. Section 26 28 16 – Enclosed Switches and Circuit Breakers
- L. Section 26 29 13 – Enclosed Controllers
- M. Section 26 36 23 – Automatic Transfer Switches

#### **1.2 REFERENCE**

- A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

#### **1.3 DESCRIPTION**

- A. Section includes computer based, fault current, arc flash, and overcurrent protective device coordination studies for an electrical distribution system, based on actual equipment supplied. Set protective devices based on results of the protective device coordination study.
  - 1. Coordination of series-rated devices is not permitted.
- B. Furnish field information and data needed for the studies.
- C. Available fault current and electrical equipment interrupting capacity indicated on drawings are based on the short circuit study performed during design as part of the construction documents.
- D. Provide studies and reports prior to manufacture of the electrical distribution equipment.
- E. Equipment submittal will not be approved until the coordination study is complete and the equipment submittals indicate compliance with the study recommendations.

#### 1.4 REFERENCE STANDARDS

- A. ANSI C57.12.10 – American National Standard for Transformers-230 kV and Below 833/958-8333/10 417 kVA, Single-Phase, and 750/862-60 000/80 000/100 000 kVA, Three-Phase, w/o Load Tap Changing; and 3750/4687-60 000/80 000 kVA with Load Tap Changing-Safety Requirements
- B. ANSI C57.12.22 – American National Standard for Transformers-Pad-Mounted, Compartmental- Type, Self-Cooled, Three-Phase Distribution Transformers with High-Voltage Bushings, 2500 kVA & Smaller:  
High-Voltage, 34 500 GrdY/19 920 V & Below; Low Voltage, 480 V & Below- Requirements
- C. ANSI C57.12.40 – American National Standard for Secondary Network Transformers-Subway and Vault Types (Liquid Immersed)-Requirements
- D. ANSI C57.12.90 – General Requirements for Liquid-Immersed Distribution Power and Regulating Transformers
- E. ANSI C57.96 – Distribution and Power Transformers, Guide for Loading Dry-Type (Appendix to ANSI C57.12 Standards)
- F. IEEE 141 – Recommended Practice for Electric Power Distribution for Industrial Plants
- G. IEEE 241 – Recommended Practice for Electric Power Systems in Commercial Buildings
- H. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
- I. IEEE 399 – Recommended Practice for Power System Analysis
- J. IEEE 620 – Guide for the Presentation of Thermal Limit Curves for Squirrel Cage Induction Machines
- K. IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems
- L. IEEE 1584 – Guide for Performing Arc-Flash Hazard Calculations
- M. IEEE C37.010 – Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
- N. IEEE C37.20.1 – IEEE Standard for Metal-Enclosed, Low-Voltage Power Circuit Breaker Switchgear
- O. IEEE 37.46 – American National Standard Specifications for Power Fuses and Fuse-Disconnecting Switches
- P. IEEE C57.12 – General Requirements for Liquid-Immersed Distribution, Power and Regulating Transformers
- Q. IEEE C57.96 – IEEE Guide for Loading Dry-Type Distribution and Power Transformers
- R. ICEA P-32-382 – Short-Circuit Characteristics of Insulated Cable
- S. ICEA P-45-482 – Short-Circuit Performance of Metallic Shielding and Sheaths of Insulated Cable
- T. NEMA MG 1 – Motors and Generators
- U. NFPA 70 – National Electrical Code (NEC)
- V. NFPA 70B – Recommended Practice for Electrical Equipment Maintenance
- W. NFPA 70C – Hazardous Locations Classification

X. NFPA 70E – Standard for Electrical Safety in Workplace

**1.5 SUBMITTALS**

- A. Product Data: Computer software program to be used for studies. Include specific software version for owner record.
- B. Product Certificates:
  - 1. Coordination-study and fault-current-study computer software programs, certifying compliance with IEEE 399.
  - 2. Arc flash calculations computer software programs, certifying compliance with IEEE 1584.
- C. Qualification Data: For coordination study specialist.
  - 1. Submit qualifications of the organization proposed for performing the study. Include description of the equipment and computer-based computation methods or programs used and the names and experience histories of the personnel who will perform the study.
- D. Other Action Submittals: Subsequent to having approval for system protective devices submit the following in digital format (submit for review and approval by University previous to applying arc flash labels or have 3<sup>rd</sup> party testing firm implement coordination recommended settings):
  - 1. Electrical one-line drawing drafted in computer software program with component names.
    - a. Drawing maximum text height of 3/32". Maximum paper size 30"x42". Provide multiple drawing sheets as required.
  - 2. Fault current study report
  - 3. Equipment evaluation report
  - 4. Coordination study input data, including completed computer program input data sheets
  - 5. Coordination Study Report
  - 6. Arc Flash Study and Report
  - 7. Arc Flash labels
  - 8. Serving utility information with utility letterhead, including but not limited to:
    - a. Protective device part numbers/settings
    - b. Maximum available 1P and 3P fault
    - c. Line conductor sizes/lengths
    - d. Transformer impedance
    - e. Serving voltage
  - 9. Provide copy of Owner's electrical safety program if site specific standards vary from instructions noted in this project specification. All software files, including report documents and system study native files (including relevant library files), to allow review and future use of files
  - 10. Sample energized work permit form
  - 11. Provide thumb drive, or similar shared drive, with all SKM files created to complete power system study

**1.6 QUALITY ASSURANCE**

- A. Perform studies using SKM Analysis Software. Software algorithms shall comply with

requirements of standards and guides specified in this Section. Manual calculations are not acceptable.

- B. Coordination Study Specialist Qualifications: An organization experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
  - 1. Perform study under the direct supervision and control of a Registered Professional Electrical Engineer licensed in the State of California, with a minimum of 5 years recent experience in performing protective device coordination studies, arc flash calculations, and electrical system analysis.
- C. Comply with IEEE 242 for short circuit currents and coordination time intervals.
- D. Comply with IEEE 399 for general study procedures.
- E. Comply with IEEE 1584 for arc flash calculations.

## **PART 2 - PRODUCTS**

### **2.1 COMPUTER SOFTWARE DEVELOPERS**

- A. Computer Software Developers: Subject to compliance with requirements, provide products by one of the following:
- B. Basis of Design Product:
  - 1. SKM Systems Analysis, Inc.
  - 2. or equal

### **2.2 COMPUTER SOFTWARE PROGRAM REQUIREMENTS**

- A. Comply with IEEE 399 and IEEE 1584.
- B. Analytical features of fault current study computer software program shall include "mandatory," "very desirable," and "desirable" features as listed in IEEE 399 Table 7-4.
- C. Computer software program shall be capable of plotting and diagramming time-current characteristic curves as part of its output. Computer software program reports device settings and ratings of all overcurrent protective devices and demonstrates selective coordination by computer-generated, time-current coordination plots.
- D. Arc Flash Calculations: Software program capable of calculating Arc Flash Incident Energy (AFIE) levels and flash protection boundary distances.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices for coordination are indicated on drawings.
- B. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

- C. Provide the study based on the actual electrical equipment supplied for the project.

### 3.2 POWER SYSTEM DATA

- A. Gather and tabulate the following input data to support coordination study:
  - 1. Product Data for overcurrent protective devices specified in other Division 26 Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with power riser diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
  - 2. Impedance of utility service entrance(s).
  - 3. Power Riser Diagrams: In hard copy and electronic copy formats, showing the following:
    - a. Circuit breaker and fuse-current ratings and types
    - b. Relays and associated power and current transformer ratings and ratios
    - c. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios
    - d. Generator kilovolt amperes, size, voltage, and source impedance
    - e. Cables: Indicate conduit material, sizes of conductors, conductor material, insulation, and length
      - 1) Prior to equipment purchase, utilize conservative lengths (up/down included) based on planned conduit routing to validate equipment ratings. Final study to utilize contractor provided as-built lengths to confirm equipment ratings.
    - f. Busway ampacity and impedance
    - g. Motor horsepower and code letter designation according to NEMA MG 1
    - h. Load current that is the basis for sizing continuous ratings of circuits for cables and equipment
  - 4. Data sheets to supplement power riser diagrams, cross-referenced with tag numbers on diagrams, showing the following:
    - a. Special load considerations, including starting inrush currents and frequent starting and stopping
    - b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability
    - c. Motor full-load current, locked-rotor current, service factor, starting time, type of start, and thermal-damage curve
    - d. Generator thermal-damage curve
    - e. Ratings, types, and settings of utility company's overcurrent protective devices
    - f. Special overcurrent protective device settings or types stipulated by utility company
    - g. Time-current characteristic curves of devices indicated to be coordinated
    - h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers
    - i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays
    - j. Panelboards, switchboards, automatic transfer switch, switchgear

ampacity, and interrupting rating in amperes rms symmetrical

- 1) Automatic transfer switch withstand rating to comply with UL 1008. Equivalent trip curves are not accepted for specific breaker rated equipment – exact breaker and associated trip unit must be listed on UL certification.

### 3.3 FAULT CURRENT STUDY

- A. Calculate maximum available short circuit current in amperes rms symmetrical at circuit breaker positions of electrical power distribution system. Provide calculation for a current immediately after initiation and for a three-phase bolted short circuit at the following:
  1. Switchgear and switchboard bus
  2. Medium-voltage controller
  3. Motor control center
  4. Distribution panelboard
  5. Branch circuit panelboard
  6. Disconnect switches
  7. Automatic transfer switch
  8. Manual transfer switch
  9. Equipment fed by Variable Frequency Drive (VFD)
- B. For standard non-bypass Pulse Width Modulation VFDs, a line short circuit condition may be ignored.
- C. Verify mechanical equipment served meets or exceeds maximum short circuit available.
- D. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for project. Include studies of system switching configurations and alternate operations that could result in maximum fault conditions.
  1. Model the entire electrical distribution system from utility company point of connection to circuit breakers in 208 V distribution panels at secondary side of distribution transformers. Include mechanical HVAC equipment, motor driven equipment feeder circuits, and elevator feeder circuits.
  2. Model shall include components of the distribution system which would be exposed to fault current levels of 10,000 A symmetrical on a calculated basis.
- E. Calculate momentary and interrupting duties on basis of maximum available fault current.
- F. Perform calculations to verify interrupting ratings of overcurrent protective devices in compliance with IEEE 241 and IEEE 242.
  1. Transformers:
    - a. ANSI C57.12.10
    - b. ANSI C57.12.22
    - c. ANSI C57.12.40
    - d. IEEE C57.12.00
    - e. IEEE C57.96
  2. Medium-Voltage Circuit Breakers: IEEE C37.010
  3. Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.20.1
  4. Low-Voltage Fuses: IEEE C37.46

A. Study Report:



1. Show calculated X/R ratios and equipment interrupting rating (5-cycle) fault currents on power riser diagrams in report. List other output values from computer analyses, including momentary (1/2-cycle), interrupting (5-cycle), and 30-cycle fault current values for 3-phase, 2-phase, and phase-to-ground faults.
  2. Show interrupting (5-cycle) and time-delayed currents (6 cycles and above) on medium-voltage circuit breakers to set relays and assess the sensitivity of overcurrent relays.
- B. Equipment Evaluation Report:
1. Prepare report on adequacy of overcurrent protective devices and conductors by comparing fault current ratings of devices with calculated fault current momentary and interrupting duties.
  2. For 600V overcurrent protective devices, ensure interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
  3. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in standards to 1/2-cycle symmetrical fault current.
  4. Verify adequacy of phase conductors at maximum 3-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure short circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
  5. Notify Owner's Representative promptly of discrepancies, problem areas, or inadequacies and provide recommendations for problem resolution.
  6. Equipment with lower duty equipment will not be accepted. Series rating of equipment is not permitted.

### 3.4 COORDINATION STUDY

- A. Perform coordination study using approved computer software program. Prepare a written report using results of fault current study. Comply with IEEE 399.
1. Calculate maximum and minimum 1/2-cycle short circuit currents.
  2. Calculate maximum and minimum interrupting duty (5 cycles to 2 seconds) short circuit currents.
  3. Calculate maximum and minimum ground-fault currents.
- B. Comply with NFPA 70 for overcurrent protection of circuit elements and devices.
- C. Comply with IEEE 241 IEEE 242 recommendations for fault currents and time intervals.
- D. Transformer Primary Overcurrent Protective Devices:
1. Devices non-operational in response to the following:
    - a. Inrush current when first energized
    - b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
    - c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
  2. Protect transformers according to IEEE C57.12.00, for fault currents by device settings.

- E. Protect motors served by voltages more than 600 V according to IEEE 620.
- F. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32- 382, ICEA P-45-482, and conductor melting curves in IEEE 242. Demonstrate equipment withstands the maximum short circuit current for a time equivalent to tripping time of primary relay protection or total clearing time of fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short circuit current. Verify adequacy of phase conductors at maximum three-phase bolted fault currents, equipment grounding conductors, and grounding electrode conductors at maximum ground-fault currents.
- G. Include voltage classes of equipment from utility's incoming line protective device down to and including each panelboard. The phase and ground overcurrent protection shall be included as well as settings for other adjustable protective devices.
- H. Selective Coordination: Overcurrent devices installed upstream and downstream of automatic transfer switches and/or associated with NEC Article 700 Emergency and 701 Legally Required loads shall be selectively coordinated from source of supply (both normal and emergency sources) through final device. Change specific circuit breakers (type, frame, trip-unit, etc.) and equipment bus rating as necessary to meet this requirement.
  - 1. Additionally, provide selective coordination for ground fault through-out.
- I. Coordination Study Report: Prepare a written report indicating results of coordination study:
  - 1. Tabular Format of Settings Selected for Overcurrent Protective Devices:
    - a. Device tag
    - b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values
    - c. Circuit breaker sensor rating; and long-time, short-time, and instantaneous settings
    - d. Fuse-current rating and type
    - e. Ground-fault relay-pickup and time-delay settings
    - f. Manufacturer and type of device
    - g. Range of adjustments and recommended settings
  - 2. Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate adequate time separation exists between devices installed in series, drawn to show the boundaries of device operation on log-log scale graphs, including power utility company's upstream devices. Where time current curves do not explicitly illustrate selective coordination but breakers have been tested and documented as being selectively coordinated, submit manufacturer's literature to substantiate device coordination. Include on curve sheet a title and legend identifying portion of the system covered. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
    - a. Device tag
    - b. Voltage and current ratio for curves
    - c. Three-phase and single-phase damage points for each transformer
    - d. No damage, melting, and clearing curves for fuses
    - e. Cable damage curves
    - f. Transformer inrush points, full-load amps, and damage curves
    - g. Maximum fault current cutoff point
    - h. Generator decrement curve and full-load amps

3. Plot characteristics where applicable:
    - a. Medium- and low- voltage fuses including minimum melt, total clearing and damage bands
    - b. Low-voltage circuit breaker trip devices
    - c. Transformer full-load current, magnetizing inrush current, and ANSI transformer withstand parameters
    - d. Ground-fault protective devices
    - e. Motor starting characteristics and motor damage points
    - f. Generator short circuit decrement curve and generator damage point
    - g. Conductor damage curves
    - h. Electric utility's protective devices
    - i. Medium-voltage equipment relays
  4. Notify Owner's Representative promptly of discrepancies, problem areas, or inadequacies and provide recommendations for problem resolution. Propose approaches to effectively protect the underrated equipment. Present technical evaluation with discussion of logical compromises for best coordination.
- J. Completed data sheets for setting of overcurrent protective devices.

### **3.5 ARC FLASH STUDY**

- A. Perform arc flash calculations for Arc Flash Incident Energy (AFIE) levels and flash protection boundary distances. Utilize short circuit rating of equipment identified in fault current study – note infinite bus fault current alone is not acceptable.
- B. Model worst-case arc flash conditions
  1. Equipment with PPE rating greater than 2 shall be investigated. Investigation shall include adjustment of upstream overcurrent device settings to determine if PPE rating can be reduced with minimal compromise to coordination with other overcurrent devices.
- C. Arc Flash Study Report: Provide study results in tabular form and include:
  1. Device or bus name
  2. Bolted fault and arcing fault current levels
  3. Arc Flash Incident Energy (AFIE) level at 455 mm expressed in cal/cm<sup>2</sup>
  4. Flash protection boundary distances including:
    - a. Limited shock approach boundary
    - b. Restricted shock approach boundary
  5. Trip/Delay time
  6. Breaker opening time
  7. Working distance
  8. Equipment class and bus gap
  9. Personal protective equipment class (PPE)
- D. Provide recommendation for reducing AFIE levels and enhancing worker safety.

### **3.6 FIELD QUALITY CONTROL**

- A. Inspect, set, test, and calibrate the protective relays, circuit breakers, fuses, and other applicable devices per requirements in Section 26 08 12 – Power Distribution Acceptance Tests and Section 26 08 13 – Power Distribution Acceptance Test Tables.
- B. Upon final approval of study, provide weatherproof vinyl or polyester arc flash label for all

electrical equipment defined above. Label shall include calculated flash protection boundary, incident energy in cal/cm<sup>2</sup> at working distance (mm working distance based on equipment class, per IEEE 1584), required PPE level, limited approach, restricted approach, equipment name, company name/logo who performed the study, available fault current, overcurrent device settings if applicable, and date label was produced.

1. Label to comply with ANSI Z535. Use "WARNING" (ANSI safety orange background with an orange exclamation point safety symbol) for all arc flash levels.
2. Per NFPA 70E 130.5(C), due to use of incident energy analysis method, PPE categories shall not be provided on labels unless site specific standard PPE categories differ from incident energy levels noted in NFPA 70E Table 130.7(C)(16).
3. Include verbiage on label noting study should be re-examined once every (5) years or upon modifications to electrical system.

### **3.7 ADJUSTING**

- A. Make modifications to equipment, as required, to accomplish conformance with equipment evaluation study.
- B. Confirm that all electrical distribution equipment is rated for 110% of the fault duty that is applied per the evaluation study. All equipment must be fully rated. The use of series ratings to achieve sufficient duty is not acceptable.
- C. Adjust relay and overcurrent protective device settings according to recommended settings table provided by overcurrent protective device coordination study.
- D. Notify Owner's Representative in writing of any required major modifications.

### **3.8 INSTALLATION**

- A. Install PPE labels on each piece of equipment prior to energizing equipment.
- B. PPE labels shall be protected by clear plastic cover, weatherproof type material, or laminated and mounted on front of equipment. Taping of PPE label to front of equipment is unacceptable.
- C. PPE label shall be clearly visible upon approach to equipment.
- D. For large pieces of equipment, label shall be placed near main overcurrent device or incoming feeder to equipment. For equipment such as switchboards, UPS, or switchgear, with multiple vertical sections, provide (1) label per vertical section.
- E. Contractor to provide one-line diagrams (meet IEEE/ANSI standard 141), mounted on 24"x36" (minimum) Styrofoam backboard. These one-line diagrams shall be mounted in each electrical room.
- F. Label shall be mounted at a minimum of 42" to bottom and maximum 66" to top above finished floor.
- G. Label shall be installed on all switchboards, distribution panelboard, panelboards, VFDs, disconnects, motor controllers, elevator controllers, lighting controllers, transformers with operable doors, and any other electrical equipment with hinged doors.

## **SECTION 26 05 93 - ELECTRICAL SYSTEMS**

### **FIRESTOPPING PART 1 - GENERAL**

#### **1.1 RELATED WORK**

- A. Section 07 84 13 – Penetration Firestopping
- B. Section 26 05 33 – Raceways and Boxes for Electrical Systems
- C. Section 26 05 36 – Cable Trays for Electrical Systems
- D. Section 26 25 00 – Enclosed Bus Assemblies

#### **1.2 REFERENCE**

- A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

#### **1.3 DESCRIPTION**

- A. Section includes through-penetration firestop systems for penetrations through fire-resistance-rated constructions (walls, partitions, floors, and ceilings) including both empty openings and openings containing electrical penetrating items, including but not limited to raceways, cables, cable trays, busways, and wireways.

#### **1.4 REFERENCE STANDARDS**

- A. ASTM E-814 – Standard Test Method for Fire Tests of Through-Penetration Firestops
- B. UL 1479 - Fire Tests of Through-Penetration Firestops

#### **1.5 PERFORMANCE REQUIREMENTS**

- A. Provide firestop system to resist spread of fire, resist passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated.
- B. Firestop systems shall be UL Classified for the application and correspond to those indicated by reference to designations listed by UL Fire Resistance Directory.
- C. Conform to applicable Code requirements of Authority Having Jurisdiction.

#### **1.6 SUBMITTALS**

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For each through-penetration firestop system, show each type of construction condition penetrated, relationships to adjoining construction, and type of penetrating item. Include firestop design designation of qualified testing and inspecting agency that evidences compliance with requirements for each condition indicated.
  - 1. Submit documentation, including illustrations, from a qualified testing and inspecting agency that is applicable to each through-penetration firestop system configuration for construction and penetration items, including documentation of

UL certification for firestop systems.

- C. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- D. Material Safety Data Sheets provided with product delivered to job site.
- E. Certification of compliance with Building Codes of the State California of Project location.
- F. Inspection reports
- G. Onsite Training Letter: Firestop manufacturer to provide and contractor to submit letter stating the names(s) of the companies, person(s) in attendance and date of onsite training as required in section 1.7.

### **1.7 QUALITY ASSURANCE**

- A. Installer Qualifications: A firm experienced in installing through-penetration firestop systems similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful performance.
- B. Firestopping tests shall be performed by a qualified testing and inspecting agency, or another agency performing testing and follow-up inspection services for firestop systems acceptable to Authorities Having Jurisdiction.
- C. Manufacturer's representative shall be on-site during initial installation of firestop systems to train appropriate Contractor personnel in proper selection and installation procedures.

### **1.8 DELIVERY, STORAGE AND HANDLING**

- A. Deliver through-penetration firestop system products to Project site in original, unopened containers or packages with intact and legible manufacturers' labels identifying product, type and manufacturer, and UL Label where applicable.
- B. Store and handle materials for through-penetration firestop systems to prevent their deterioration or damage due to moisture, temperature changes, contaminants, or other causes.
- C. Handle in accordance with recommended procedures, precautions, or remedies described in material safety data sheets as applicable.

### **1.9 PROJECT CONDITIONS**

- A. Do not install through-penetration firestop systems when ambient or substrate temperatures are outside limits permitted by through-penetration firestop systems' manufacturers or when substrates are wet due to rain, frost, condensation, or other causes.
- B. Ventilate through-penetration firestop systems per manufacturers' written instructions by natural means or, where this is inadequate, forced-air circulation.

### **1.10 COORDINATION**

- A. Coordinate construction of openings and penetrating items to ensure that through-penetration firestop systems are installed according to specified requirements.

- B. Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate through- penetration firestop systems.
- C. Notify Owner's Representative at least 7 days in advance of through-penetration firestop system installations; confirm dates and times on days preceding each series of installations.
- D. Do not cover up through-penetration firestop system installations that will become concealed behind other construction until each installation has been examined by Owner's Representative.

#### **1.11 SEQUENCING**

- A. Sequence work to avoid interferences with building finishes and installation of other products.

#### **1.12 WARRANTY**

- A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1 year warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

#### **1.13 LEED REQUIREMENTS**

- A. The materials/products/methods specified in this section have an impact on the Project's LEED requirements. The General Contractor shall verify and document the contribution of the materials/products/methods provided to the Project's LEED requirements. This contribution shall be documented as specified in this section, Division 01 section Sustainable Architecture and LEED Requirements, Division 01 section Construction Waste Management, and as required in the [LEED 2009 for New Construction and Major Renovation, and errata] [LEED v4 Building Design and Construction: New Construction and Major Renovation, and errata]. LEED requirements impacted by this section are:
  - 1. Credit MR2: Construction Waste Management. See Division 01 Section Construction Waste Management for construction waste management requirements.
  - 2. Credit MR5: Regional Materials.
  - 3. Credit EQ4.1: Low Emitting Materials, Adhesives & Sealants.
  - 4. Credit EQ4.2: Low Emitting Materials, Paints & Coatings
  - 5. Prerequisite MR – Construction and Demolition Waste Management Planning
  - 6. Prerequisite MR – PBT Source Reduction - Mercury
  - 7. Credit MR – Building Product Disclosure and Optimization – Environmental Product Declarations
  - 8. Credit MR – Building Product Disclosure and Optimization – Sourcing of Raw Materials
  - 9. Credit MR – Building Product Disclosure and Optimization – Material Ingredients
  - 10. Credit MR – PBT Source Reduction - Mercury
  - 11. Credit MR – PBT Source Reduction – Lead, Cadmium, and Copper
  - 12. Credit MR – Construction and Demolition Waste Management
  - 13. Credit MR 4 – Recycled Content
  - 14. Credit MR 5 – Regional Materials

15. Credit EQ – Low Emitting Materials]

## **PART 2 - PRODUCTS**

### **2.1 LEED MATERIAL REQUIREMENTS**

- A. Products and materials provided in this section shall comply with and contribute to the Project's LEED requirements. LEED requirements are as indicated in this section and as specified in Division 01 section Sustainable Architecture and LEED Requirements. Contributions to LEED requirements shall be documented as indicated in the submittals paragraph of this section and as specified in Division 01 section Sustainable Architecture and LEED Requirements]

### **2.2 MANUFACTURERS**

- A. 3M (Fire Protection Products Division), Hilti Inc, Tremco (Sealant/Weatherproofing Division), Nelson Firestop Products, Specified Technologies Inc, RectorSeal Corporation, or equal.

### **2.3 MATERIALS**

- A. Firestop Products: UL 1479, ASTM E-814 tested for specific fire-rated construction conditions conforming to construction assembly type, penetrating item type, annular space requirements and fire-rating involved for each separate instance; materials shall not contain flammable solvents.
- B. Firestop Systems: Produced by the same manufacturer.
- C. VOC Content: Penetration firestopping sealants and sealant primers shall comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):
1. Sealants: 250 g/L
  2. Sealant Primers for Nonporous Substrates: 250 g/L
  3. Sealant Primers for Porous Substrates: 775 g/L

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine areas and conditions for compliance with requirements for opening configurations, penetrating items and other conditions affecting performance of firestopping.
- B. Do not proceed with installation until unsatisfactory conditions have been corrected.

### **3.2 PREPARATION**

- A. Clean out openings immediately prior to installing through-penetration firestop system to comply with firestop system manufacturer's written instructions.
- B. Provide masking and temporary covering to prevent soiling of adjacent surfaces by firestopping materials.
- C. Comply with manufacturer's recommendations for temperature and humidity



conditions before, during and after installation of firestopping.

### **3.3 INSTALLATION**

- A. Comply with "System Performance Requirements" Article in Part 1 and with firestop system manufacturer's written installation instructions and drawings for products and applications indicated.
- B. Install forming/damming/backing materials and other accessories of types required to support fill materials during application as required. After installing fill materials and allowing them to fully cure, remove combustible forming materials and other accessories not indicated as permanent components of firestop systems.
- C. Each conduit penetration through a fire rated assembly is to be dedicated to a single conduit. Multiple conduits penetrating a single opening is not acceptable unless a UL listed, multi-conduit assembly is used.

### **3.4 IDENTIFICATION**

- A. Identify through-penetration firestop systems with pressure-sensitive, self-adhesive, preprinted vinyl labels. Attach labels permanently to surfaces of penetrated construction on both sides of each firestop system installation where labels will be visible to anyone seeking to remove penetrating items or firestop systems. Include label(s) complying with 1 or 2 below.
  - 1. Custom label with the following information:
    - a. The words: "Warning—Through-Penetration Firestop System—Do Not Disturb. Notify Building Management of Any Damage."
    - b. Contractor's name, address, and phone number
    - c. Through-penetration firestop system designation of applicable testing and inspecting agency
    - d. Date of installation
    - e. Through-penetration firestop system manufacturer's name
    - f. Installer's name
  - 2. Manufacturer's preprinted labels with similar information per 1 above.

### **3.5 FIELD QUALITY CONTROL**

- A. Inspecting Agency: Owner's Representative will engage a qualified independent inspecting agency to inspect through-penetration firestop systems and to prepare test reports.
  - 1. Inspecting agency will state in each report whether inspected through-penetration firestop systems comply with or deviate from requirements.
- B. Provide certification by Installer that all through-penetration firestop systems have been firestopped in accordance with applicable Building Codes of the State California.
- C. Proceed with enclosing through-penetration firestop systems with other construction only after inspection reports are issued and firestop installations comply with requirements.
- D. Where deficiencies are found, repair or replace through-penetration firestop systems so

they comply with specifications.

**3.6 CLEANING**

- A. Clean surfaces adjacent to sealed holes and joints to be free of excess firestop materials and soiling as work progresses.

**END OF SECTION 26 05 93**

## **SECTION 26 08 00 - COMMISSIONING OF ELECTRICAL**

### **SYSTEMS PART 1 - GENERAL**

#### **1.1 SUMMARY**

- A. Section Includes:
  - 1. System specific commissioning
  - 2. Electrical systems to be commissioned are as follows:
    - a. Occupancy sensors for lighting and/or HVAC,
    - b. Daylight/photocell controls (exterior or interior)
    - c. Other programmable lighting controls
    - d. Electrical metering systems
    - e. Interface with building energy management system (if applicable)
    - f. Emergency power systems (if applicable)
- B. Related Sections:
  - 1. 01 33 00 Division 1 Submittal procedures
  - 2. 01 77 00 Division 1 Close out procedures
  - 3. 01 78 23 Division 1 Operating and Maintenance Data
  - 4. 01 91 00 Division 1 Commissioning

#### **1. DESCRIPTION OF WORK – REFER TO SECTION 01 91 00**

#### **1. SUBMITTALS – REFER TO SECTION 01 91 00**

### **PART 2 – PRODUCTS – REFER TO SECTION 01 91**

### **00 PART 3 – EXECUTION**

#### **3.1 COMMISSIONING PROCESS AND PROCEDURES – REFER TO SECTION 019100**

#### **3.2 PRE-FUNCTIONAL CHECKLIST**

- A. Pre-Functional Test is defined under Section 019100. Only the sample checklists are provided in this section as an indication of the format and rigor of the required pre-functional checklists and documentation (refer to 260800 - *Exhibit A*). 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 019100.
- 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
- G. that the installation conforms to the design objectives and the system is ready for Functional Testing.
- H. 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 019100.

### **3.3 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 019100. 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 FPT's.
- C. Only the sample functional tests are provided in this section as an indication of the format and rigor of the required for functional tests and documentation (refer to 260800 - *Exhibit B*). 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 019100 for additional requirements regarding Functional Tests.

**END OF SECTION 26 08 00**

**SECTION 26 08 00 (EXHIBIT A)**  
**SAMPLE PRE-FUNCTIONAL CHECKLIST**  
**(PFC)**  
**FOR OCCUPANCY SENSORS**

Project \_\_\_\_\_

**PFC - \_\_\_\_\_ LIGHTING OCCUPANCY SENSORS**

**Components included:** OCCUPANCY SENSORS, SWITCHPACKS

**1. 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.

\_\_\_\_\_

Electrical Contractor                      Date

\_\_\_\_\_

General Contractor                      Date

Pre-functional checklist items are to be completed as part of startup & initial checkout, preparatory to functional testing.

- This checklist does not take the place of the manufacturer's recommended checkout and startup 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.
- Contractors assigned responsibility for sections of the checklist shall be responsible to see that checklist items by their subcontractors are completed and checked off.
- "Contr." column or abbreviations in brackets to the right of an item refer to the contractor responsible to verify completion of this item. A/E = architect/engineer, All = all contractors, CA = commissioning agent, CC = controls contractor, EC = electrical contractor, GC =

general contractor, MC = mechanical contractor, SC = sheet metal contractor, TAB = test and balance contractor, \_\_\_\_\_ =

**Approvals.** This filled-out checklist has been reviewed. Its completion is approved with the exceptions noted below.

\_\_\_\_\_  
Commissioning Agent      Date                      Owner's Representative      Date

**2. Requested documentation submitted**

Check if Okay. Enter comment or note number if deficient.

Check	Equip Tag:				
Manufacturer's cut sheets					
Installation and startup manual and plan					
Sequences and control strategies					
O&M manuals					

- **Documentation complete as per contract documents for given trade** -  
..... **YES** \_\_\_\_\_ **NO**

**3. Model verification**

1 = as specified, 2 = as submitted, 3 = as installed. Check if Okay. Enter note number if deficient.

Equip Tag-->				
Make	1			
	2			
	3			
Model	1			
	2			
	3			
Volts/phase	1			
	2			
	3			

- **The equipment installed matches the specifications for given trade** -  
..... **YES** \_\_\_\_\_ **NO**

**4. Installation Checks**

Check if Okay. Enter comment or note number if deficient.

Check	Equip Tag->				
Sensor type as specified for location					
Sensor mounted is secure and is as specified					

Sensor mounting is selected to prevent false detection resulting from motion in adjacent spaces				
Sensor wiring is as shown in plans and it is energized regardless of whether the controlled zone is on or off				
Sensor is mounted so that it provides reasonable control coverage for the area				
Switch pack location is located in a concealed location and exterior tile or lighting fixture is marked as specified to easily locate the switch pack for servicing purposes				
All wiring between sensor is switch pack is per plans and specifications and are provided in either conduits or other raceways as specified				
Switch pack voltage rating is compatible with lighting circuit voltage in the room				
Sensor location is not subject to drafts from adjacent air registers				
Sensor location is not subject to extreme temperature variations				

- **The checklist items of Part 4 are all successfully completed for given trade.....** YES \_\_\_\_\_ NO \_\_\_\_\_

5. **Operational Checks** (These augment mfr's list. This is not the functional performance testing.) Check if Okay. Enter comment or note number if deficient.

Check	Equip Tag->				
Sensor timing is adjusted and verified as shown in plans					
Sensor sensitivity as adjusted as shown in plans					

**END OF EXHIBIT**



## **SECTION 26 08 12 - POWER DISTRIBUTION ACCEPTANCE**

### **TESTS PART 1 - GENERAL**

#### **1.1 RELATED WORK**

- A. Section 26 05 13.16 – Medium-Voltage, Single- and Multi-Conductor Cables
- B. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables
- C. Section 26 05 26 – Grounding and Bonding for Electrical Systems
- D. Section 26 05 73 – Power System Studies
- E. Section 26 12 19 – Pad-Mounted, Liquid-Filled, Medium-Voltage Transformers
- F. Section 26 13 16 – Medium-Voltage Fusible Pad-Mounted Switchgear
- G. Section 26 13 23 – Medium-Voltage Pad-Mounted Switchgear
- H. Section 26 22 00 – Low-Voltage Transformers
- I. Section 26 23 00 – Low-Voltage Switchgear
- J. Section 26 24 13 – Switchboards
- K. Section 26 24 16.13 – Lighting and Appliance Panelboards
- L. Section 26 27 13 – Electrical Metering
- M. Section 26 28 16 – Enclosed Switches and Circuit Breakers
- N. Section 26 29 13 – Enclosed Controllers
- O. Section 26 32 13 – Engine Generators
- P. Section 26 36 23 – Automatic Transfer Switches

#### **1.2 REFERENCE**

- A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions and sections under Division 01 General Requirements.

#### **1.3 DESCRIPTION**

- A. Section includes acceptance testing requirements for assessing the suitability for service and reliability of the power distribution system.
- B. Contractor to ensure all tested electrical equipment, both contractor and Owner supplied, is operational and within industry and manufacturer's tolerances and is installed in accordance with design specifications.
- C. Tests and inspections shall be performed after installation.
- D. Tests and inspections shall determine suitability for energization.
- E. Electrical systems shall pass tests prior to substantial completion or Owner occupancy.
- F. This specification requires contractor to engage services of testing agency.
- G. All tests tables referenced in this specification are to standard NETA Power Distribution Acceptance Test Tables.

- H. Items to be tested and inspected as follows:
1. 600-volt conductors and cables
  2. Medium-voltage cables
  3. Electrical metering
  4. Engine generator
  5. Dry type transformers (small)
  6. Dry type transformers (large)
  7. Liquid filled transformers
  8. Low-voltage switchgear
  9. Switchboard
  10. Medium-voltage metal-enclosed air switches
  11. Medium-voltage oil switches
  12. Medium-voltage air circuit breakers
  13. Medium-voltage vacuum circuit breakers
  14. Low-voltage power circuit breakers
  15. Low-voltage insulated-case/molded-case circuit breakers
  16. Low-voltage disconnect switches
  17. Medium-voltage SF<sub>6</sub> circuit breakers
  18. Medium-voltage SF<sub>6</sub> switches
  19. Medium-voltage surge arresters
  20. Network protectors (600 V class)
  21. Automatic transfer switches
  22. Motor control and motor control center
  23. Metal-enclosed busways
  24. Ground fault protection systems
  25. Grounding systems
  26. Protective relays (as applicable)
  27. Instrument transformers
  28. Thermographic survey

#### **1.4 REFERENCE STANDARDS**

- A. ANSI/IEEE C2 – National Electrical Safety Code
- B. ANSI/IEEE C37 – Guides and Standards for Circuit Breakers, Switchgear, Relays, Substations, and Fuses
- C. ANSI/IEEE C37.04 – Standard Rating Structure for AC High Voltage Circuit Breaker
- D. ANSI/IEEE C57 – Distribution, Power, and Regulating Transformers
- E. ANSI/IEEE C57.13.1 – Guide for Field Testing of Relaying Current Transformers
- F. ANSI/IEEE C57.13.3 – Grounding of Instrument Transformer Secondary Circuits and Gases
- G. ANSI/IEEE C57.104 – Guide for the Interpretation of Gases Generated in Oil-immersed Transformers
- H. ANSI/IEEE C62 – Surge Protection
- I. ANSI/IEEE Std. 43 – IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery
- J. ANSI/IEEE Std. 48 – Standard Test Procedure and Requirements for High-Voltage Alternating- Current Cable Terminations

- K. ANSI/IEEE Std. 81 – Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
- L. ANSI/IEEE Std. 141 – IEEE Recommended Practice for Electrical/Power Distribution for Industrial Plants (IEEE Red Book)
- M. ANSI/IEEE Std. 142 – IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems (IEEE Green Book)
- N. ANSI/IEEE Std. 241 – IEEE Recommended Practice for Electrical Power Systems in Commercial Buildings (IEEE Gray Book)
- O. ANSI/IEEE Std. 242 – IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (IEEE Buff Book)
- P. ANSI/IEEE Std. 399 – IEEE Recommended Practice for Power Systems Analysis (IEEE Brown Book)
- Q. ANSI/IEEE Std. 400 – Guide for Making High-Direct-Voltage Tests on Power Cable Systems in the Field
- R. ANSI/IEEE Std. 446 – IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications (IEEE Orange Book)
- S. ANSI/IEEE Std. 493 – IEEE Recommended Practice for the Design of Reliable Industrial and Commercial Power Systems (IEEE Gold Book)
- T. ANSI/IEEE Std. 1100 – IEEE Recommended Practice for Powering and Grounding Sensitive Electronic Equipment (IEEE Emerald Book)
- U. ASTM D877 – Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
- V. ASTM D823 – Standard Practices for Sampling Electrical Insulating Liquids
- W. ASTM D924 – Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids
- X. ASTM D971 – Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Methods
- Y. ASTM D974 – Standard Test Method for Acid and Base Number by Color-Indicator Titration
- Z. ASTM D1298 – Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method
- AA. ASTM 1500 – Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale)
- BB. ASTM D1524 – Standard Test Method for Visual Examination of Used Electrical Insulating Oils of Petroleum Origin in the Field
- CC. ASTM D1816 – Standard Test Method for Dielectric Breakdown Voltage of Insulating Oils of Petroleum Origin Using VDE Electrodes
- DD. ASTM D2285 – Standard Test Method for Interfacial Tension of Electrical Insulating Oils of Petroleum Origin Against Water by the Drop-Weight Method
- EE. ASTM D3612 – Standard Test Method for Analysis of Gases Dissolved in Electrical Insulating Oil by Gas Chromatography

- FF. ASTM D3613 – Standard Practice for Sampling Insulating Liquids for Gas Analysis and Determination of Water Content
- GG. NETA – Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems
- HH. NEMA AB 4 – Guidelines for Inspection and Preventive Maintenance of Molded-Case Circuit Breakers Used in Commercial and Industrial Applications
- II. NEMA MG1 – Motors and Generators JJ. NFPA 70 – National Electrical Code
- KK. NFPA 70B – Recommended Practice for Electrical Equipment Maintenance
- LL. NFPA 70E – Electrical Safety Requirements for Employee Workplaces MM. NFPA 101 – Life Safety Code
- NN. NFPA 110 – Emergency and Standby Power Systems
- OO. NIST – National Institute of Standards and Technology
- PP. OSHA – Part 1910 – Subpart S – 1910.308 – Special Systems

### 1.5 SUBMITTALS

- A. Test Reports: Include the following:
  - 1. Summary of project
  - 2. Description of equipment tested
  - 3. Equipment used to conduct the test
  - 4. Description of test
  - 5. Test results, as compared to manufacturers' or industry accepted standards and tolerances
  - 6. Conclusions and recommendations
  - 7. Signature of responsible test organization authority
- B. List of equipment used to perform tests. Identify the following:
  - 1. Type
  - 2. Manufacturer
  - 3. Model number
  - 4. Serial number
  - 5. Date of last calibration
  - 6. Documentation of calibration leading to NIST standards

### 1.6 QUALITY ASSURANCE

- A. Qualifications of Testing Agency:
  - 1. Testing firm shall be a corporately and financially independent testing organization that can function as an unbiased testing authority, professionally independent of the manufacturer, supplier, and installers of equipment or system evaluated by the testing firm.
  - 2. Testing firm shall be regularly engaged in testing of electrical equipment, devices, installations and systems.
  - 3. Testing firm will be a member of NETA
  - 4. Testing firm shall meet Federal Occupational Safety and Health Administration (OSHA) requirements for accreditation of independent testing laboratories.
  - 5. The on-site test technician will possess a NETA Level 3 certification or greater.

6. Testing firm shall use technicians who are regularly employed by the firm for testing services.
7. Testing firm shall submit proof of above qualifications with bid documents when requested.

## **PART 2 - PRODUCTS**

### **2.1 Not applicable to this Section.**

## **PART 3 - EXECUTION**

### **3.1 PREPARATION**

- A. Documentation: Deliver the following to testing firm, minimum two weeks prior to commencement of testing:
  1. Complete set of electrical plans and specifications, with available short circuit indicated on power riser diagrams.
  2. Approved submittals and shop drawings of equipment being tested.
  3. Pertinent change orders.
  4. Evaluation, overcurrent protective device coordination and arc flash studies, per requirements in Section 26 05 73 – Power System Studies.
- B. Schedule: Notify Owner's Representative 10 working days prior to performance of any tests.
- C. Coordination: Coordinate with Construction Manager/Owner's Representative the testing schedule and availability of equipment ready for testing.
- D. Test Power: Provide test power (including specialized) for equipment testing before and after service energizing.

### **3.2 FIELD QUALITY CONTROL**

- A. Inspection and Test Procedures: Comply with NETA.
  1. 600 V Conductors and Cables:
    - a. Visual and Mechanical Inspection:
      - 1) Compare cable data with drawing and specifications.
      - 2) Inspect exposed sections of cables for physical damage.
      - 3) Verify tightness of accessible bolted electrical connections by calibrated torque wrench in accordance with manufacturer's published data or NETA Table 12.
      - 4) Perform thermographic survey of bolted electrical connections in accordance with paragraph "Thermographic Survey."
      - 5) Inspect compression-applied connectors for correct cable match and indentation.
      - 6) Verify visible cable bends meet or exceed ICEA and manufacturer's minimum allowable bending radius.
      - 7) For cables are terminated through window-type current transformers, provide an inspection to verify neutral and ground conductors are correctly placed for operation of protective devices.

- 8) Inspect for correct identification and arrangements.
- 9) Inspect jacket and insulation condition.
- b. Electrical Tests:
  - 1) Perform insulation-resistance test using megohm meter. Applied potential to be 1000 VDC. Individually test each conductor with other conductors grounded. Test duration shall be one minute.
  - 2) Perform continuity tests to insure correct cable connection.
- c. Test Values:
  - 1) Insulation-resistance values should not be less than 50 megohms.
2. Medium-Voltage Cables:
  - a. Visual and Mechanical Inspection:
    - 1) Compare cable date with drawings and specifications.
    - 2) Inspect exposed sections of cables for physical damage.
    - 3) Verify tightness of accessible bolted connections by calibrated torque wrench in accordance with manufacturer's published data or NETA Table 12.
    - 4) Perform thermographic survey of bolted electrical connections in accordance with paragraph "Thermographic Survey."
    - 5) Inspect compression-applied connectors for correct cable match and indentation.
    - 6) Inspection for shield grounding, cable support, and termination.
    - 7) Verify visible cable bends meet or exceed ICEA and manufacturer's minimum allowable bending radius.
    - 8) Inspect for adequate fireproofing in common cable areas, if specified.
    - 9) For cables are terminated through window-type current transformers, provide an inspection to verify neutral and ground conductors are correctly placed and shields are correctly terminated for operation of protective devices.
    - 10) Inspect jacket and insulation condition.
    - 11) Inspect for correct identification and arrangements.
  - b. Electrical Tests:
    - 1) Perform shield-continuity test on each power cable by ohmmeter method and record value.
    - 2) Perform insulation-resistance test using megohm meter with voltage output of at least 2500 V. Individually test each conductor with other conductors and shields grounded. Test duration shall be 1 minute.
    - 3) Perform DC high-potential test on cables, including terminations and joints after cable system installation and before placing cable in service. Adhere to precautions and limits as specified in applicable NEMA/ICEA Standards for the specific cable. Perform tests in accordance with ANSI/IEEE Standard 400. Test voltages shall not exceed 80% of cable manufacturer's factory test value or maximum test voltage in NETA Table 6.
      - a) Insure input voltage to test set is regulated.
      - b) Current-sensing circuits in test equipment shall measure only leakage current associated with cable under test and shall not

- include internal leakage of test equipment.
  - c) Record wet- and dry-bulb temperatures or relative humidity and temperature.
  - d) Test each section of cable individually.
  - e) Individually test each conductor with other conductors grounded. Ground shields.
  - f) Terminations shall be adequately corona-suppressed by guard ring, field reduction sphere, or other suitable method as necessary.
  - g) Insure maximum test voltage does not exceed limits for terminators specified in ANSI/IEEE Standard 48 or manufacturer's specifications.
  - h) Apply DC high-potential test in at least 5 equal increments until maximum test voltage is reached. No increment shall exceed voltage rating of the cable. Record DC leakage current at each step after constant stabilization time consistent with system charging current.
  - i) Raise conductor to specified maximum test voltage and hold for 15 minutes on shielded cable and 5 minutes on non-shielded cable. Record readings of leakage current at 30 seconds and one minute and at one- minute intervals thereafter.
  - j) Reduce conductor test potential to zero and measure residual voltage at discrete intervals.
  - k) Apply grounds for time period adequate to drain insulation stored charge.
  - l) When new cables are spliced into existing cables, DC high-potential test shall be performed on new cable prior to splicing in accordance with this section. After test results are approved for new cable and splice is complete, perform insulation-resistance test and shield-continuity test on the length of new and existing cable including the splice. After satisfactory insulation-resistance test, DC high-potential test shall be performed on cable using test voltage acceptable to Owner's Representative and not exceeding 60% of factory test value.
- c. Test Values:
  - 1) Shielding must exhibit continuity. Investigate resistance values in excess of 10 ohms per 1000 ft of cable.
  - 2) Graphic plots may be made of leakage current versus step voltage at each increment and leakage current versus time at final test voltages.
    - a) Step voltage slope should be reasonably linear.
    - b) Capacitive and absorption current should decrease continually until steady state leakage is approached.
- 3. Electrical Metering:
  - a. Visual and Mechanical Inspection:
    - 1) Compare equipment nameplate data with drawings and specifications.

- 2) Inspect physical and mechanical condition.
- 3) Verify tightness of electrical connections.
- 4) Inspect cover gasket, cover glass, condition of spiral spring, disc clearance, contacts, and case-shorting contacts, as applicable.
- 5) Verify freedom of movement, correct travel and alignment, and tightness of mounting hardware.
- b. Electrical Tests:
  - 1) Check calibration of meters at cardinal points.
  - 2) Calibrate watt-hour meters according to manufacturer's published data.
  - 3) Verify instrument multipliers.
  - 4) Electrically confirm current transformer and voltage transformer secondary circuits are intact.
4. Engine Generator:
  - a. Visual and Mechanical Inspection:
    - 1) Compare equipment nameplate data with drawings and specifications.
    - 2) Inspect physical and mechanical condition.
    - 3) Inspect correct anchorage and grounding.
    - 4) Inspect air baffles, filter media, and cooling fans.
    - 5) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA Table 12.
    - 6) Confirm correct application of manufacturer's recommended lubricants.
  - b. Electrical and Mechanical Tests:
    - 1) Perform insulation-resistance test on generator winding with respect to ground in accordance with ANSI/IEEE Standard 43. Calculate polarization index.
    - 2) Test protective relay devices in accordance with paragraph "Protective Relays."
    - 3) Perform phase-rotation test to determine compatibility with load requirements.
    - 4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
    - 5) Perform vibration baseline test. Plot amplitude versus frequency for each main bearing cap.
    - 6) Conduct performance test in accordance with NFPA Standard 110, Section 7- 13 (Installation Acceptance).
    - 7) Verify correct functioning of governor and regulator.
    - 8) Verify function and temperature regulation for battery and engine heaters.
  - c. Test Values:
    - 1) Polarization index values shall be in accordance with ANSI/IEEE Standard 43.
    - 2) Vibration levels shall be in accordance with manufacturer's published data.
    - 3) Performance tests shall conform to manufacturer's published data and NFPA 110.
    - 4) Vibration amplitudes shall not exceed values shown in NETA Table 10.
    - 5) Bolt-torque levels shall be in accordance with NETA Table 12, unless



- otherwise specified by manufacturer.
5. Dry Type Transformers (Small):
    - a. Visual and Mechanical Inspection:
      - 1) Compare equipment nameplate data with drawings and specifications.
      - 2) Inspect physical and mechanical condition.
      - 3) Inspect anchorage, alignment, and grounding.
      - 4) Verify that resilient mounts are free and that any shipping brackets have been removed.
      - 5) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA Table 12.
    - 6) [Perform thermographic survey of bolted electrical connections, in accordance with paragraph "Thermographic Survey."]**
    - 7) Verify that as-lift tap connections are as specified.
    - b. Electrical Tests:
      - 1) Perform insulation-resistance tests winding-to-winding and each winding-to-ground with test voltage in accordance with NETA Table 5. Calculate dielectric absorption ratio or polarization index.
    - c. Test Values:
      - 1) Bolt-torque levels should be in accordance with NETA Table 12, unless otherwise specified by manufacturer.
      - 2) Insulation-resistance test values at one minute should be in accordance with NETA Table 5.
      - 3) The dielectric absorption or polarization index shall be greater than 1.0 and shall be recorded for future reference.
  6. Dry Type Transformers (Large):
    - a. Visual and Mechanical Inspection:
      - 1) Compare equipment nameplate data with drawings and specifications.
      - 2) Inspect physical and mechanical condition.
      - 3) Verify control and alarm settings on temperature indicators are as specified.
      - 4) Verify cooling fans operate correctly and fan motors have correct overcurrent protection.
      - 5) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA Table 12.
      - 6) Perform thermographic survey of bolted electrical connections in accordance with paragraph "Thermographic Survey."
      - 7) Perform specific inspections and mechanical tests as recommended by manufacturer.
      - 8) Make a close examination of shipping brackets or fixtures that may not have been removed during installation. Insure resilient mounts are free.
      - 9) Verify seismic bracing is correct.

- 10) Verify winding core, frame, and enclosure grounding are correct.
- 11) Verify as-lift tap connections are as specified.
- b. Electrical Tests:
  - 1) Perform insulation-resistance tests winding-to-winding and each winding-to-ground with test voltage in accordance with NETA Table 5.
  - 2) Calculate polarization index.
  - 3) Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's instructions.
  - 4) Perform turns-ratio test on tap connections. Verify winding polarities are in accordance with nameplate.
  - 5) Perform an excitation-current test on each phase.
  - 6) Measure resistance of each winding at each tap connection.
  - 7) Verify core is solidly grounded. If core is insulated and removable core ground strap is available, perform core insulation-resistance test at 500 VDC.
  - 8) Verify correct secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.
- c. Test Values:
  - 1) Bolt-torque levels shall be in accordance with NETA Table 12, unless otherwise specified by manufacturer.
  - 2) Insulation-resistance test values at one minute should not be less than values recommended in NETA Table 5. Results shall be temperature corrected in accordance with NETA Table 14.
  - 3) Polarization index should be compared to manufacturer's factory test results. If manufacturer's data is not available, acceptance test results will serve as baseline data.
  - 4) Turns-ratio test results should not deviate more than 0.5% from either adjacent coils or calculated ratio.
  - 5) CH and CL dissipation-factor/power-factor values will vary due to support insulators and bus work used on dry transformers. The following should be expected on CHL power factors:
    - a) Power Transformers: 2% or less
    - b) Distribution Transformers: 5% or less
  - 6) Consult transformer manufacturer's or test equipment manufacturer's data for additional information.
  - 7) If winding-resistance test results vary more than 1% from adjacent windings, consult manufacturer.
  - 8) Typical excitation current test data pattern for three-legged core transformer is two similar current readings and one lower current reading.
  - 9) If core insulation resistance is less than one megohm at 500 VDC, consult manufacturer.
7. Liquid Filled Transformers:
  - a. Visual and Mechanical Inspection:

- 1) Compare equipment nameplate data with drawings and specifications.
  - 2) Inspect physical and mechanical condition for physical damage, cracked insulators, and tightness of connection.
  - 3) Verify removal of shipping bracing after final placement.
  - 4) Inspect impact recorder prior to unloading, if applicable.
  - 5) Verify alarm, control, and trip settings on temperature and level indicators are as specified.
  - 6) Verify cooling fans and pumps operate correctly and fans and pump motors have correct overcurrent protection.
  - 7) Verify operation of alarm, control, and trip circuits from temperature and level indicators, pressure relief device, and fault pressure relay.
  - 8) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA Table 12.
  - 9) Perform thermographic survey in accordance with paragraph "Thermographic Survey."
  - 10) Verify correct liquid level in tanks and bushings.
  - 11) Perform specific inspections and mechanical tests as recommended by manufacturer.
  - 12) Verify correct equipment grounding.
  - 13) Verify seismic bracing is correct.
- b. Electrical Tests:
- 1) Perform insulation-resistance tests, winding-to-winding and each winding-to-grounding with test voltage in accordance with NETA Table 5. Test duration shall be for 10 minutes with resistance tabulated at 30 seconds, 1 minute, and 10 minutes.
  - 2) Calculate polarization index.
  - 3) Perform a turns-ratio test on no-load tap-changer positions and load tap-changer positions. Verify tap setting is as specified. Verify winding polarities are in accordance with nameplate.
  - 4) Perform insulation power-factor/dissipation-factor tests on windings and correct to 68°F in accordance with test equipment manufacturer's instructions.
  - 5) Perform power-factor/dissipation-factor tests (or hot collar watts-loss tests) on bushings and correct to 68°F in accordance with test equipment manufacturer's instructions.
  - 6) Perform excitation-current tests in accordance with test equipment manufacturer's instructions.
  - 7) Measure resistance of each high-voltage winding in each no-load tap-changer position. Measure resistance of each low-voltage winding in each load tap-changer position, if applicable.
  - 8) If core ground strap is accessible, measure core insulation resistance at 500 VDC.
  - 9) Measure percentage of oxygen in nitrogen blanket.

- 10) Remove sample of insulating liquid in accordance with ASTM D923. Sample shall be tested for the following:
  - a) Dielectric breakdown voltage: ASTM D877 and/or ASTM D1816.
  - b) Acid neutralization number: ASTM D974.
  - c) Specific gravity: ASTM D1298.
  - d) Interfacial tension: ASTM D971 or ASTM D2285.
  - e) Color: ASTM D1500.
  - f) Visual condition: ASTM D1524.
  - g) Measure dissipation factor or power factor in accordance with ASTM D924.
- 11) Remove sample of insulating liquid in accordance with ASTM D3613 and perform dissolved gas analysis (DGA) in accordance with ANSI/IEEE C57.104 or ATSM D3612.
- 12) Test instrument transformers in accordance with paragraph "Instrument Transformers."
- 13) Test surge arresters in accordance with paragraph "Surge Arresters."
- c. Test Values:
  - 1) Bolt-torque levels shall be in accordance with NETA Table 12, unless otherwise specified by manufacturer.
  - 2) Insulation-resistance test values at one minute should not be less than values recommended in NETA Table 5. Resistance values to be temperature corrected in accordance with NETA Table 14.
  - 3) Polarization index should be compared to manufacturer's factory test results. If manufacturer's data is not available, acceptance test results will serve as baseline data.
  - 4) Turns-ratio test results shall not deviate more than 0.5% from either the adjacent coils or the calculated ratio.
  - 5) Maximum power factor of liquid-filled transformers corrected to 68°F shall be in accordance with transformer manufacturer's published data. Representative values are shown in NETA Table 3. Compare with test equipment manufacturer's published data.
  - 6) Investigate bushing power factors and capacitances that vary from nameplate values by more than 10%. Investigate any bushing hot collar watts-loss results that exceed test equipment manufacturer's published data.
  - 7) Typical excitation-current test data pattern for three-legged core transformer is two similar current readings and one lower current reading.
  - 8) Consult manufacturer if winding-resistance measurements vary more than 1% from adjacent windings.
  - 9) Consult manufacturer if core insulation is less than one megohm at 500 VDC.
  - 10) Insulating liquid shall comply with NETA Table 4.
  - 11) Evaluate results of dissolved-gas analysis in accordance with IEEE Standard C57.104. Use results as baseline for future tests.
8. Low-Voltage Switchgear and Switchboard Assemblies:
  - a. Visual and Mechanical Inspection:

- 1) Compare equipment nameplate data with drawings and specifications.
- 2) Inspect physical and mechanical condition.
- 3) Confirm correct application of manufacturer's recommended lubricants.
- 4) Verify appropriate anchorage, required area clearances, grounding and correct alignment.
- 5) Inspect doors, panels, and sections for paint, dents, scratches, fit, and missing hardware.
- 6) Verify fuse and/or circuit breaker sizes and types correspond to drawings and coordination study as well as to circuit breaker's address for microprocessor- communication packages.
- 7) Verify that current and potential transformer ratios correspond to drawings.
- 8) Verify tightness of accessible bolted electrical connections by calibrated torque- wrench. Refer to manufacturer's published data or NETA Table 12 for proper torque values.
- 9) Perform thermographic survey of bolted electrical connections in accordance with paragraph "Thermographic Survey."
- 10) Confirm correct operation and sequencing of electrical and mechanical interlock systems.
  - a) Attempt closure on locked-open devices. Attempt to open locked-closed devices.
  - b) Make key exchange with devices operated in off-normal positions.
- 11) Inspect insulators for evidence of physical damage or contaminated surfaces.
- 12) Verify correct barrier and shutter installation and operation.
- 13) Exercise active components.
- 14) Inspect mechanical indicating devices for correct operation.
- 15) Verify filters are in place and/or vents are clear.
- 16) Perform visual and mechanical inspection of instrument transformers, in accordance with paragraph "Instrument Transformers."
- 17) Inspect control power transformers.
  - a) Inspect physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
  - b) Verify that primary and secondary fuse ratings or circuit breakers match drawings.
  - c) Verify correct functioning of draw-out disconnecting and grounding contacts and interlocks.

- b. Electrical Tests:
- 1) Perform tests on all instrument transformers in accordance with paragraph "Instrument Transformers."
  - 2) Perform resistance tests through bus joints with low-resistance ohmmeter. Joints that cannot be directly measured due to permanently installed insulation wrap shall be indirectly measured from closest accessible connection.
  - 3) Perform insulation-resistance tests in each bus section, phase-to-phase and phase-to-ground for one minute in accordance with NETA Table 1.
  - 4) Perform over-potential test on each bus section, each phase-to-ground with phases not under test grounded, in accordance with manufacturer's published data. In the absence of any published data, NETA Table 2 shall apply. Test voltage shall be applied for one minute.
  - 5) Perform insulation-resistance tests at 1000 VDC on control wiring. Test duration shall be one minute. Do not perform this test on wiring connected to solid-state components. Follow manufacturer's recommendation.
  - 6) Perform current injection tests on the entire current circuit in each section of switchgear.
    - a) Perform current tests by primary injection, where possible, with magnitudes such that minimum of 1.0 amp flows in secondary circuit.
    - b) Where primary injection is impractical, utilize secondary injection with minimum current of 1.0 amp.
    - c) Test current at each device.
  - 7) Determine accuracy of meters and calibrate watt-hour meters in accordance with paragraph "Electrical Metering." Verify multipliers.
  - 8) Perform phasing check on double-ended switchboard/switchgear to insure correct bus phasing from each source.
  - 9) Perform the following tests on control power transformers:
    - a) Perform insulation-resistance tests. Perform measurements from winding- to-winding and each winding-to-ground. Test voltages shall be in accordance with NETA Table 1 unless otherwise specified by manufacturer.
    - b) Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to correct secondary voltage. Confirm potential at all devices.
    - c) Verify correct secondary voltage by energizing primary winding with system voltage. Measure secondary voltage with secondary wiring disconnected.
    - d) Verify correct function of control transfer relays located in switchboard/switchgear with multiple control power sources.

- 10) Potential Transformer Circuits:
  - a) Perform insulation-resistance tests. Perform measurements from winding- to-winding and each winding-to-ground. Test voltages shall be in accordance with NETA Table 1, unless otherwise specified by manufacturer.
  - b) Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to correct secondary voltage.
  - c) Verify secondary voltage by energizing primary winding with system voltage. Measure secondary voltage with secondary wiring disconnected.
- 11) Verify operation of switchgear/switchboard space heaters.
- c. Test Values:
  - 1) Bolt-torque levels shall be in accordance with NETA Table 12, unless otherwise specified by manufacturer.
  - 2) Compare bus connection resistances to values of similar connections.
  - 3) Insulation-resistance values for bus, control wiring, and control power transformers shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA Table 1. Values of insulation resistance less than this table or manufacturer's minimum should be investigated. Over-potential tests should not proceed until insulation- resistance levels are raised above minimum values.
  - 4) Bus insulation shall withstand the over-potential test voltage applied.
  - 5) Contact resistance values shall not exceed high limit of normal range as indicated in manufacturer's published data. If manufacturer's data is not available, investigate values that deviate from similar bus by more than 50% of lowest value.
9. Medium-Voltage Metal-Enclosed Air Switches:
  - a. Visual and Mechanical Inspection:
    - 1) Compare equipment nameplate data with drawings and specifications.
    - 2) Inspect physical and mechanical condition.
    - 3) Confirm correct application of manufacturer's recommended lubricants.
    - 4) Verify appropriate anchorage, alignment and required area clearances.
    - 5) Verify appropriate equipment grounding.
    - 6) Verify correct blade alignment, blade penetration, travel stops, and mechanical operation.
    - 7) Verify fuse sizes and types are in accordance with drawing and short-circuit and coordination studies.
    - 8) Verify expulsion-limiting devices are in place on holders having expulsion-type elements.
    - 9) Verify each fuse holder has adequate mechanical support.
    - 10) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA Table 12.

- 11) Test interlocking systems for correct operating and sequencing.
- 12) Verify correct phase-barrier materials and installation.
- 13) Compare switchblade clearances with industry standards.
- 14) Inspect indicating and control devices for correct operation.
- 15) Record as-found and as-left operation-counter readings.
- b. Electrical Tests:
  - 1) 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 Table 1.
  - 2) Perform an over-potential test on each pole with switch closed. Test each pole- to- ground with other poles grounded. Test voltage shall be in accordance with manufacturer's published data or NETA Table 11.
  - 3) Measure contact resistance across each switchblade and fuse holder.
  - 4) Measure fuse resistance.
  - 5) Verify space heater operation.
  - 6) Perform insulation-resistance test on control wiring at 1000 VDC. Test duration shall be one minute. Do not perform this test on wiring connected to solid- state relays. Follow manufacturer's recommendations.
- c. Test Values:
  - 1) Bolt-torque levels shall be in accordance with NETA Table 12, unless otherwise specified by manufacturer.
  - 2) Insulation shall withstand over-potential test voltage applied.
  - 3) Minimum insulation-resistance shall be in accordance with manufacturer's published data or NETA Table 1.
  - 4) Investigate any contact resistance values that deviate from adjacent poles or similar switches by more than 50% of lowest value.
  - 5) Investigate fuse resistance values that deviate from each other by more than 15%.
  - 6) Control wiring insulation-resistance shall comply with manufacturer's published data. In the absence of manufacturer's published data, use NETA Table 1. Values of insulation resistance less than this table or manufacturer's minimum shall be investigated.
10. Medium-Voltage Oil Switches:
  - a. Visual and Mechanical Inspection:
    - 1) Compare equipment nameplate data with drawings and specifications.
    - 2) Inspect physical and mechanical condition.
    - 3) Inspect anchorage, alignment, grounding and required clearances.
    - 4) Perform mechanical operation and contact alignment tests on both the switch and its operating mechanism.
    - 5) Check each fuse holder for adequate support and contact.
    - 6) Verify fuse sizes and types correspond to drawings.
    - 7) Test electrical and mechanical interlock systems for correct operation and sequencing.
    - 8) Verify tightness of accessible bolted electrical connections and/or cable



- connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA Table 12.
- 9) Perform thermographic survey of accessible bolted electrical connections in accordance with paragraph "Thermographic Survey."
  - 10) Verify insulating oil level is correct.
  - 11) Confirm correct application of manufacturer's recommended lubricants.
  - 12) Record as-found and as-left operation-counter readings.
- b. Electrical Tests:
- 1) Measure contact resistance.
  - 2) Remove a sample of insulating liquid in accordance with ASTM D923.  
Sample shall be tested for the following:
    - a) Dielectric breakdown voltage: ASTM D877.
    - b) Color: ASTM D1500.
    - c) Visual condition: ASTM D1524.
  - 3) Perform insulation-resistance tests pole-to-pole, pole-to-ground, and across open poles. Test duration shall be one minute. Use a test voltage in accordance with NETA Table 1 or manufacturer's published data.
  - 4) Perform insulation-resistance test on control wiring at 1000 VDC. Test duration shall be one minute. Do not perform this test on wiring connected to solid-state relays. Follow manufacturer's recommendation.
  - 5) Perform and over-potential test on each pole with switch closed. Test each pole-to-ground with other poles grounded. Test voltage shall be in accordance with manufacturer's published data or NETA Table 11.
- c. Test Values:
- 1) Bolt-torque levels shall be in accordance with NETA Table 12, unless otherwise specified by manufacturer.
  - 2) Contact resistance values shall not exceed high limit of normal range as indicated in manufacturer's published data. If manufacturer's data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50% of lowest value.
  - 3) Insulating liquid shall comply with NETA Table 4.
  - 4) Control wiring insulation resistance shall comply with manufacturer's published data. In the absence of manufacturer's published data, use NETA Table 1. Values of insulation resistance less than this table or manufacturer's minimum shall be investigated.
11. Medium-Voltage Air Circuit Breakers:
- a. Visual and Mechanical Inspection:
- 1) Compare nameplate date with drawings and specifications.
  - 2) Inspect physical and mechanical condition.
  - 3) Confirm correct application of manufacturer's recommended lubricants.
  - 4) Inspect anchorage, alignment, and grounding.
  - 5) Inspect arc chutes.
  - 6) Inspect moving and stationary contacts for condition, wear, and alignment.
  - 7) Verify maintenance devices are available for servicing and operating breaker.
  - 8) Verify primary and secondary contact wipe and other dimensions

- vital to satisfactory operation are correct.
- 9) Perform mechanical operator and contact alignment tests on breaker and its operating mechanism in accordance with manufacturer's published data.
  - 10) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA Table 12.
  - 11) Perform thermographic survey of accessible bolted electrical connections in accordance with paragraph "Thermographic Survey."
  - 12) Check cell fit and element alignment.
  - 13) Check racking mechanism.
  - 14) Inspect puffer operation.
  - 15) Record as-found and as-left operation-counter readings.
  - 16) Show close/open breaker and check for binding, friction, contact alignment, and penetration. Verify that contact sequence is in accordance with manufacturer's published data. In the absence of manufacturer's published data, refer to ANSI C37.04.
  - 17) Perform time travel analysis.
- b. Electrical Tests:
- 1) Measure contact resistance.
  - 2) Measure insulation-resistance pole-to-pole, pole-to-ground, and across open poles. Test duration shall be one minute. Use a test voltage in accordance with NETA Table 1 or manufacturer's published data.
  - 3) Perform insulation-resistance test at 1000 VDC on all control wiring. Test duration shall be one minute. Do not perform the test on wiring connected to solid-state components. Follow the manufacturer's recommendation.
  - 4) With breaker in test position, make the following tests:
    - a) Trip and close breaker with control switch.
    - b) Trip breaker by operating each protective relay.
    - c) Verify trip-free and anti-pump function.
    - d) Test minimum pickup voltages for trip and close coils, if applicable, in accordance with NETA Table 20.
  - 5) Perform dissipation-factor/power-factor test with breaker in open and closed position.
  - 6) Perform an over-potential test in accordance with manufacturer's published data.
  - 7) Confirm operation of cubicle space heaters.
  - 8) Test instrument transformers in accordance with paragraph "Instrument Transformer."
  - 9) Measure arc diverter blowout coil circuit resistance.
- c. Test Values:
- 1) Bolt-torque levels shall be in accordance with NETA Table 12, unless otherwise specified by manufacturer.
  - 2) Compare microhm of millivolt drop values to manufacturer's published data. In the absence of manufacturer's data, compare adjacent poles or

- similar breakers. Investigate deviations of more than 50% from lowest value.
- 3) Minimum circuit breaker insulation-resistance should comply with NETA Table 1.
  - 4) Dissipation-factor/power-factor test results shall be compared to previous tests of similar breakers or manufacturer's published data.
  - 5) Insulation shall withstand over-potential test voltage applied.
  - 6) Minimum pickup for trip and close coils shall be in accordance with manufacturer's published data.
  - 7) Compare circuit breaker travel and velocity values to manufacturer's acceptable limits.
  - 8) Control wiring insulation-resistance shall comply with manufacturer's published data. In the absence of manufacturer's published data, use NETA Table 1. Values of insulation resistance less than this table or manufacturer's minimum shall be investigated.
12. Medium-Voltage Vacuum Circuit Breakers:
- a. Visual and Mechanical Inspection:
    - 1) Compare equipment nameplate data with drawings and specifications.
    - 2) Inspect physical and mechanical condition.
    - 3) Confirm correct application of manufacturer's recommended lubricants.
    - 4) Inspect anchorage, alignment, and grounding.
    - 5) Perform mechanical operational tests on circuit breaker and its operating mechanism.
    - 6) Measure critical distances such as contact gap as recommended by manufacturer.
    - 7) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA Table 12.
    - 8) Perform thermographic survey of accessible bolted electrical connections in accordance with paragraph "Thermographic Survey."
    - 9) Record as-found and as-left operation-counter readings.
    - 10) Confirm correct application of manufacturer's recommended lubricants.
    - 11) Perform time-travel analysis.
  - b. Electrical Tests:
    - 1) Perform contact-resistance test.
    - 2) Perform minimum pickup voltage tests on trip and close coils.
    - 3) Verify trip, close, trip-free, and anti-pump function.
    - 4) With breaker in test position, make the following tests:
      - a) Trip and close breaker with control switch.
      - b) Trip breaker by operating each protective relay.
      - c) Verify trip-free and anti-pump function.
      - d) Test minimum pickup voltages for trip and close coils, if applicable, in accordance with NETA Table 20.
    - 5) Perform insulation-resistance tests pole-to-pole, pole-to-ground, and across open poles. Test duration shall be one minute. Use a minimum

- test voltage in accordance with NETA Table 1 or manufacturer's published data.
- 6) Perform vacuum bottle integrity (over-potential) test across each vacuum bottle with breaker in open position in strict accordance with manufacturer's instructions. 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 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 breaker manufacturer's recommended maximum.)
  - 7) Perform insulation-resistance tests on all control wiring at 1000 VDC. Test duration shall be one minute. Do not perform this test on wiring connected to solid-state relays. Follow manufacturer's recommendation.
  - 8) Perform dissipation-factor/power-factor tests on each pole with breaker open and each phase with breaker closed.
  - 9) Perform dissipation-factor/power-factor tests on each bushing. Use conductive straps and hot collar procedures if bushings are not equipped with a power factor tap.
  - 10) Perform over-potential tests in accordance with manufacturer's instructions.
  - 11) Test instrument transformers in accordance with paragraph "Instrument Transformers."
- c. Test Values:
- 1) Bolt-torque levels shall be in accordance with NETA Table 12, unless otherwise specified by manufacturer.
  - 2) Compare contact resistance to adjacent poles or similar breakers. Investigate deviations of more than 50%. Investigate any value exceeding manufacturer's tolerance.
  - 3) Minimum insulation-resistance shall comply with NETA Table 1.
  - 4) Contact displacement shall be in accordance with factory-recorded data marked on nameplate of each vacuum breaker or bottle.
  - 5) Interrupter shall withstand over-potential voltage applied.
  - 6) Compare circuit breaker travel and velocity values to manufacturer's acceptable limits.
  - 7) Control wiring insulation-resistance shall comply with manufacturer's published data. In the absence of manufacturer's published data, use NETA Table 1. Values of insulation resistance less than this table or manufacturer's minimum shall be investigated.
  - 8) Dissipation-factor/power-factor test results shall be compared to manufacturer's published data. In the absence of manufacturer's published data, comparison shall be made to similar breakers.
  - 9) Dissipation-factor/power-factor and capacitance test results shall be within 10% of nameplate rating for bushings.

- 10) Insulation shall withstand over-potential test voltage applied.
13. Low-Voltage Power Circuit Breakers:
  - a. Visual and Mechanical Inspection:
    - 1) Compare nameplate data with drawings and specifications.
    - 2) Inspect physical and mechanical conditions.
    - 3) Confirm correct application of manufacturer's recommended lubricants.
    - 4) Inspect anchorage, alignment, and grounding.
    - 5) Inspect arc chutes.
    - 6) Inspect moving and stationary contacts for condition, wear, and alignment.
    - 7) Verify maintenance devices are available for serving and operating breaker.
    - 8) Verify primary and secondary contact wipe and other dimensions vital to satisfactory operation of breaker are correct.
    - 9) Perform mechanical operator and contact alignment tests on breaker and its operating mechanism.
    - 10) Verify tightness of accessible bolted bus connections by calibrated torque- wrench method. Refer to manufacturer's instructions or NETA Table 12 for correct torque levels.
    - 11) Perform thermographic survey of accessible bolted bus connections in accordance with paragraph "Thermographic Survey."
    - 12) Check cell fit and element alignment.
    - 13) Check racking mechanism.
    - 14) Record as-found and as-left operation-counter readings.
  - b. Electrical Tests:
    - 1) Perform contact-resistance test.
    - 2) Perform insulation-resistance test at 1000 VDC from pole-to-pole and from each pole-to-ground with breaker closed and across open contacts of each phase. Test duration shall be one minute. Use a minimum test voltage in accordance with NETA Table 1 or manufacturer's published data.
    - 3) Perform insulation-resistance test at 1000 VDC on control wiring. Test duration shall be one minute. Do not perform test on wiring connected to solid-state components. Follow manufacturer's recommendation.
    - 4) Make adjustments for final trip settings in accordance with overcurrent protective device coordination study.
    - 5) Determine minimum pickup current by primary current injection.
    - 6) Determine long-time delay by primary current injection.
    - 7) Determine short-time pickup and delay by primary current injection.
    - 8) Determine ground-fault pickup and delay by primary current injection.
    - 9) Determine instantaneous pickup value by primary current injection.
    - 10) Verify trip unit calibrations by secondary injection.
    - 11) Activate auxiliary protective devices, such as ground-fault or undervoltage relays, to insure operation of shunt trip devices. Check operation of electrically operated breakers in their cubicles. Perform minimum operation voltage on shunt trip and close coils in accordance with NETA Table 20.

- 12) Verify correct operation of auxiliary features such as trip and pickup indicators, zone interlocking, electrically close and trip operations, trip-free, anti-pump function, and trip unit battery condition. Reset all trip logs and indicators.
- 13) Check charging mechanism.
- 14) Determine minimum operation voltage on shunt trip and close coils in accordance with NETA Table 20.
- c. Test Values:
  - 1) Bolt-torque levels shall be in accordance with NETA Table 12, unless otherwise specified by manufacturer.
  - 2) Compare microhm or millivolt drop values to adjacent poles or similar breakers. Investigate deviations of more than 50% of the lowest value. Investigate any value exceeding manufacturer's recommendations.
  - 3) Circuit breaker insulation resistance shall be in accordance with NETA Table 1.
  - 4) Control wiring insulation-resistance shall comply with manufacturer's published data. In the absence of manufacturer's published data, use NETA Table 1. Values of insulation-resistance less than this table or manufacturer's minimum shall be investigated.
  - 5) Trip characteristics of breakers shall fall within manufacturer's published time- current tolerance bands.
  - 6) Minimum operation voltages on shunt trip and close coils shall be in accordance with manufacturer's published data. In the absence of manufacturer's data, refer to NETA Table 20.
14. Low-Voltage Insulated-Case/Molded-Case Circuit Breakers, 225A and Larger:
  - a. Visual and Mechanical Inspection:
    - 1) Compare nameplate date with drawings and specifications.
    - 2) Inspect circuit breaker for correct mounting.
    - 3) Check cell fit, element alignment and racking mechanism for draw-out breakers.
    - 4) Operate circuit breaker to insure smooth operation.
    - 5) Inspect case for cracks or other defects.
    - 6) Verify tightness of accessible bolted electrical connections and/or cable connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA Table 12.
    - 7) Inspect mechanism contacts and arc chutes in unsealed units.
  - b. Electrical Tests:
    - 1) Perform a contact-resistance test.
    - 2) Perform insulation-resistance test at 1000 VDC from pole-to-pole and from each pole-to-ground with breaker closed and across open contacts of each phase. Test duration shall be one minute. Use a minimum test voltage in accordance with NETA Table 1 or manufacturer's published data.
    - 3) Perform insulation-resistance test at 1000 VDC on all control wiring. Test duration shall be one minute. Do not perform the test on wiring connected to solid-state components. Follow manufacturer's recommendation.

- 4) Perform adjustments for final trip settings in accordance with overcurrent protective device coordination study.
  - 5) Perform long-time delay time-current characteristic tests by passing 300% rated current through each pole separately, unless series testing is required to defeat ground fault functions.
  - 6) Determine short-time pickup and delay by primary current injection.
  - 7) Determine ground-fault pickup and time delay by primary current injection.
  - 8) Determine instantaneous pickup current by primary injection using run-up or pulse method.
  - 9) Verify correct operation of auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and anti-pump function.
  - 10) Verify trip unit calibrations by secondary injection.
  - 11) Determine minimum operation voltage on shunt trip and close coils in accordance with NETA Table 20.
  - 12) Check charging mechanism.
- c. Test Values:
- 1) Bolt-torque levels shall be in accordance with NETA Table 12, unless otherwise specified by manufacturer.
  - 2) Compare microhm or millivolt drop values to adjacent poles or similar breakers. Investigate deviations of more than 50% of lowest value. Investigate any value exceeding manufacturer's recommendations.
  - 3) Circuit breaker insulation-resistance shall be in accordance with NETA Table 1.
  - 4) Control wiring insulation-resistance shall comply with manufacturer's published data. In the absence of manufacturer's published data, use NETA Table 1. Values of insulation resistance less than this table or manufacturer's minimum shall be investigated.
  - 5) Trip characteristic of breakers shall fall within 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 Table 7. Circuit breakers exceeding specified trip time at 300% of pickup shall be tagged defective.
  - 6) For molded-case circuit breakers, instantaneous pickup values shall be within manufacturer's published data or tolerances shown in NETA Table 8.
  - 7) Minimum operation voltages on shunt trip and close coils shall be in accordance with manufacturer's published data. In the absence of manufacturer's data, refer to NETA Table 20.
15. Low-Voltage Disconnect Switches:
- a. Visual and Mechanical Inspection:
    - 1) Compare equipment nameplate data with drawings and specifications.
    - 2) Inspect physical and mechanical condition.
    - 3) Inspect anchorage, alignment, grounding, and required clearances.
    - 4) Verify correct blade alignment, blade penetration, travel stops, and mechanical operation.
    - 5) Verify that fuse sizes and types are in accordance with drawings,

- 6) short-circuit and overcurrent protective device coordination studies.
  - 7) Verify that each fuse has adequate mechanical support and contact integrity.
  - 8) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA Table 12.
  - 9) Perform thermographic survey of accessible bolted electrical connection in accordance with paragraph "Thermographic Survey."
  - 10) Verify operation and sequencing of interlocking systems.
  - 11) Verify correct phase barrier installation.
  - 12) Verify correct operation of all indicating and control devices.
  - 13) Confirm correct application of manufacturer's recommended lubricants.
- b. Electrical Tests:
- 1) Measure contact resistance across each switchblade and fuseholder.
  - 2) Perform insulation-resistance test at 1000 VDC from pole-to-pole and from each pole-to-ground. Test duration shall be one minute. Use a minimum test voltage in accordance with NETA Table 1 or manufacturer's published data.
  - 3) Measure fuse resistance.
  - 4) Perform ground fault test, if applicable.
- c. Test Values:
- 1) Compare bolted connection resistances to values of similar connections.
  - 2) Bolt-torque levels should be in accordance with NETA Table 12, unless otherwise specified by the manufacturer.
  - 3) Compare microhm or millivolt drop values to adjacent poles or similar switches. Investigate deviations of more than 50% of lowest value. Investigate any value exceeding manufacturer's recommendations.
  - 4) Minimum insulation-resistance shall be in accordance with manufacturer's published data or NETA Table 1.
  - 5) Investigate fuse-resistance values that deviate from each other by more than 15%.
16. Medium-Voltage SF<sub>6</sub> Circuit Breakers:
- a. Visual and Mechanical Inspection:
- 1) Compare equipment nameplate date with drawings and specifications.
  - 2) Inspect physical and mechanical condition.
  - 3) Inspect anchorage, alignment and grounding.
  - 4) Verify that all maintenance devices such as special tools and gauges specified by the manufacturer are available for servicing and operating the breaker.
  - 5) Remove a sample of SF<sub>6</sub> gas if provisions are made for sampling and test in accordance with NETA Table 13.
  - 6) Inspect operating mechanism and SF<sub>6</sub> gas-insulated system in accordance with



- manufacturer's published data.
- 7) Test for SF<sub>6</sub> gas leaks if temperature-corrected pressure/density alarms or metering indicate a need.
  - 8) Verify correct operation of alarms and pressure-limit switches for pneumatic, hydraulic, and SF<sub>6</sub> gas pressure as recommended by manufacturer.
  - 9) If recommended by manufacturer, slow close/open breaker and check for binding, friction, contact alignment, and penetration. Verify that contact sequence is in accordance with manufacturer's published data. In the absence of manufacturer's published data, refer to ANSI/IEEE C37.04.
  - 10) Perform time-travel analysis.
  - 11) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA Table 12.
  - 12) Confirm correct application of manufacturer's recommended lubricants.
  - 13) Record as-found and as-left operation-counter readings.
- b. Electrical Tests:
- 1) Measure contact resistance.
  - 2) Perform insulation-resistance tests pole-to-pole, pole-to-ground, and across open poles. Test duration shall be one minute. Use a test voltage in accordance with NETA Table 1 or manufacturer's published data.
  - 3) Perform insulation-resistance test on control wiring at 1000 VDC. Test duration shall be one minute. Do not perform this test on wiring connected to solid-state relays. Follow manufacturer's recommendation.
  - 4) Verify trip, close, trip-free, and anti-pump function.
  - 5) Perform power-factor or dissipation-factor tests on breaker and bushings. Use hot collar procedures if bushings are not equipped with power-factor tap.
  - 6) Perform over-potential test in accordance with manufacturer's published data.
  - 7) Perform minimum pickup voltage tests on trip and close coils in accordance with NETA Table 20.
  - 8) Trip circuit breaker by operation of each protective device.
  - 9) Test instrument transformers in accordance with paragraph "Instrument Transformers."
- c. Test Values:
- 1) Bolt-torque levels shall be in accordance with NETA Table 12, unless otherwise specified by manufacturer.
  - 2) Compare microhm or millivolt values to adjacent poles or similar breakers or manufacturer's published data. Investigate deviations of more than 50% of lowest value. Investigate any value exceeding manufacturer's recommendations.

- 3) Compare circuit breaker travel and velocity values with manufacturer's published data.
  - 4) Circuit breaker insulation resistance should be in accordance with NETA Table 1. Refer to NETA Table 14 for temperature correction factors.
  - 5) Dissipation-factor/power-factor test results shall be compared to previous tests of similar breakers or manufacturer's published data.
  - 6) SF<sub>6</sub> gas should have values in accordance with NETA Table 13.
  - 7) Insulation shall withstand over-potential test voltage applied.
  - 8) Minimum pickup for trip and close coils shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, refer to NETA Table 20.
17. Medium-Voltage SF<sub>6</sub> Switches:
- a. Visual and Mechanical Inspection:
    - 1) Compare equipment nameplate data with drawings and specifications.
    - 2) Inspect physical and mechanical condition.
    - 3) Inspect anchorage, alignment and grounding.
    - 4) Inspect and service mechanical operator and SF<sub>6</sub> gas-insulated system in accordance with the manufacturer's published data.
    - 5) Inspect operating mechanism and SF<sub>6</sub> gas-insulated system in accordance with manufacturer's published data.
    - 6) Verify correct operation of SF<sub>6</sub> gas pressure alarms and limit switches, if applicable, as recommended by the manufacturer.
    - 7) Measure critical distances as recommended by the manufacturer.
    - 8) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA Table 12.
    - 9) Verify each fuse has adequate mechanical support and contact integrity.
    - 10) Verify fuse sizes and types correspond to drawings.
    - 11) Verify operation and sequencing of interlocking systems.
    - 12) Confirm correct application of manufacturer's recommended lubricants.
    - 13) Test for SF<sub>6</sub> gas leaks in accordance with manufacturer's published data.
    - 14) Record as-found and as-left operation-counter readings.
  - b. Electrical Tests:
    - 1) Measure contact resistance.
    - 2) Perform insulation-resistance tests pole-to-pole, pole-to-ground, and across open poles. Test duration shall be one minute. Use a test voltage in accordance with NETA Table 1 or manufacturer's published data.
    - 3) Perform insulation-resistance test on control wiring at 1000 VDC. Test duration shall be one minute. Do not perform this test on wiring connected to solid-state relays. Follow manufacturer's recommendations.
    - 4) Remove a sample of SF<sub>6</sub> gas if provisions are made for sampling and test in accordance with NETA Table 13.
    - 5) Perform over-potential test across each gas bottle with the switch in the open position in accordance with the manufacturer's published data.
    - 6) Verify open and close operation from control devices, if applicable.

- c. Test Values:
  - 1) Bolt-torque levels shall be in accordance with NETA Table 12 unless otherwise specified by manufacturer.
  - 2) Compare microhm or millivolt drop values to adjacent poles or similar switches. Investigate deviations of more than 50% of lowest value. Investigate any value exceeding manufacturer's recommendations.
  - 3) Insulation-resistance should be in accordance with manufacturer's published data or NETA Table 1.
  - 4) Critical distances of operating mechanism should be in accordance with manufacturer's published data.
  - 5) The gas interrupters shall withstand the over-potential voltage applied.
  - 6) Insulation shall withstand over-potential test voltage applied.
  - 7) SF6 gas should have values in accordance with NETA Table 13.
- 18. Medium-Voltage Surge Arresters:
  - a. Visual and Mechanical Inspection:
    - 1) Compare equipment nameplate data with drawings and specifications.
    - 2) Inspect physical and mechanical condition.
    - 3) Inspect anchorage, alignment and grounding.
    - 4) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA Table 12.
    - 5) Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.
    - 6) Verify the stroke counter is correctly mounted and electrically connected, if applicable.
    - 7) Record stroke counter reading.
  - b. Electrical Tests:
    - 1) Perform resistance measurements through bolted connections.
    - 2) Perform insulation-resistance test in accordance with NETA Table 1.
    - 3) Test grounding connection with a point-to-point resistance test.
    - 4) Perform a watts-loss test.
  - c. Test Values:
    - 1) Bolt-torque levels shall be in accordance with NETA Table 12, unless otherwise specified by manufacturer.
    - 2) Compare microhm or millivolt drop values to manufacturer's published data. In the absence of manufacturer's data, compare similar units. Investigate deviations of more than 50% from lowest value.
    - 3) Insulation resistance should be in accordance with manufacturer's published data or NETA Table 1.
    - 4) Resistance between the arrester ground terminal and ground shall be less than 0.5 ohm.
    - 5) Compare watts-loss to similar units.
- 19. Network Protectors – 600V Class:
  - a. Visual and Mechanical Inspection:
    - 1) Open protector and rack it out of enclosure. Note network bus and

transformer generally will be energized. Exercise extreme caution. Observe clearance and check for smoothness of operation when racking.

- 2) Compare equipment nameplate data with drawings and specifications.
  - 3) Inspect physical and mechanical condition.
  - 4) Inspect anchorage, alignment and grounding.
  - 5) Confirm correct application of manufacturer's recommended lubricants.
  - 6) Inspect enclosure door gasket and sight glass for damage.
  - 7) Inspect interior of enclosure for debris or damaged components. Inspect insulating components, current-carrying parts, and secondary disconnecting devices. Exercise extreme caution when working around network bus conductors.
  - 8) Check for missing parts on protector. Check tightness of electrical and mechanical connections. Tighten as necessary according to manufacturer's published data.
  - 9) Inspect insulating barriers for damage and correct mounting.
  - 10) Inspect network protector fuse covers, fuses, and blown fuse indicators for damage. Inspect closing motor brushes and commutator surface for damage. Inspect motor brake mechanism, if applicable.
  - 11) Remove and inspect arc chutes for damage.
  - 12) Verify sequence of main and arcing contacts by slow-closing protector. Adjust as necessary according to manufacturer's published data.
  - 13) Manually open and close protector and verify mechanism latches correctly in each position. Verify correct operation of position indicator.
  - 14) Verify electrical connections to network and auxiliary relays. Inspect electromechanical relays for freedom of movement of internal parts.
  - 15) Verify electrical connections to auxiliary switches, secondary disconnects, current transformers, voltage transformers, control power transformers, closing motors, contactors, trip coils, loading resistors, and other auxiliary devices.
  - 16) Record the as-found and as-left operations-counter reading.
  - 17) Perform leak test on submersible enclosure in accordance with manufacturer's published data.
- b. Electrical Tests:
- 1) Perform insulation-resistance tests on each pole, phase-to-phase and phase- to- ground with protector closed and across each open pole. Test duration shall be one minute. Test voltage shall be in accordance with NETA Table 1 or manufacturer's published data.
  - 2) Perform insulation-resistance tests at 1000 VDC for one minute on control wiring and electromechanical components. For units with solid-state components, follow manufacturer's recommendations.
  - 3) Verify current transformer ratios in accordance with paragraph

- “Instrument Transformers.”
- 4) Measure contact resistance.
  - 5) Measure resistance of each protector power fuse.
  - 6) Measure minimum pickup voltage of motor control relay.
  - 7) Verify motor can charge closing mechanism at minimum voltage specified by manufacturer.
  - 8) Measure minimum pickup voltage of trip actuator. Verify actuator resets correctly.
  - 9) Calibrate network protector relays in accordance with paragraph “Protective Relays.”
  - 10) Verify phase rotation, phasing and synchronized operation as required by the application.
  - 11) Perform operational tests:
    - a) Verify correct operation of mechanical and electrical interlocks.
    - b) Verify trip-free operation.
    - c) Verify correct operation of auto-open-close control handle.
    - d) Verify protector will close with voltage on transformer side only.
    - e) Verify protector will open when source feeder breaker is opened.
- c. Test Values:
- 1) Insulation-resistance of protector components shall be in accordance with NETA Table 1.
  - 2) Bolt-torque levels shall be in accordance with NETA Table 12, unless otherwise specified by the manufacturer.
  - 3) Control wiring insulation shall be in accordance with manufacturer’s published data. In the absence of manufacturer’s published data, use NETA Table 1. Values of insulation-resistance less than this table or manufacturer’s minimum should be investigated.
  - 4) Contact resistance shall be in accordance with manufacturer’s published data. In the absence of manufacturer’s published data, compare contact resistance to adjacent poles or similar protectors. Investigate deviations of more than 50% of the lowest value.
  - 5) Fuse resistance values shall not deviate by more than 15% of the lowest reading.
  - 6) Minimum voltage to operate trip actuator shall not exceed 7.5% of rated control circuit voltage.
  - 7) Minimum acceptable motor-closing voltage shall not exceed 75% of rated control circuit voltage.
  - 8) Network protector should automatically close upon closing feeder breaker with normal load demand and automatically trip when source feeder breaker is opened.
20. Automatic Transfer Switches:
- a. Visual and Mechanical Inspection:
    - 1) Compare equipment nameplate data with drawings and specifications.
    - 2) Inspect physical and mechanical condition.
    - 3) Confirm correct application of manufacturer’s recommended lubricants.
    - 4) Verify manual transfer warnings are attached and visible.

- 5) Verify tightness of control connections.
- 6) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA Table 12.
- 7) Perform thermographic survey of accessible bolted electrical connections in accordance with paragraph "Thermographic Survey."
- 8) Perform manual transfer operation.
- 9) Verify positive mechanical interlocking between normal and alternative sources.
- 10) Inspect anchorage, alignment, grounding and required clearances.
- b. Electrical Tests:
  - 1) Measure contact resistance.
  - 2) Perform insulation-resistance tests, phase-to-phase and phase-to-ground, with switch in both source positions. Test duration shall be one minute. Use a test voltage in accordance with NETA Table 1 or manufacturer's published data. For control devices that cannot tolerate test voltage, follow manufacturer's recommendation.
  - 3) Verify settings and operation of control devices.
  - 4) Calibrate and set relays and timers in accordance with paragraph "Protective Relays."
  - 5) Verify phase rotation, phasing and synchronized operation as required by the application.
  - 6) Perform automatic transfer tests:
    - a) Simulate loss of normal power.
    - b) Return to normal power.
    - c) Simulate loss of emergency power.
    - d) Simulate all forms of single-phase conditions.
  - 7) Verify correct operation and timing of following functions:
    - a) Normal source voltage-sensing relays.
    - b) Engine start sequence.
    - c) Time delay upon transfer.
    - d) Alternate source voltage-sensing relays.
    - e) Automatic transfer operation.
    - f) Interlocks and limit switch function.
    - g) Time delay and retransfer upon normal power restoration.
    - h) Engine cool down and shutdown feature.
- c. Test Values:
  - 1) Bolt-torque levels shall be in accordance with NETA Table 12, unless otherwise specified by manufacturer.
  - 2) Insulation-resistance test voltage and minimum values shall be in accordance with NETA Table 1.
  - 3) Compare microhm values to adjacent poles or similar switches. Investigate deviations of more than 50% of lowest value. Investigate any value exceeding manufacturer's recommendations.
21. Motor Control and Motor Control Center:
  - a. Visual and Mechanical Inspection:
    - 1) Compare equipment nameplate data with drawings and specifications.
    - 2) Inspect physical and mechanical condition.

- 3) Inspect anchorage, alignment and grounding.
  - 4) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA Table 12.
  - 5) Verify controller mechanical operations. Inspect gap, wipe, alignment, and pressure are in accordance with manufacturer's published data.
  - 6) Verify motor running protection installed and properly sized.
  - 7) Confirm correct application of manufacturer's recommended lubricants.
- b. Electrical Tests:
- 1) Perform resistance tests through all bus joints with low-resistance ohmmeter. Any joints that cannot be directly measured due to permanently installed insulation wrap shall be indirectly measured from closest accessible connection.
  - 2) Perform insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground with controller closed and across each open pole. Test duration shall be one minute. Use a test voltage in accordance with NETA Table 1 or manufacturer's published data. For control devices that cannot tolerate test voltage, follow manufacturer's recommendations.
  - 3) Perform insulation-resistance tests at 1000 VDC on control wiring. Test duration shall be one minute. Do not perform this test on wiring connected to solid-state components. Follow manufacturer's recommendations.
  - 4) Test motor protection devices in accordance with manufacturer's published data. In the absence of manufacturer's data, use paragraph "Protective Relays."
  - 5) Test circuit breakers in accordance with paragraph "Low-Voltage Insulated- Case/Molded-Case Circuit Breakers."
  - 6) Perform operational tests by initiating control devices.
- c. Test Values:
- 1) Bolt-torque levels shall be in accordance with NETA Table 12, unless otherwise specified by manufacturer.
  - 2) Compare bus connection resistances to values of similar connections.
  - 3) Insulation-resistance values for bus, control wiring, and control power transformers shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA Table 1. Values of insulation-resistance less than this table or manufacturer's minimum should be investigated.
  - 4) Motor protection parameters shall be in accordance with manufacturer's published data.
22. Metal Enclosed Busways:
- a. Visual and Mechanical Inspection:
- 1) Compare equipment nameplate data with drawings and specifications.
  - 2) Inspect busway for physical damage and correct connection in accordance with single-line diagram.

- 3) Inspect for appropriate bracing, suspension, alignment, and enclosure ground.
  - 4) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA Table 12.
  - 5) Perform thermographic survey of bolted electrical connections in accordance with paragraph "Thermographic Survey".
  - 6) Confirm physical orientation in accordance with manufacturer's labels to insure adequate cooling.
  - 7) Examine outdoor busway for removal of "weep-hole" plugs, if applicable, and correct installation of joint shield.
- b. Electrical Tests:
- 1) Measure insulation resistance of each busway, phase-to-phase and phase-to-ground for one minute, in accordance with NETA Table 1.
  - 2) Perform over-potential test on each busway, phase-to-ground with phases not under test grounded, in accordance with manufacturer's published data. Test voltage shall be applied for one minute. If manufacturer has recommendation for this test, it shall be in accordance with NETA Table 17.
  - 3) Perform contact-resistance test on each connection point of non-insulated busway. On insulated busway, measure resistance of assembled busway section and compare values to adjacent phase.
  - 4) Perform phasing test on each busway tie section energized by separate sources. Tests must be performed from their permanent sources.
  - 5) Verify operation of busway space heaters.
- c. Test Values:
- 1) Bus bolt-torque levels shall be in accordance with NETA Table 12, unless otherwise specified by manufacturer.
  - 2) Insulation-resistance test voltages and resistance values shall be in accordance with manufacturer's specifications or NETA Table 1. Minimum resistance values are for nominal 1000 ft busway run or megohms for 1000 ft. For busway runs over 1000 ft, convert the measured resistance value to the 1000 ft nominal value:
    - a)  $R_{1000\text{ ft}} = \text{Measured Resistance} \times \text{Length of Run} / 1000\text{ ft}$
  - 3) Values of insulation-resistance less than NETA Table 1 or manufacturer's minimum should be investigated. Over-potential tests should not proceed until insulation-resistance levels are raised above minimum values.
  - 4) Over-potential test voltages shall be applied in accordance with manufacturer's recommendations. Insulation shall withstand over-potential test voltage applied.
23. Ground Fault Protection Systems:
- a. Visual and Mechanical Inspection:
    - 1) Compare equipment nameplate data with drawings and specifications.
    - 2) Visually inspect components for damage and errors in polarity or



conductor routing:

- a) Verify ground connection is made ahead of neutral disconnect link and online side of any ground fault sensor.
  - b) Verify neutral sensors are connected with correct polarity on both primary and secondary.
  - c) Verify all phase conductors and neutral pass through sensor in same direction for zero sequence systems.
  - d) Verify grounding conductors do not pass through zero sequence sensors.
  - e) Verify grounded conductor is solidly grounded.
- 3) Verify tightness of accessible bolted electrical connections, including control circuits, by calibrated torque-wrench method in accordance with manufacturer's published data or NETA Table 12.
  - 4) Verify correct operation of self-test panel.
  - 5) Set pickup and time-delay settings in accordance with settings provided on drawings and in specifications. Record operation and test sequences as required by NFPA 70.
  - 6) Verify the control power transformer has adequate capacity for the system.
- b. Electrical Tests:
- 1) Measure system neutral-to-ground insulation resistance with neutral disconnect link temporarily removed. Replace neutral disconnect link after testing.
  - 2) Perform insulation-resistance test of control wiring at 1000 VDC for one minute. Do not perform this test on wiring connected to solid-state components. Follow manufacturer's recommendations.
  - 3) Perform the following pickup tests using primary injection:
    - a) Verify relay does not operate at 90% of pickup setting.
    - b) Verify pickup is less than 125% of setting or 1200 amp, whichever is smaller.
  - 4) For summation type systems using phase-neutral current transformers, verify correct polarities by applying current to each phase-neutral current transformer pair. This test also applies to molded-case breakers using external neutralcurrent transformer.
    - a) Relay should operate when current direction is the same relative to polarity marks in the two current transformers.
    - b) Relay should not operate when current direction is opposite relative to polarity marks in the two current transformers.
  - 5) Measure time delay of the relay at 150% or greater of pickup.
  - 6) Verify reduced voltage tripping capability: 55% for AC systems and 80% for DC systems.
- c. Test Values:
- 1) System neutral-to-ground insulation shall be minimum of one megohm.
  - 2) Insulation resistance values shall be in accordance with NETA Table 1.
  - 3) Relay timing shall be in accordance with manufacturer's specifications but must also be no longer than one second at 3000 amp.
  - 4) Bus bolt-torque levels shall be in accordance with NETA Table 12,

- unless otherwise specified by manufacturer.
24. Grounding Systems:
    - a. Visual and Mechanical Inspection:
      - 1) Verify ground system is in compliance with drawings, specifications, and NFPA 70.
      - 2) Inspect physical and mechanical condition.
      - 3) Inspect anchorage.
    - b. Electrical Tests:
      - 1) Perform 3 point fall-of-potential or alternative test in accordance with ANSI/IEEE 81 on all newly established grounding electrode systems.
      - 2) Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral, and/or derived neutral points.
      - 3) Make resistance measurements in dry weather not earlier than 48 hours after rainfall.
    - c. Test Values:
      - 1) The resistance between the main grounding electrode and ground should be no greater than five ohms. (Reference ANSI/IEEE 142.) Investigate any values above five ohms and notify Owner's Representative immediately for further instructions.
      - 2) Investigate point-to-point resistance values that exceed 0.5 ohm.
  25. Protective Relays (as applicable):
    - a. Visual and Mechanical Inspection:
      - 1) Compare equipment nameplate data with drawings and specifications.
      - 2) Inspect relays and cases for physical damage. Remove shipping restraint material.
      - 3) Tighten case connectors. Inspect cover for correct gasket seal. Clean cover glass. Inspect shorting hardware, connection paddles, and knife switches. Remove foreign material from case. Verify target reset.
      - 4) Inspect relay for foreign material, particularly in disc slots of damping and electromagnets. Verify disk clearance. Verify contact clearance and spring bias. Inspect spiral spring convolutions. Inspect disk and contacts for freedom of movement and correct travel. Verify tightness of mounting hardware and connections. Burnish contacts. Inspect bearings and pivots.
      - 5) Set relays in accordance with coordination study supplied.
    - b. Electrical Tests:
      - 1) Perform insulation-resistance test on each circuit-to-frame. Determine from manufacturer's instructions allowable procedures for this test for solid-state and microprocessor-based relays.
      - 2) Inspect targets and indicators. Determine pickup and dropouts of electromechanical targets. Verify operation of light-emitting diode indicators. Set contrast for liquid-crystal display readouts.
      - 3) Functional Operation:
        - a) IEEE 2/62 Timing Relay
          - i) Determine time delay.

- ii) Verify operation of instantaneous contacts.
- b) IEEE 21 Distance Relay
  - i) Determine maximum reach.
  - ii) Determine maximum torque angle.
  - iii) Determine offset.
  - iv) Plot impedance circle.
- c) IEEE 24 V/Hz Relay
  - i) Determine pickup frequency at rated voltage.
  - ii) Determine pickup frequency at second voltage level.
  - iii) Determine time delay.
- d) IEEE 25 Sync Check Relay
  - i) Determine closing zone at rated voltage.
  - ii) Determine maximum voltage differential that permits closing at zero degrees.
  - iii) Determine live line, live bus, dead line, and dead bus set points.
  - iv) Determine time delay.
  - v) Verify dead bus/live line, dead line/live bus and dead bus/dead line control functions.
- e) IEEE 27 Undervoltage Relay
  - i) Determine dropout voltage.
  - ii) Determine time delay.
  - iii) Determine time delay at second point on timing curve for inverse time relays.
- f) IEEE 32 Directional Power Relay
  - i) Determine minimum pickup at maximum torque angle.
  - ii) Determine closing zone.
  - iii) Determine maximum torque angle.
  - iv) Determine time delay
  - v) Verify time delay at second point on timing curve for inverse time relays.
  - vi) Plot operating characteristic.
- g) IEEE 40 Loss of Field (Impedance) Relay
  - i) Determine maximum reach.
  - ii) Determine maximum torque angle.
  - iii) Determine offset.
  - iv) Plot impedance circle.
- h) IEEE 46 Current Balance Relay
  - i) Determine pickup of each unit.
  - ii) Determine percent slope.
  - iii) Determine time delay.
- i) IEEE 46N Negative Sequence Current Relay
  - i) Determine negative sequence alarm level.
  - ii) Determine negative sequence minimum trip level.
  - iii) Determine maximum time delay.
  - iv) Verify two points on  $(I_2)^2t$  curve.
- j) IEEE 47 Phase Sequence or Phase Balance Voltage Relay
  - i) Determine positive sequence voltage to close normally open contact.
  - ii) Determine positive sequence voltage to open normally

- closed contact (undervoltage trip).
- iii) Verify negative sequence trip.
- iv) Determine time delay to close normally open contact with sudden application of 120% of pickup.
- v) Determine time delay to close normally closed contact upon removal of voltage when previously set to rated system voltage.
- k) IEEE 49R Thermal Replica Relay
  - i) Determine time delay at 300% of setting.
  - ii) Determine second point on operating curve.
  - iii) Determine pickup.
- l) IEEE 49T Temperature (RTD) Relay
  - i) Determine trip resistance.
  - ii) Determine reset resistance.
- m) IEEE 50 Instantaneous Overcurrent Relay
  - i) Determine pickup.
  - ii) Determine dropout.
  - iii) Determine time delay.
- n) IEEE 51 Time Overcurrent
  - i) Determine minimum pickup.
  - ii) Determine time delays at 2 points on time current curve.
- o) IEEE 55 Power Factor Relay
  - i) Determine tripping angle.
  - ii) Determine time delay.
- p) IEEE 59 Overvoltage Relay
  - i) Determine overvoltage pickup.
  - ii) Determine time delay to close contact with sudden application of 120% of pickup.
- q) IEEE 60 Voltage Balance Relay
  - i) Determine voltage difference to close contacts with one source at rated voltage.
  - ii) Plot operating curve for relay.
- r) IEEE 63 Transformer Sudden Pressure Relay
  - i) Determine rate-of-rise or pickup level of suddenly applied pressure in accordance with manufacturer's specifications.
  - ii) Verify operation of 63 FPX seal-in circuit.
  - iii) Verify trip circuit to remote breaker.
- s) IEEE 64 Ground Detector Relay
  - i) Determine maximum impedance to ground causing relay pickup.
- t) IEEE 67 Directional Overcurrent Relay
  - i) Determine directional unit minimum pickup at maximum torque angle.
  - ii) Determine closing zone.
  - iii) Determine maximum torque angle.
  - iv) Plot operating characteristics.
  - v) Determine overcurrent unit pickup.
  - vi) Determine overcurrent unit time delay at 2 points on time

- current curve.
- u) IEEE 79 Reclosing Relay
  - i) Determine time delay for each programmed reclosing interval.
  - ii) Verify lockout for unsuccessful reclosing.
  - iii) Determine reset time.
  - iv) Determine close pulse duration.
  - v) Verify instantaneous overcurrent lockout.
- v) IEEE 81 Frequency Relay
  - i) Verify frequency set points.
  - ii) Determine time delay.
  - iii) Determine undervoltage cutoff.
- w) IEEE 85 Pilot Wire Monitor
  - i) Determine overcurrent pickup.
  - ii) Determine undercurrent pickup.
  - iii) Determine pilot wire ground pickup level.
- x) IEEE 87 Differential
  - i) Determine operating unit pickup.
  - ii) Determine operation of each restraint unit.
  - iii) Determine slope.
  - iv) Determine harmonic restraint.
  - v) Determine instantaneous pickup.
  - vi) Plot operating characteristics for each restraint.
- c. Control Verification:
  - 1) Verify each relay contact performs its intended function in control scheme including breaker trip tests, close inhibit tests, 86 lockout tests, and alarm functions.
  - 2) For microprocessor-based relays, verify all inputs, outputs, internal logic, and timing elements used in protection, metering, and control functions.
- d. Systems Tests:
  - 1) After the equipment is energized, measure magnitude and phase angle of inputs and compare to expected values.
- e. Test Values:
  - 1) When not otherwise specified, use manufacturer's recommended tolerances.
  - 2) When critical test points are specified, relay should be calibrated to those points even though other test points may be out of tolerance.
- 26. Instrument Transformers:
  - a. Visual and Mechanical Inspection:
    - 1) Compare equipment nameplate data with drawings and specifications.
    - 2) Inspect physical and mechanical condition.
    - 3) Verify correct connection of transformers with system requirements.
    - 4) Verify adequate clearance between primary and secondary circuit wiring.
    - 5) Verify tightness of accessible bolted electrical connections by calibrated torque- wrench method in accordance with manufacturer's published data or NETA Table 12.
    - 6) Perform thermographic survey of bolted electrical connections in accordance with paragraph "Thermographic Survey."

- 7) Verify required grounding and shorting connections provide contact.
  - 8) Verify correct operation of transformer withdrawal mechanism and grounding operation.
  - 9) Verify correct primary and secondary fuse sizes for potential transformers.
  - 10) Confirm correct application of manufacturer's recommended lubricants.
- b. Electrical Tests – Current Transformers:
- 1) Perform insulation-resistance test of current transformer and wiring-to-ground at 1000 VDC. Do not perform this test on wiring connected to units with solid-state components. Follow manufacturer's recommendations.
  - 2) Perform polarity test of each current transformer.
  - 3) Perform ratio-verification test using voltage or current method in accordance with ANSI/IEEE C57.13.1.
  - 4) Perform excitation test on transformers used for relaying applications in accordance with ANSI/IEEE C57.13.1.
  - 5) Measure current circuit burdens at transformer terminal and determine total burden.
  - 6) When applicable, perform insulation-resistance and dielectric withstand tests on primary winding with secondary grounded. Test voltages shall be in accordance with NETA Tables 5 and 9 respectively.
  - 7) Verify that current circuits are grounded and have only one grounding point in accordance with ANSI/IEEE C57.13.3.
- c. Electrical Tests – Voltage Transformers:
- 1) Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Test voltages shall be applied for one minute in accordance with NETA Table 5. For units with solid-state components, follow manufacturer's recommendation.
  - 2) Perform polarity test on each transformer to verify polarity marks or H1-X1 relationship as applicable.
  - 3) Perform turns ratio test on all tap positions, if applicable.
  - 4) Measure potential circuit burdens at transformer terminals and determine total burden.
  - 5) Perform dielectric withstand test on primary windings with secondary windings connected to ground. Dielectric voltage shall be in accordance with NETA Table 9. Test voltage shall be applied for one minute.
- d. Test Values:
- 1) Insulation-resistance measurement on instrument transformer shall not be less than that shown in NETA Table 5.
  - 2) Bolt-torque levels shall be in accordance with NETA Table 12, unless otherwise specified by the manufacturer.
  - 3) Polarity results shall agree with system drawings.
  - 4) Compare measured burdens to calculated burdens supplied by Owner's Representative.
  - 5) Ratio accuracies shall be within 0.5% of nameplate or manufacturer's published data.

- 6) Insulation shall withstand over-potential test voltage applied.
27. Thermographic Survey:
- a. Visual and Mechanical Inspection:
    - 1) Inspect physical, electrical, and mechanical conditions.
    - 2) Remove all necessary covers prior to thermographic inspection.
    - 3) Equipment to be inspected shall include all current-carrying devices.  
Provide report including the following:
      - a) Discrepancies.
      - b) Temperature difference between area of concern and reference area.
      - c) Cause of temperature difference.
      - d) Areas inspected. Identify inaccessible and unobservable areas and equipment.
      - e) Identify load conditions at time of inspection.
      - f) Provide photographs and thermogram of deficient area.
  - b. Test Parameters:
    - 1) Inspect distribution systems with imaging equipment capable of detecting minimum temperature difference of 2°F at 86°F.
    - 2) Equipment shall detect emitted radiation and convert detected radiation to visual signal.
    - 3) Thermographic surveys should be performed during periods of maximum possible loading but not less than 40% of rated load of the electrical equipment being inspected. Refer to NFPA 70B, Section 20.17 (Infrared Inspection).
  - c. Test Results:
    - 1) Temperature differences of 2°F to 5 °F indicate possible deficiency and warrant investigation.
    - 2) Temperature differences of 7°F to 27°F indicate deficiency; repair as time permits.
    - 3) Temperature differences of 29°F and above indicate major deficiency; repair immediately.
    - 4) Suggested actions based on temperature rise can be found in NETA Table 18.
- B. Test Reports:
1. Testing firm shall do the following:
    - a. Prepare test report, including description of equipment tested, description of test, test results, conclusions and recommendations, retesting results, list of test equipment used and calibration date.
    - b. Show test results in comparison to industry and manufacturer's values and tolerances.
    - c. Interpret test results in writing and give recommendations for acceptance or rejection upon consultation with Owner's Representative and prior to energizing equipment.
    - d. Assure electrical equipment is operational and within industry and manufacturer's tolerances and is installed in accordance with contract documents.
    - e. Assure suitability of energization.

- f. Report to the Owner's Representative any system, material, or workmanship that is found defective on the basis of acceptance tests.
  - g. Retest equipment when required.
  - h. Maintain written record of tests.
  - i. Utilize safety practices during the tests in accordance with:
    - 1) Acceptable state and local safety operating procedures
    - 2) Owner's safety practices
    - 3) OSHA
    - 4) NFPA 70E
  - j. Perform tests with apparatus de-energized and grounded, except where otherwise specifically required ungrounded by test procedures.
  - k. Assemble and certify final test report.
  - l. Provide 4 copies of complete test report.
  - m. Attach label to all tested equipment with indication of date tested and testing firm name.
2. Contractor shall do the following:
- a. Investigate, replace, or repair any fault in material or in any part of the installation revealed by the tests.
  - b. Deliver one copy of each test report directly to Owner's Representative within 30 days after completion of testing, unless directed otherwise. Insert a copy of each test report in the equipment operation and maintenance manuals.
- C. Test Equipment:
- 1. Test Instrument Calibration:
    - a. Testing firm shall have calibration program that assures test instruments are maintained with rated accuracy.
    - b. Instruments shall be calibrated in accordance with the following frequency schedule:
      - 1) Field instruments: Analog, 6 months maximum; Digital, 12 months maximum
      - 2) Laboratory instruments: 12 months
      - 3) Leased specialty equipment: 12 months where accuracy is guaranteed by lessor
    - c. Dated calibration labels shall be visible on test equipment.
    - d. Records, which show date and results of instruments calibrated or tested, must be kept up-to-date.
    - e. Up-to-date instrument calibration instructions and procedures shall be maintained for test instrument.
    - f. Equipment used for field testing shall be more accurate than instrument being tested.
    - g. Calibrating standard applied to testing equipment shall be of higher accuracy than instrument tested.

**END OF SECTION 26 08 12**



## **SECTION 26 09 23 - LIGHTING CONTROL DEVICES**

### **PART 1 - GENERAL**

#### **1.1 RELATED WORK**

- A. Section 26 00 00 - General Electrical Requirements
- B. Section 26 50 00 - Lighting

#### **1.2 REFERENCE**

- A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

#### **1.3 DESCRIPTION OF SYSTEM**

- A. Provide devices such as wall box dimmers, wall and ceiling mounted occupancy sensors, ambient light sensors, sensor power packs, etc., as shown on drawings.
- B. Openings shall be covered with devices and matching plates.
- C. Devices of same type shall be from same manufacturer.

#### **1.4 REFERENCE STANDARDS**

- A. UL20 - General Use Snap Switches.
- B. UL773A - Non-Industrial Photoelectric Switches for Lighting Control.
- C. UL924 - Emergency Lighting and Power Equipment
- D. NEMA WD 7 - Occupancy Motion Sensors.
- E. NEMA IP - Ingress Protection Rating
- F. California Building Energy Efficiency Standards
- G. California Title 20 Appliance Efficiency Database

#### **1.5 SUBMITTALS**

- A. Product Data: For each type of product indicated.
- B. Shop Drawings shall include:
  - 1. Bill of material
  - 2. Schematic diagrams
  - 3. Suggested manufacturer layouts of all devices including overlays of product range.
- C. Samples: One for each type of device and wall plate specified, in each color specified upon request.
- D. Manufacturer's Installation Instructions:
  - 1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination,

preparation, installation, and starting of product.

- E. Test Reports: Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.

Closeout Submittals:

- 1. Project Record Documents:
  - a. Record actual locations and type of devices.
- 2. Operation and Maintenance Data:
  - a. Include in manufacturers' packing label warnings and instruction manuals with labeling conditions.
  - b. Include source and current prices of replacement parts and supplies.

## 1.6 QUALITY ASSURANCE

- A. Obtain devices from one source and by single manufacturer.
- B. Regulatory Requirements:
  - 1. Comply with NFPA 70 for components and installation.
  - 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

## 1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store in clean, dry space. Maintain factory unopened packaging until ready for installation.

## 1.8 WARRANTY

- A. Refer to Division 01 and Section 26 00 00 – General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1-year warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Manufacturers (Per campus standard):
  - 1. Wall Box Dimmers: Acuity nLight
  - 2. Low Voltage Switches: Acuity nLight
  - 3. Sensors and Power Packs: Acuity nLight
  - 4. Exterior Occupancy Sensors: Acuity nLight
  - 5. UL 924 Emergency Bypass/Control Device: Acuity nLight
  - 6. Exterior Photocells: Acuity nLight
  - 7. Self-Contained Automatic Timer Switches: Acuity nLight
  - 8. Line voltage devices when approved for use:
    - a. Ceiling mounted occupancy sensor: Legrand DT-355, or approved equal
    - b. Wall mount line voltage dimming: Legrand RH4FBL3PTC, or approved equal
    - c. Intermatic time clocks and photocell: to be approved by campus

- B. It is the responsibility of Electrical Contractor to ensure devices submitted meet or exceed functional intent and design quality standards.

## **2.2 FABRICATION AND MANUFACTURE**

- A. Devices shall be UL listed for loads and voltages as indicated in contract drawings and specifications.
- B. Devices shall comply with CA Title 20 Appliance Efficiency Regulations.

## **2.3 WALL BOX DIMMERS**

- A. Dimmers shall:
  - 1. Operate in ambient temperature range of 32°F to 104°F.
  - 2. Be linear slide or pushbutton preset or programmable dimmers with power-failure memory.
  - 3. Incorporate separate control of intensity and ON/OFF.
  - 4. Include voltage compensation circuitry that adjusts firing angle of dimmer to compensate light output for variations in AC line voltage. Dimmers in which firing angle is held constant with varying AC line voltage shall not be acceptable.
  - 5. Provide smooth and continuous IESNA Square Law Dimming Curve throughout entire dimming range.
  - 6. Incorporate filter network to minimize interference (RFI) with radio, audio, and video equipment.
  - 7. Incorporate air-gap switch to meet requirements of UL 20 for air-gap switches in incandescent dimmers.
- B. LED dimmers shall:
  - 1. Be approved for use with luminaire and driver.
  - 2. Provide smooth non-flicker dimming of controlled luminaires.
  - 3. Be 0-10V type, unless noted otherwise on drawings.
  - 4. Provide at least 10 steps for continuously dimmed luminaires.
  - 5. Refer to Section 26 5000 – Interior Lighting for solid state dimming ballast/driver specification.

## **2.4 LOW-VOLTAGE SWITCHES**

- A. Low voltage switches shall:
  - 1. Mount in a single or double gang box.
  - 2. Be capable of multi-way switching.

## **2.5 OCCUPANCY AND VACANCY SENSORS**

- A. Sensors shall:
  - 1. Operate with all lamp and ballast combinations; including magnetic, hybrid, and solid- state ballasts/drivers.
  - 2. Operate with ultrasonic, microphonic, passive infrared or presence technologies as indicated on drawings.
  - 3. Have visible LED to indicate occupant detection.
  - 4. Have adjustable time delay with a maximum setting of 30 minutes and adjustable

- sensitivity.
  - 5. Contain isolated relay, or remote relay with normally open, normally closed, and common outputs for use with HVAC system, data logging, controlled receptacles or other system control options where indicated in the contract documents.
  - 6. Be provided with ceiling, wall or wall switch style mounting as indicated on drawings.
  - 7. Have daylight filter to ensure PIR sensor is insensitive to short-wavelength waves emitted by the sun.
  - 8. Incorporate by-pass switch to enable lighting to be turned on if sensor fails.
  - 9. Be low voltage wired in parallel to common power pack, where applicable
- B. Occupancy Sensor shall:
- 1. Provide automatic ON, automatic OFF operation where indicated on drawings.
- C. Vacancy Sensor shall:
- 1. Provide manual ON, automatic OFF operation where indicated on drawings.
- D. Partial-ON Occupancy Sensor shall:
- 1. Provide automatic ON for a portion of the luminaires within a space and automatic OFF for all luminaires within a space where indicated on drawings. The additional luminaires within a space will be controlled ON manually but will be forced OFF when occupancy is not detected.
- E. Partial-OFF Occupancy Sensor shall:
- 1. Provide manual ON, automatic OFF for a portion of the luminaires within an area where indicated on drawings.

## **2.6 AMBIENT LIGHT SENSORS**

- A. Ambient light sensors shall:
- 1. Incorporate photoconductive cell to measure light levels between 1 and 1,000 footcandles.
  - 2. Be adjustable with deadband feature to prevent cycling of lighting from minor changes in cloud cover.
  - 3. Have adjustable time delay range from 3 to 5 minutes.
  - 4. Not permit lighting systems to be turned on if enough daylight is present.
  - 5. Incorporate by-pass switch to enable lighting to be turned on if sensor fails.

## **2.7 POWER PACKS**

- A. Sensor power packs shall:
- 1. Be self-contained transformer relay modules.
  - 2. Have universal rated voltage inputs 120-277 VAC, 60 Hz.
  - 3. Have normally closed dry contacts rated for switching 120-277 volts, 60 Hz. 20 amp loads. Provide 24VDC output capable of controlling low-voltage occupancy sensors.

## **2.8 EXTERIOR OCCUPANCY SENSORS**

- A. Exterior occupancy sensors shall:
- 1. Be a completely self-contained device capable of detecting presence in the controlled range by detecting changes between infrared energy in motion

and the background space.

2. Utilize passive infrared detection technology and a three level Fresnel lens to increase detection density and accuracy of motion detection.
3. Be capable of mounting vertically or horizontally onto a standard outdoor junction box or integral to exterior luminaires.
4. Cover up to 35 ft with a field of view of 180 degrees or 52.5 ft with a field of view of 270 degrees.
5. Have an operating temperature range of -40°F to 130°F.
6. Be IP66 rated for outdoor applications.
7. Include a built-in light level sensor, adjustable by the user that will keep lights from turning on during daylight hours.
8. Have user-adjustable time delay settings, including an override ON option that enables controlled lights to be turned on remotely for the length of the time delay.
9. Be compatible with all electronic ballasts and LED drivers with no minimum load requirements.

## **2.9 UL 924 EMERGENCY BYPASS/CONTROL DEVICES**

- A. UL 924 listed bypass relays shall:
  1. Be UL924 listed and labeled for connection to both normal and emergency lighting power sources.
  2. Have universal rated voltage inputs 120-277 VAC, 60 Hz.
  3. Have normally closed dry contacts rated for switching 120-277 volts, 60 Hz. 20 amp loads.
  4. Have integral manual test switch.
  5. Have auxiliary isolated normally closed contact for connection to remote test switch, fire alarm system, or other external system capable of providing a normally closed dry contact closure.
  6. Have status indication for presence of normal and emergency power sources and current operational mode (normal or emergency).
  7. Utilize zero crossing circuitry to protect relay contacts from the damaging effects of inrush current generated by switching electronic ballast loads.
  8. Be forced into the emergency mode upon loss of normal power sense and turn ON the emergency lighting.
  9. Automatically switch emergency lighting ON/OFF as normal lighting is switched. When normal power is not available, the unit shall force and hold emergency lighting ON regardless of the state of any external control device until normal power is restored.
- B. Operational temperature range shall be -40°F to 140°F.
- C. Device shall have universal mounting; surface, above suspended ceiling or recessed.

## **2.10 EXTERIOR PHOTOCELLS**

- A. Photocells shall:
  1. Have universal rated voltage inputs 120-277 VAC, 60 Hz.
  2. Be rated for up to 2,000 watts.

3. Have cadmium sulfide, 1" diameter cell.
4. Have SPST normally closed contacts.
5. Have a minimum delay of 3 minutes to prevent false switching.
- B. ON/OFF adjustment shall be done by moving light selector with range from 2 to 50 footcandles.
- C. Operational temperature range shall be -40°F to 140°F.
- D. Enclosure shall be die cast zinc, gasketed for maximum weatherproofing.
- E. Enclosure shall include positioning lug on top.
- F. Mounting shall be for 1/2" conduit nipple.

## **2.11 SELF-CONTAINED AUTOMATIC TIMER SWITCHES**

- A. Timer switches shall:
  1. Have universal rated voltage inputs 120-277 VAC, 60 Hz.
  2. Be programmable to turn lights OFF after a preset time.
  3. Have a ground wire and ground strap for safety with a latching air gap relay switching mechanism.
  4. Use Zero Crossing Circuitry to increase the relay life, protect from the effects of inrush current.
  5. Be compatible with all electronic ballasts, motor loads, LEDs and LED drivers, compact fluorescent and inductive loads. Triac and other harmonic generating devices shall not be allowed.
  6. Have no minimum load requirement and shall be capable of controlling 0 to 800 watt incandescent, fluorescent @ 100/120 VAC, 50/60 Hz; 0 to 1200 watts fluorescent @ 230/277 VAC, 50/60 Hz; 1/6 hp @ 125 VAC. LED with internal or external driver@ 100/120VAC.
  7. Have the option for light flash warning at five minutes before the timer runs out and again when the countdown reaches one minute.
  8. Have the option for a beep warning that shall sound every five seconds once the time switch countdown reaches one minute.
  9. Have manual feature for timer reset where pressing the ON/OFF switch for more than 2 seconds resets the timer to the programmed time-out period.
  10. Have a feature that shows the timer's countdown.
  11. Have the calibration switch for setting time-out, time scroll, one second light flash, and beep warning shall be concealed to prevent tampering of adjustments and hardware.
  12. Have a maximum allowed over-ride period no greater than 2 hours.
  13. Be capable of operating as an ON/OFF switch.
  14. Utilize terminal style wiring.
  15. Have a 100% OFF override switch with no leakage current to the load.

## **2.12 FINISHES**

- A. Color:
  1. Wall box dimmers, low-voltage switches, occupancy sensors, ambient light sensors and device cover plates: Per architect.

### **PART 3 - EXECUTION**

#### **3.1 INSTALLATION**

- A. Install devices at heights scheduled, and as indicated on drawings.
- B. Install wall devices vertically on latch side of door within 6" of frame edge, unless otherwise noted.
- C. Install ceiling devices as shown on drawings and as recommended by device manufacturer.
- D. Ceiling mounted occupancy sensors shall be located minimum of 6 ft from supply air diffusers.
- E. Install devices plumb, level with finished surfaces and free from blemishes.
- F. Verify device locations prior to rough in.
- G. Control wiring shall be low voltage, Class II wiring, electrically isolated from power wiring by a Class II transformer.
- H. Provide separate neutral conductor for each dimmer.
- I. Provide remote power pack and isolated relay outputs where wall switch style mounting is specified.
- J. Wiring shall be in conduit.
- K. Electrical Contractor shall be responsible for final adjustment and testing of all devices.
- L. All lighting control devices shall be installed and programmed by a certified California Advanced Lighting Control Training Program Installer.
- M. All line voltage controls shall be wired ahead of any room occupant controls so that lighting controls remain energized at all times.

#### **3.2 TESTING**

- A. Verify proper location and operation of all devices.
- B. Verify dimmers function without:
  - 1. Producing lamp flicker or audible noise.
  - 2. Interference of audio and visual equipment.
- C. Adjust occupancy sensors for a 15, UNO minute time delay.
- D. Adjust occupancy sensor sensitivity such that movement outside range of coverage shall not trigger sensor.
- E. Adjust ambient light sensor to maintain illuminance level equal to light level from controlled lighting in the space when no daylight is present or as indicated per drawings. Demonstrate ambient light sensor(s) control lighting as specified.
- F. The functionality of all installed lighting controls shall be verified by a certified California Advanced Lighting Control Training Program-Acceptance Test Technician as required in California Building Energy Efficiency Standards.

**END OF SECTION 26 09 23**



## **SECTION 26 09 26 - LIGHTING CONTROL SYSTEM**

### **PART 1 - GENERAL**

#### **1.1 RELATED WORK**

- A. Section 26 00 00 – General Electrical Requirements
- B. Section 26 05 33 – Surface Metallic Raceway System
- C. Section 26 09 23 – Lighting Control Devices
- D. Section 26 27 26 – Wiring Devices
- E. Section 26 51 00 – Interior Lighting
- F. Section 26 56 00 – Exterior Lighting

#### **1.2 REFERENCE**

- A. The Work under this section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

#### **1.3 DESCRIPTION**

- A. Provide a complete, functional, intelligent, low-voltage, networkable lighting control system consisting of, but not limited to, distributed relay modules, controllers, enclosures, occupancy sensors, photosensor daylight controls, switch stations, and auxiliary equipment for control of all types of lighting sources whether served from 120V or 277V, emergency or normal power.
- B. The lighting control system specified in this section shall provide time-based, sensor-based (both occupancy and daylight), and manual lighting control.
- C. The system shall be capable of turning lighting loads on/off as well as dimming lights (if lighting load is capable of being dimmed). Specific dimmers will be capable of “dimming lights to off.”
- D. All system devices shall be networked together, enabling digital communication between devices.
- E. The system architecture shall be capable of enabling stand-alone groups (rooms) of devices to function in some default capacity, even if network connectivity to the greater system is lost.
- F. The system architecture shall facilitate remote operation via a computer connection.
- G. The lighting control system shall interface with the projects building management system (BMS).

#### **1.4 LIGHTING CONTROLS NARRATIVE**

- A. Lighting Controls Concepts
  - 1. Digital room devices shall connect via free topology (daisy-chain, star or t-tap) to the distributed relay modules using CAT 5e cables with RJ-45 connectors to

provide both data and power to room devices. Relay control modules and lighting control panels shall be capable of networking together and connect back to a network controller. Features of the local lighting control network include:

- a. Automatic configuration and binding of occupancy sensors, switches and lighting loads to the most energy-efficient sequence of operation based upon the devices attached.
- b. Replacement of any device in the network with a standard off the shelf unit without requiring commissioning, configuration or setup.
- c. Button press configuration to change the automatic configuration, including binding and load parameters without tools, using only the buttons on the digital devices in the local network.
- d. Two-way infrared communications for control by handheld remotes, and configuration by a handheld tool including adjusting load parameters, sensor configuration and binding, within a line of sight of up to 30 feet from a sensor, wall switch or IR receiver.

B. Lighting Control Strategies

1. Astronomic Timeclock Scheduling: Clock shall automatically calculate sunrise and sunset times based on date and geographical positioning. Sunrise and sunset or selectable offset of up to 120 minutes may be used as activation times for any system timer.
2. Timeclock Scheduling: Time of day events in public areas, and other spaces as indicated in drawings and schedules are keyed to project programming requirements. Programmable digital wall switches shall be provided with minimum of 24 available times (scheduled events) for use in developing time-of-day automated schedules. Timer shall have ability to turn relay outputs ON or OFF at standard times in 1-minute increments or at times calculated by astronomical clock for sunrise and sunset with offset. Timers shall be day-of- week selectable timers and may be programmed to activate on combination of days of week (Sunday through Saturday), on days, or to activate on specific date only ("Holiday Schedule"). Non-holiday timer shall be capable of being programmed either to halt operation on holidays or to ignore holidays and continue normal operations on holidays.
  - a. Blink Alert/Beep Warning: Programmable digital wall switches shall be set to blink prior to being turned OFF. Blink alert times shall be adjustable between 1 and 10 minutes in 1-minute increments. Relays programmed for blink alert function shall blink prior to turning OFF to warn occupants of upcoming OFF event. If ON command is received during blink alert time, relay output will be overridden and left ON for override time. Override times shall be adjustable from 1 to 6 hours in 1-hour increments.
3. Timer Switch: Digital countdown timer switch set to time-out after 2 hours with time scroll down if button is held used in single entrance electrical, mechanical and communication rooms as well as other storage rooms less than 50 square feet. Multi-entrance electrical and mechanical rooms will use programmable digital wall

switches set to time-out after 2 hours.

- a. Blink Alert/Beep Warning: Digital countdown timer switch or programmable digital wall switch shall be set to blink prior to being turned OFF. Blink alert times shall be adjustable between 1 and 10 minutes in 1-minute increments. Relays programmed for blink alert function shall blink prior to turning OFF to warn occupants of upcoming OFF event. If ON command is received during blink alert time, relay output will be overridden and left ON for override time. Override times shall be adjustable from 1 to 6 hours in 1-hour increments.
4. Vacancy/Occupancy Sensing: Enclosed spaces such as storage rooms, conference rooms, break rooms and private offices shall function as manual-on control spaces with vacancy sensor extinguishing lights after a 15 or 30-minute interval of no observed occupancy.
  - a. Occupancy Sensors for toilet rooms and stairwells shall operate as automatic-on control spaces with occupancy sensor extinguishing lights after a 15 or 30-minute interval of no observed occupancy.
5. Daylight Sensor Dimming: Light fixtures in perimeter daylight zones are governed in groups by photosensors determining real time daylight availability within primary daylight where applicable. Fluorescent and LED light fixtures are dimmed accordingly when daylight is present.
6. Preset Scene: Allows for programming preset scenes for flexibility, repeatability and fine tuning of light levels in various spaces.

#### **1.5 REFERENCE STANDARDS**

- A. ANSI/IEEE C62.41-1991 – Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits
- B. ANSI/NFPA 70 – National Electrical Code
- C. ASTM D4674-02a – Standard Test Method for Accelerated Testing for Color Stability of Plastics Exposed to Indoor Fluorescent Lighting and Window-Filtered Daylight
- D. IEC 801-2 – Electrostatic Discharge Testing Standard
- E. IEC/EN 60669-2-1 – Switches for household and similar fixed electrical installations – electronic switches
- F. ISO 9001:2000 – Quality Management Systems
- G. NEMA FCC – Emission Standards, Part 15
- H. UL 508 – Standard for Industrial Control Equipment
- I. UL 916 – Energy Management
- J. UL 924 – Emergency Lighting and Power Equipment
- K. UL 1472 – Solid-State Dimming Controls
- L. California Building Energy Efficiency Standards
- M. California Title 20 Appliance Efficiency Database

## 1.6 SUBMITTALS

- A. Submit under provisions of Division 01 and Division 26.
- B. Submittal package shall include, but not be limited to the following. Submittals that do not contain information listed below will not be considered for approval.
  - 1. Bill of materials consisting of detailed itemized listing of proposed equipment, including quantities and capacities for major system components.
  - 2. Product data sheets detailing major system components.
  - 3. Typical wiring diagrams for components interconnectivity per room type.
  - 4. Overall system schematic showing interconnection detail of each control with sufficient detail to indicate relative placement of major system components and labeled for the associated zones and spaces.
  - 5. Relay schedules indicating power source, scheduling and connected devices.
  - 6. Low-voltage switch schedule for multi-zone switches showing zones/scenes controlled.
  - 7. Shop drawings that include name of project, quantity and physical dimensions of major system components, wire sizes and counts for required connections between system components.
  - 8. Coordination plan drawings showing manufacturers suggested layout of all devices coordinated for ceiling types, lighting layouts, door swings.
  - 9. Example Contractor Startup/Commissioning Worksheet – must be completed prior to factory start-up.
  - 10. Hardware and Software Operation Manuals.
  - 11. Other operational descriptions as necessary.

## 1.7 QUALITY ASSURANCE

- A. Factory Assembly: Relays, contactors, controllers, enclosures, occupancy sensors, photosensor daylight controls switch stations and miscellaneous components shall be factory assembled and tested. System components shall arrive at job site completely prewired and ready for installation, requiring only connection of lighting circuits and low-voltage control stations and/or network terminations. Connections shall be made to clearly and permanently labeled termination points. Systems that require field assembly shall not be acceptable.
- B. Component Testing: System components and assemblies shall be individually tested prior to assembly. Once assembled, finished products shall be tested for proper operation of control functions per specifications prior to shipment.
- C. Provide system software, hardware and equipment that is designed, tested, manufactured and warranted by a single manufacturer.
- D. NEC Compliance: System components shall comply with applicable sections of National Electrical Code (NEC) as required.
- E. NEMA Compliance: System components shall comply with applicable portions of NEMA standards pertaining to types of electrical equipment and enclosure.
- F. UL Approval: Applicable equipment shall be UL listed under section 916/508 and shall bear labels indicating compliance.

- G. FCC Emissions: Applicable equipment shall comply with FCC emissions standards specified in Part 15, Subpart J for Class A applications.
- H. Manufacturer's Quality System: Registered to ISO 9001:2000 Quality Standard, including in- house engineering for product design activities.
- I. Lighting control system components:
- J. Listed by UL specifically for the required loads. Provide evidence of compliance upon request.

### **1.8 PROJECT CONDITIONS**

- A. Do not install equipment until following conditions can be maintained in spaces to receive equipment:
- B. Ambient temperature: 32° to 104° F (0° to 40° C).
- C. Relative humidity: maximum 90 percent, non-condensing.
- D. Lighting control system shall be protected from dust and debris during installation.

### **1.9 RECORD DOCUMENTS**

- A. After system installation and testing, submit record documents under provisions of Division 01 and Division 26.
- B. Accurately record location of switches, power supplies and control enclosures. Include description of switching and circuiting arrangements.

### **1.10 OPERATION AND MAINTENANCE MANUALS**

- A. After system installation and testing, submit operation and maintenance manuals under provisions of Division 01 and Division 26.
- B. Include replacement part numbers.

### **1.11 WARRANTY**

- A. Contractor shall warranty completed lighting control system wiring and equipment to be free from inherent mechanical and electrical defects for period of (5) five years from date of substantial completion.
- B. Warranty service for equipment shall be provided by system supplier's factory-trained representative during normal working hours, Monday through Friday, excluding holidays. Warranty shall include parts, labor, and necessary travel.

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS**

- A. Acuity nLight (Campus Standard – No Substitutions)

### **2.2 ROOM CONTROLLERS/RELAY MODULES**

- A. Room Controllers shall be provided to match the room lighting load and control requirements. All room controllers shall be capable of connecting to a networked lighting control system. The control units shall include the following features:

1. Automatic room configuration to the most energy-efficient sequence of operation based upon the devices in the room.
  2. Default automatic configuration capabilities, allowing a room controller to be replaced with an off-the-shelf unit without requiring any configuration or setup.
  3. Device Status LEDs to indicate:
    - a. Data transmission
    - b. Device has power
    - c. Status for each load
    - d. Configuration status
  4. Quick installation features including:
    - a. Standard junction box mounting
    - b. Quick low voltage connections using standard RJ-45 patch cable
  5. Plenum rated
  6. Manual override and LED indication for each load
  7. Dual voltage (120/277 VAC, 60 Hz)
  8. Zero cross circuitry for each load.
- B. Class 2 Lighting Control Relays
1. Provide quantities of Class 2 lighting control relays as indicated on drawings and schedules and as specified herein.
  2. Class 2 lighting control relays shall be individually UL and CUL listed and shall bear labels indicating compliance.
  3. Class 2 lighting control relays shall be designed for control of 120 or 277 VAC lighting control circuits at full 20 amps.
  4. Each Class 2 lighting control relay shall contain necessary equipment to provide status monitoring and pilot light activation.
  5. Control relays shall have 14,000 Amp SCCR.
- C. On/Off Room Controllers shall include:
1. Multiple relay configurations
  2. Efficient 150 mA switching power supply
  3. Minimum of three RJ-45 DLM local network ports
- D. On/Off/Dimming Room Controllers shall include:
1. Real time current monitoring
  2. Multiple relay configurations
  3. Efficient 250 mA switching power supply
  4. Minimum of four RJ-45 DLM local network ports.
  5. One 0-10 volt analog output per relay for control of compatible ballasts and LED drivers.
  6. Optional Network Bridge for BACnet MS/TP communications.
  7. The following dimming attributes shall be selectable using a wireless configuration tool:
    - a. Establish preset level for each load from 0-100%
    - b. Set high and low trim for each load
    - c. Set lamp burn in time for each load up to 100 hours

### **2.3 DIGITAL WALL OR CEILING MOUNTED OCCUPANCY SENSOR SYSTEM**

- A. Wall or ceiling mounted passive infrared (PIR), ultrasonic (UT) or dual technology (DT)

(passive infrared and ultrasonic) occupancy sensor as indicated on plans. Furnish the Company's system which accommodates the square-foot coverage requirements for each area controlled, utilizing room controllers, digital occupancy sensors and accessories which suit the lighting and electrical system parameters.

- B. Digital Occupancy Sensors shall provide display for digital calibration and electronic documentation. Features include the following:
  - 1. Digital calibration and pushbutton programming for the following variables:
    - a. Sensitivity – 0-100% in 10% increments
    - b. Time delay – 1-30 minutes in 1-minute increments
    - c. Test mode – Five second time delay
    - d. Detection technology – PIR, Ultrasonic or Dual Technology activation and/or re- activation.
    - e. Walk-through mode
    - f. Load parameters including Auto/Manual-ON, blink warning, and daylight enable/disable when photosensors are included in the lighting control local network.
  - 2. One or two RJ-45 port(s) for connection to lighting control local network.
  - 3. Two-way infrared (IR) transceiver to allow remote programming through handheld commissioning tool.
  - 4. Device Status LEDs including:
    - a. PIR Detection
    - b. Ultrasonic detection
    - c. Configuration mode
    - d. Load binding
  - 5. Assignment of occupancy sensor to a specific load within the room without wiring or special tools.
  - 6. Manual override of controlled loads.
- C. Multiple occupancy sensors may be installed in a room using the free topology lighting control local network.

#### **2.4 DIGITAL WALL SWITCHES**

- A. Low voltage momentary pushbutton switches in 1, 2, 3, 4, 5 and 8 button configurations; compatible with wall plates with decorator opening. Wall switches shall include the following features:
  - 1. Two-way infrared (IR) transceiver for use with configuration remote controls.
  - 2. Removable buttons for field replacement with engraved buttons and/or alternate color buttons. Button replacement may be completed without removing the switch from the wall.
  - 3. Red configuration LED on each switch that blinks to indicate data transmission.
  - 4. Blue Load/Scene Status LED on each switch button with the following characteristics:
    - a. Bi-level LED
    - b. Dim locator level indicates power to switch
    - c. Bright status level indicates that load or scene is active
  - 5. Dimming switches shall include seven bi-level LEDs to indicate load levels using 14 steps.

- B. The following switch attributes shall be available for selection using a wireless configuration tool:
  - 1. Load and Scene button function may be reconfigured for individual buttons (from Load to Scene, and vice versa).
  - 2. Individual button function may be configured to Toggle, On only or Off only.
  - 3. Individual scenes may be locked to prevent unauthorized change.
  - 4. Fade Up and Fade Down times for individual scenes may be adjusted from 0 seconds to 18 hours.
  - 5. Ramp rate may be adjusted for each dimmer switch.
  - 6. Switch buttons may be bound to any load on a room controller and are not load type dependant; each button may be bound to multiple loads.
- C. Switch Plates and Control Stations
  - 1. Provide switch plates and switches of quantities and type shown on drawings and specified herein.
  - 2. Switch plates shall consist of control panel faceplate, switches, LED pilot lights and mounting hardware.
  - 3. Switch plates shall be finished as specified in Section 26 2726 - Wiring Devices.
  - 4. Switch plates shall be designed to mount to standard electrical gang boxes for either flush or surface mounting.
  - 5. Switch plate labeling and switch identification shall be accomplished through use of engraved phenolic labels, permanently attached to switch plate or engraved into control panel faceplate material. Silk-screening or painted labeling shall not be acceptable.
  - 6. Provide with custom engraving with appropriate button, zone and scene engraving descriptions. Contractor to provide engraving schedule to Owner's Representative prior to release for fabrication. Refer to Electrical Lighting Switch Schedule E-011 thru E-017.
  - 7. Switch plates shall be supplied with appropriate number of momentary pushbutton type switches as indicated on drawings.
  - 8. Switches shall be momentary pushbutton type with pilot light.
- D. Two RJ-45 ports for connection to lighting control local network.
- E. Multiple digital wall switches shall be installed in a room by connecting them to the free topology local lighting control network.

## **2.5 DIGITAL PHOTSENSORS**

- A. Digital photosensors shall work with room controllers to provide automatic switching or dimming for any load type connected to a room controller. Closed loop photosensors shall measure the ambient light in the space and control a single lighting zone. Open loop photosensors shall measure incoming daylight in the space and be capable of controlling up to three lighting zones. Photosensors shall be interchangeable without the need for rewiring.
- B. Digital photosensors shall include the following features:
  - 1. An internal photodiode that measures only within the visible spectrum and has a response curve that closely matches the photopic curve. The photodiode shall not



measure energy in either the ultraviolet or infrared spectrums. The photocell shall have a sensitivity of less than 5% for any wavelengths less than 400 nanometers or greater than 700 nanometers.

2. Sensor light level range shall be from 1-10,000 footcandles (fc).
  3. The capability of switching one-third, one-half or all lighting ON and OFF, or raising or lowering lighting levels, for each controlled zone, depending on the selection of room controller(s) and load binding to room controller(s).
  4. For switching daylight harvesting, the photosensor shall provide a deadband or a separation between the "ON Setpoint" and the "OFF Setpoint" that will prevent the lights from cycling after they turn off.
  5. For dimming daylight harvesting, the photosensor shall provide the option, when the daylight contribution is sufficient, of turning lights off or dimming lights to a user-selectable minimum level.
  6. The capability for wall-switch to override sensor, allowing occupants to reduce lighting level or, if permitted by system administrator, raise and lower lighting levels for a selected period of time or cycle of occupancy.
  7. Infrared (IR) transceiver for configuration and/or commissioning with a handheld configuration tool, to transmit detected light level to wireless configuration tool.
  8. Red configuration LED that blinks to indicate data transmission.
  9. Blue status LED indicates test mode, override mode and load binding.
  10. Recessed switch to turn controlled load(s) ON and OFF.
  11. One RJ-45 port for connection to local lighting control network.
  12. An adjustable head and a mounting bracket to accommodate multiple mounting methods and building materials. The photosensor shall be capable of being mounted on a ceiling tile, skylight light well, suspended light fixture or backbox.
- C. Closed loop digital photosensors include the following additional features:
1. An internal photodiode that measures light in a 100-degree angle, cutting off the unwanted light from bright sources outside of this cone.
  2. Automatic self-calibration, initiated from the photosensor, a wireless configuration tool or a PC with appropriate software.
  3. Automatically establishes setpoints following self-calibration.
  4. A sliding setpoint control algorithm for dimming daylight harvesting with a "Day Setpoint" and the "Night Setpoint" to prevent the lights from cycling.
- D. Open loop digital photosensors include the following additional features:
1. An internal photodiode that measures light in a 60-degree angle cutting off the unwanted light from the interior of the room.
  2. Automatically establishes setpoints following calibration using a wireless configuration tool or a PC with appropriate software.
  3. A proportional control algorithm for dimming daylight harvesting with a "Setpoint" to be

maintained during operation.

## **2.6 CONFIGURATIONS TOOLS**

- A. A wireless configuration tool shall be provided to facilitate customization of local lighting control networks and set up of open loop daylighting sensors. The configuration tool will communicate to control devices using infrared, while PC software is connected to the local network via USB interface.
- B. Features and functionality of the wireless configuration tool shall include:
  - 1. Two-way infrared (IR) communication with lighting control IR-enabled devices within a range of approximately 30 feet.
  - 2. High visibility display, pushbutton user interface and menu-driven operation.
  - 3. Read, modify and send parameters for occupancy sensors, daylighting sensors, room controllers and buttons on digital wall switches.
  - 4. Save up to nine occupancy-sensor setting profiles, and apply profiles to selected sensors.
  - 5. Temporarily adjust light level of any load(s) on the local network and incorporate those levels in scene setting.
  - 6. Adjust or fine-tune daylighting settings established during auto-commissioning and input light level data to complete commissioning of open loop daylighting controls.

## **2.7 NETWORK BRIDGE**

- A. The network bridge connects a local lighting control network to a BACnet-compliant network for communication between rooms, panels and a segment manager or BAS. Each local network shall include a network bridge component to provide a connection to the local network room devices. The network bridge shall use industry standard BACnet MS/TP network communication.
  - 1. The network bridge may be incorporated directly into the room controller hardware or be provided as a separate module connected on the local network through an available RJ-45 port.
  - 2. Provide operation to automatically discover all room devices connected to the local network and make all device parameters visible to the segment manager via the segment network. No commissioning shall be required for set up of the network bridge on the local network.
  - 3. The network bridge shall automatically create standard BACnet objects for selected room device parameters to allow any BACnet-compliant BAS to include lighting control features as provided by the digital lighting control room devices on each local network. Standard BACnet objects shall be provided as follows:
    - a. Read/write the normal or after-hours schedule state for the room
    - b. Read the detection state of the occupancy sensor
    - c. Read/write the On/Off state of loads
    - d. Read/write the dimmed light level of loads

- e. Read the button states of switches
- f. Read total current in amps, and total power in watts through the room controller
- g. Read/write occupancy sensor time delay, PIR sensitivity and ultrasonic sensitivity settings
- h. Activate a preset scene for the room
- i. Read/write daylight sensor fade time and day and night setpoints
- j. Read the current light level, in footcandles, from interior and exterior photosensors and photocells
- k. Set daylight sensor operating mode
- l. Read/write wall switch lock status

## **2.8 NETWORK CONTROLLER**

- A. The Digital Lighting Control System shall include at least one network controller to manage network communication. It shall be capable of serving up a graphical user interface via a standard web browser. Each network controller shall have support for one, two or three networks as required and allow for control of a maximum of 127 local networks (rooms) and/or lighting control panels per segment network.
- B. Operational features of the Network Controller shall include the following:
  - 1. Connection to PC or LAN via standard Ethernet TCP/IP.
  - 2. Graphical user interface, compatible with Internet Explorer 8, or equal browser.
  - 3. Log in security capable of restricting some users to view-only or other limited operations.
  - 4. Automatic discovery of all digital lighting control devices on the segment network(s).
  - 5. After discovery, all rooms and panels shall be presented in a standard navigation tree format. Selecting a device from the tree will allow the device settings and operational parameters to be viewed and changed by the user.
  - 6. Ability to view and modify room device operational parameters. It shall be possible to set device parameters independently for normal hours and after-hours operation.
  - 7. Ability to set up schedules for rooms and control panels. Schedules shall automatically set controlled zones or areas to either normal hours or after hours mode of operation.
  - 8. Ability to group rooms and loads for common control by schedules, switches or network commands.
  - 9. Ability to monitor connected load current and display power consumption for areas equipped with room controllers incorporating the integral current monitoring feature.
  - 10. Provide seamless integration with the BAS via BACnet IP
- C. Networking
  - 1. Individual lighting controllers shall be capable of being connected together and programmed on single network cable. Network cable shall consist of shielded single twisted pair.

2. Once connected together, entire control system shall be accessible from single point where system user may program, monitor and control any control device on network. Switch input on network shall be able to control relay outputs on network without limitation.
3. Programming: Programmable controllers shall be capable of being programmed, monitored or controlled through below methods, either individually or simultaneously. Regardless of method being used to program, monitor or control, programmable controller must remain completely functional during this process. Controllers that must be taken "OFF LINE" for programming are not acceptable. Programming changes shall take effect immediately as they are programmed.
4. Diagnostic Aids: Programmable lighting controllers shall indicate main power supply is present and operational via LED pilot. Relay output shall have visual indication of on/off status. System users shall be able to view current status of relay outputs, force relay output ON or OFF, and view current status of switch inputs.
5. Data Protection and Storage: Programmed data shall be stored in system that is protected from memory loss. Stored program data shall be protected from loss during power outage without power of any type for minimum period of 2 years.
6. Power Failure and Power-Up Options: Programmable lighting controllers shall automatically shut down whenever incoming power fails to be delivered to controller within required limits. When power is returned to controller, one of the following (user selectable) power-up modes will be implemented for each controlled relay output in system:
  - a. No Action: Upon restoration of incoming control power, controller electronics shall be restarted and resume normal operations, and circuits will be maintained in condition they were last in.
  - b. Exception: Time-scheduled events that were to take place during power outage will be automatically activated to bring controller into correct operating status.
  - c. ON: Upon restoration of incoming control power, controller electronics shall be restarted, and circuits shall be turned on.
  - d. OFF: Upon restoration of incoming control power, controller electronics shall be restarted, and circuits shall be turned off.
7. True Relay Status Feedback: Controller shall be provided with circuitry to monitor actual current status of each relay.
8. Staggered or Instant Relay ON/OFF Activation: Programmable lighting controller shall be provided with jumper to enable user selectable instant or staggered relay operation. In instant mode, relays in controller will be turned ON or OFF at same time. In staggered mode, relays will be turned ON or OFF with 20-msec pause between each relay being switched.
9. Input to Output Programmability: Switch input in control network may be programmed to control relay output(s) on network, without limitation.

## **2.9 EMERGENCY LIGHTING**

- A. Provide Emergency Lighting Control Unit – UL 924 listed bypass relay device to monitor a switched circuit providing normal lighting to an area. The unit shall allow for normal ON/OFF control of emergency lighting along with the normal lighting. Upon normal power failure the emergency lighting circuit will close, forcing the emergency lighting ON until normal power is restored. Features include:
1. Allow control of emergency lighting fixtures in tandem with normal lighting in an area while ensuring that emergency lighting will turn on immediately to full brightness upon loss of normal power supplying the control device. Emergency lighting operation shall be independent for each controlled area and shall not require a generalized power failure for proper operation.
  2. Have normally closed dry contacts capable of switching 120/277 volts, 50/60 Hz., 20 amp ballast load rating
  3. Have universal rated voltage inputs provided for normal power sense and normal switched power at 120-277 VAC, 60 Hz.
  4. Integral push to test button. Pressing and holding this button shall instantly force the unit into emergency mode and turn on emergency lighting. Releasing the test button shall immediately return the unit to normal operation.
  5. Auxiliary contact with dedicated leads and 24 VDC source for connection to remote test switch, fire alarm system, or other external system capable of providing a normally closed dry contact closure. Breaking contact between the terminals shall force and hold the emergency lighting on until the terminals are again closed. An integral LED indicator shall indicate the unit's current remote activation status.
  6. The device shall provide separate LEDs to indicate the presence of normal and emergency power sources. The LEDs shall indicate the unit's current operational mode (normal or emergency).
  7. The device's normal power input lead shall be connected to the line side of the control device such that any upstream fault causing a loss of power, including the tripping of the branch circuit breaker, will force the unit into the emergency mode and turn on the emergency lighting.
  8. The unit shall automatically switch emergency lighting on and off as normal lighting is switched. When normal power is not available, the unit shall force and hold emergency lighting on regardless of the state of any external control device until normal power is restored.
  9. The unit shall utilize zero crossing circuitry to protect relay contacts from the damaging effects of inrush current generated by switching electronic ballast loads.
  10. The unit shall be UL and cUL listed and labeled for connection to both normal and emergency lighting power sources.
  11. The unit shall have a 5-year warranty.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Verify that surfaces are ready to receive work.

- B. Verify field dimensions are as shown on Drawings.
- C. Verify that required utilities are available, in proper location, and ready for use.
- D. Beginning of installation means installer accepts existing conditions.

### **3.2 INSTALLATION**

- A. Install equipment as indicated on Drawings and in accordance with manufacturer's written instructions and recognized industry practices.
- B. Use minimum 18 AWG copper conductor building wire or manufacturer's standard suggested wiring size, whichever is larger, in conduit for low voltage wiring.
- C. Provide equipment at locations and in quantities indicated on drawings. Provide any additional equipment required to provide control intent.
- D. Confirm final engraving schedule with electrical engineer prior to release for production.
- E. Energize all fluorescent lamps with dimming controls for a required burn in period of 100 continuous hours.
- F. Calibrate all sensor time delays and sensitivity to guarantee proper detection of occupants and energy savings.
  - 1. Adjust time delay so that controlled area remains lighted for 5 minutes after occupant leaves area.

### **3.3 COMMISSIONING**

- A. System commissioning and startup shall be done by factory-certified field service representative during site visits to ensure proper system installation and operation under the following parameters:
  - 1. Qualifications for factory-certified field service engineer:
    - a. Minimum experience of 2 years training in the electrical/electronic field.
    - b. Certified by the equipment manufacturer on the system installed.
  - 2. Make a site visit upon completion of installation of Architectural Lighting Control Systems to:
    - a. Verify connection of power feeds and load circuits.
    - b. Verify connection and location of controls.
    - c. Energize processor panel and download system data program.
    - d. Verify proper connection of panel links (low voltage/data) and address panel.
    - e. Verify system operation control by control, circuit by circuit.
    - f. Verify proper operation of manufacturers interfacing equipment.
    - g. Verify proper operation of manufacturers supplied PC and installed programs.
    - h. Verify operation of PC modem and test dial-up access.
    - i. Verify control station setup.
    - j. Verify control station zone intent.
    - k. Verify occupancy sensor timeout and sensitivity calibration.
    - l. Calibrate Daylight Harvesting sensors and verify functionality.
    - m. Verify proper functionality and set up of all ancillary input devices and equipment.
    - n. Verify Graphical software control programming.
    - o. Obtain sign-off on system functions.
- B. Following installation completion and basic system setup, contractor shall provide a qualified, fully trained, system programmer to field program system functionality.

Programmer shall meet with Owner's Representative and Owner's Representative to determine desired sequence of operation. System programming shall be stored on USB flash drive and programming shall be multi level password protected. Programming will include:

1. Setting preset lighting levels for all areas.
2. Setting time of day Time Clock events.
3. Setting Astronomic Time Clock events.
4. All other items required for full system functionality per design intent.

### **3.4 TESTING**

- A. Tested by a Title-24 certified advanced lighting control acceptance tester.
- B. Check dimmer preset control for proper operation.
- C. Verify dimmers function without producing lamp flicker or audible noise.
- D. Verify dimmers function without interference of audio and visual equipment.
- E. Verify ambient light sensor to maintain illuminance level equal to light level from controlled lighting in the space when no daylight is present or as indicated per drawings. Demonstrate ambient light sensor(s) control lighting as specified.
- F. Verify occupancy sensors for proper time delay.
- G. Verify proper operation of occupancy sensor switches and by-pass switches.
- H. Verify occupancy sensor sensitivity such that movement outside range of coverage shall not trigger sensor.
- I. Verify system is functioning in accordance with the lighting plans, diagrams, sequences, details and specifications.
- J. Check the BAS relay interface for the occupancy annunciation of each room.
- K. Verify integration of multi-scene dimmers with the AV system.
- L. The functionality of all installed lighting controls shall be verified by a certified California Advanced Lighting Control Training Program-Acceptance Test Technician as required in 2016 California Building Energy Efficiency Standards.

### **3.5 TRAINING**

- A. Contractor shall provide, as part of this contract, minimum of 16-hours of system operation training for Owner. Training shall be at time to be stipulated by Owner's Representative and shall include system capabilities, operation, maintenance, programming and troubleshooting. Training and programming shall be completed prior to job closeout.
- B. Provide post-occupancy training and commissioning session to allow for modifications to system programming. Session to be coordinated with facilities personal 90 days after building occupancy.

### **3.6 DEMONSTRATION**

- A. Provide systems demonstration under provisions of Section 26 00 00.

- B. Demonstrate proper operation of system.
- C. Upon completion of installation and after circuits have been energized, demonstrate capability and compliance of system with specified requirements.
- D. Refer to Electrical Drawings for relay schedules and system riser diagrams.
- E. Provide written or computer-generated documentation on the commissioning of the system including room by room description including:
  - 1. Sensor parameters, time delays, sensitivities, and daylighting setpoints.
  - 2. Sequence of operation, (e.g. manual ON, Auto OFF. etc.)
  - 3. Load Parameters (e.g. blink warning, etc.)

**END OF SECTION 26 09 26**



## **26 10 00 – MEDIUM-VOLTAGE ELECTRICAL**

### **DISTRIBUTION PART 1 - GENERAL**

#### **1.1 RELATED WORK**

- A. Section 26 05 13.16 – Medium-Voltage Cable
- B. Section 26 05 33 – Raceways and Boxes for Electrical Systems
- C. Section 26 05 43 – Underground Ducts and Raceways for Electrical Systems
- D. Section 26 05 73 – Power System Studies
- E. Section 26 08 12 – Power Distribution Acceptance Tests
- F. Section 26 08 13 – Power Distribution Acceptance Test Forms
- G. Section 26 12 19 – Pad-Mounted, Liquid-Filled, Medium-Voltage Transformers
- H. Section 26 13 16 – Medium-Voltage Fusible Interrupter Switchgear

### **PART 2 - PRODUCTS**

#### **NOT USED**

### **PART 3 - EXECUTION**

#### **3.1 Qualifications for Medium Voltage Electrical Work**

- A. In addition to a C10 electrical contractor's license the qualified installer will have the following:
  - All employees of the C-10 electrical contractor will hold a valid "State Certified General Electrician" card issues by the California Department of Industrial Relations' Division of Apprenticeship Standards.
  - Person(s) performing medium voltage terminations will possess a certification indicating that they have attended formal training on splicing and terminating medium voltage cables in the types of terminations being performed. Successful completion of the course and examination will be provided to the University prior to the start of any work.
  - Person(s) performing medium voltage work or installation will have at least 5 years of verifiable experience performing such work. Submit a record of employment or projects for the University to review and approve.

#### **3.2 Acceptance Testing for Medium Voltage Work**

- A. The installing contractor will retain the services of a 3rd party testing firm to perform acceptance tests on all medium voltage equipment and cables. The 3rd part testing firm's qualifications will be submitted to the University with samples of the test forms that are scheduled for use before testing takes place. The University must approve in writing of the 3rd party testing firms qualifications prior to performing testing.

- B. The University will be present in the field for all tests, inspections and times at which equipment is first placed into service. Notify University Representative 10 working days prior to performing any tests.
- C. All equipment will be placed in its final installation location and fastened securely before acceptance testing is to take place. Acceptance test performed prior to equipment installed in its final installation location will not be considered or accepted.
- D. All cable test will be performed after cable installation is fully complete with the exceptions of termination make up. All manhole cable racking, arc proofing, duct sealing, etc. will be completed before cable is to be acceptance tested.
- E. All cable tests will be performed within 12 hours of their planned energization time. Cable test performed longer than 12 hours before energization will require a retest at the contractor's expense as test over 12 hours old will not be considered. The University will not accept cable that has been tested more than 2 separate times and recommends that the contractor sequence work appropriately so that multiple cable tests are not required as testing stresses cable.

### **3.3 Distribution Standards:**

- A. Medium voltage underground system conductors will be installed in Schedule 40 conduit. At any location that the conduit must transition above grade (such as at a pole riser) that transition will be constructed in rigid steel to a point of 15 feet above grade.
- B. Medium voltage underground conduits will be 5" and include 1 spare for each installed feeder.
- C. Medium voltage underground conduits will be encased in red concrete with a minimum of 5 sack mix. The encasement shall be 6 inches from the edge of the encasement to any part of the conduit on the top and 2 sides of the conduit and 3 inches on the bottom of the conduit.
- D. Overhead distribution construction will only be permitted to be used as an acceptable method of distribution construction by the Director of Facility Planning and Capital Projects.
- E. Overhead distribution facilities will be constructed per the current PG&E standards including phase separation compliant with current California Wildlife and Raptor Compliance.
- F. Provide shop drawings detailing the proposed pole framing on each type of framing scenario that is to be used in the project. Submit to University for approval prior to commencing work.

### **3.4 Equipment for Medium Voltage Work**

- A. Provide submittals for each piece of the medium voltage installation for the University to review and approve. Submitted items include but are not limited to: Transformers, Vaults, Cables, Conduit, Ground Wire and Fittings, Secondary Wire, Medium Voltage Terminations, Low voltage Terminations, Sectionalizing Switches, Load Interrupters,

Cable Accessories, Circuit Breakers and Fuses.

### **3.5 Splices**

- A. Splices in the medium voltage network must be shown on the drawings or approved by the University in advance.
- B. No splices will be permitted in manholes or other structures below grade.
- C. Splices will be performed in above grade junction cabinets using separable connectors.
- D. Overhead cable splices will take place at poletop dead-end locations only. Tensioned splices will not be accepted.

### **3.6 Medium Voltage Distribution Cables:**

- A. All cable will be 15 KV rated Type MV-105 220mils 133% EPR copper tape shielded cable.
- B. All medium voltage cables will be fire taped in all manholes, switches and transformers from the point of conduit entry to the cable termination.
- C. Cable installed in manholes and vaults will have sufficient slack to go once around the perimeter of the vault + 5 feet. Cable will be racked and fire taped.

### **3.7 Unit Substations:**

- A. All unit substations (transformers) will be pad mounted, oil filled units located outdoors adjacent to the building being served.
- B. All transformers will be provided with loop feed bushings with the corresponding switches to allow feeds A, B and transformer primary to be switched independently of each other.
- C. All transformers will be provided with oil immersed fusing on the primary input of the transformer.
- D. All transformers will be provided with 1 spare set of fuses attached to the primary compartment door.
- E. All transformers will be mounted on a transformer utility vault. This vault will have a manhole lid located at the front of the transformer doors and be an open bottom type vault installed on a minimum of 18' of crushed granite.
- F. Provide a sump pump connected to the building power via an emergency circuit (if available) and the storm drain.
- G. Primary and secondary conduits will be terminated in this vault and route to their appropriate switch or building main service gear.
- H. Under no circumstances will dry type unit substations or transformers be permitted.
- I. Acceptance test all medium voltage transformers per the current NETA ATS by a 3rd party testing firm that has been pre-approved by the university.
- J. Provide a starting DGA analysis of the transformer oil after the transformer has been energized and loaded for a period not less than 1 week. All dissolved gas levels shall be at "condition 1" per the IEEE standards for DGA analysis.

### **3.8 Switchgear**

- A. All critical campus loads will be fed from Medium Voltage Solid Dielectric Sectionalizing equipment to provide the greatest factor of reliability. Consult University Representative for specifics with each individual project.
- B. All switchgear will be 3 phase gang operated 15KV, 60Hz, dead front, single side access pad mounted sectionalizing switchgear. Each switchgear shall consist of a single self-supporting outdoor enclosure with SF6 insulated switches and a remote terminal unit for SCADA control. Accessory components shall be completely factory assembled, tested and then tested after installation. Interrupter switches and fuses shall be enclosed within an inner grounded steel compartment for electrical isolation and protection from contamination. Switched terminals shall be equipped with bushings for 600A continuous ratings. Fused terminals and buss terminals shall be equipped with bushing wells rated at 200A continuous.
- C. All switchgear shall employ the use for programmable, resettable fusing of the 200A continuous terminals. Fuse controller shall provide dry contacts for the status of the load switch's' position.
- D. All pad mounted switchgear shall be installed on a utility vault to facilitate pulling and racking of cables.
- E. Acceptance test all medium voltage switchgear per the current NETA ATS by a 3rd party testing firm that has been pre-approved by the University.

### **3.9 Medium Voltage Circuit Protection:**

- A. Submit qualifications of the Registered Professional Electrical Engineering firm to perform the coordination study. Firms must have at least (5) years of experience performing coordination studies on medium voltage equipment.
- B. A coordination study shall be performed on all new medium voltage equipment being installed to maintain established selectivity using IEEE standards.
- C. Submit coordination study to the University Representative for review and approval.
- D. Upon University approval 3rd party testing firm will implement recommended coordination study settings and test equipment for compliance to the recommended settings.

### **3.10 Medium Voltage Circuit Protection:**

- A. Submit qualifications of the Registered Professional Electrical Engineering firm to perform the coordination study. Firms must have at least (5) years of experience performing coordination studies on medium voltage equipment.
- B. A coordination study shall be performed on all new medium voltage equipment being installed to maintain established selectivity using IEEE standards.
- C. Submit coordination study to the University Representative for review and approval.
- D. Upon University approval 3rd party testing firm will implement recommended

coordination study settings and test equipment for compliance to the recommended settings.

**END OF SECTION 26 10 00**

## **SECTION 26 12 19 - PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE**

### **TRANSFORMERS PART 1 - GENERAL**

#### **1.1 RELATED WORK**

- A. Section 26 00 00 - General Electrical Requirements
- B. Section 26 05 48 - Vibration and Seismic Controls for Electrical Systems
- C. Section 26 05 53 - Electrical Systems Identification
- D. Section 26 08 12 - Power Distribution Acceptance Tests
- E. Section 26 08 13 - Power Distribution Acceptance Test Tables

#### **1.2 REFERENCE**

- A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

#### **1.3 DESCRIPTION OF SYSTEM**

- A. Specification covers 3-phase, liquid-filled, compartmental type, pad-mounted transformers, including tap changers, fuses, and terminations.

#### **1.4 REFERENCE STANDARDS**

- A. ANSI C57.12.22 - Standard for Transformers - Pad-Mounted, Compartmental-Type, Self-Cooled, 3- Phase Distribution Transformers with High-Voltage Bushings, 2500 kVA and Smaller: High Voltage, 34,500Grd/19,920 V and Below; Low-Voltage, 480 V and Below - Requirements.
- B. ANSI C57.12.26 - Standard for Transformers - Pad-Mounted, Compartmental-Type, Self-Cooled, 3- Phase Distribution Transformers for Use with Separable Insulated High-Voltage Connectors, H-V, 34,500 Grd/19,920 V and below; 2500 kVA and Smaller.
- C. ANSI C57.12.28 - Pad-Mounted Equipment - Enclosure Integrity.
- D. IEEE C57.12.00 - Standard General; Requirements for Liquid - Immersed Distribution, Power, and Regulating Transformers.
- E. UL 340 - Tests for Comparative Flammability of Liquids.
- F. 10 CFR 431.196 (b) (2) – Energy Conservation Standards and Their Effective Dates

#### **1.5 SUBMITTALS**

- A. Submit shop drawings for equipment provided under this Section.

### **PART 2 - PRODUCTS**

## 2.1 MANUFACTURERS

- A. Acceptable Manufacturers: ABB, Cooper, General Electric, RTE, Square D or equal
- B. Rating of transformer(s) shall be as shown on drawings:
  - 1. kVA as shown on plans
  - 2. Primary Voltage as shown on plans
  - 3. BIL 95 kV
  - 4. Secondary Voltage As required by the project.
  - 5. Impedance As required by the project.
  - 6. Transformers shall be dual rated 55/65 degree C

## 2.2 CONSTRUCTION

- A. Transformer(s) shall:
  - 1. Be compartmental type, self-cooled, tamper-resistant and weatherproof.
  - 2. Include sealed tank construction to withstand pressure of 15 psi.
  - 3. Include welded cover.
  - 4. Tank, enclosure, termination compartment and all related parts and fasteners to be stainless steel.
- B. Transformer tank and high and low voltage compartments shall be assembled as integral unit.
- C. High and low voltage compartments shall be located side by side, separated by a stainless steel barrier.
- D. Cooling panels will be provided on back of tank.
- E. High voltage compartment shall not be accessible until low voltage door has been opened.
- F. Low voltage door shall have 3-point latching mechanism with vault type handle having provisions for single padlock.
- G. Provide lifting eyes and jacking pads.
- H. Include tank grounding provisions in each compartment.
- I. Penta bolt hardware for door closure is required in addition to padlocking provisions

## 2.3 FINISH

- A. In accordance with ANSI C57.12.28 – Standard for Pad-mounted Enclosure Integrity.

## 2.4 INSULATING FLUID

- A. Coolant and insulating fluid shall be less flammable, dielectric, with fire point of not less than 300°C Liquid shall be biodegradable and nontoxic, Envirotemp FR3.

## 2.5 CORE AND COIL CONSTRUCTION

- A. Coils shall be wound with copper windings.
- B. Core shall be high grade, grain oriented silicon steel laminations.
- C. Core and coil assemblies shall be stacked core type, 3-legged construction.
- D. Internal leads shall be insulated.

- E. Manual Tap Changer:
  - 1. Provide tap changer, externally operated.
  - 2. Tap changer handle shall have provisions for padlocking.
  - 3. Tap changer shall be 5-position with four 2-1/2% full capacity taps, 2 above and 2 below rated voltage and 1 at nominal.

## 2.6 HIGH VOLTAGE COMPARTMENT

- A. Terminations:
  - 1. Terminations shall be dead front construction.
  - 2. Transformer to be loop feed with (3) 2 position switches. Provide bushing well inserts and insulated caps for unused loop feed.
  - 3. Bushing wells shall be externally clamped and externally removable.
  - 4. Provide 1 set of load break bushings and 1 load break feed-thru insert for each phase.
  - 5. Mount lightning arrestors to one side and phase conductor elbows to other side.
  - 6. Provide surge arrestors as shown on the plans and specifications.
- B. High Voltage Switch:
  - 1. Provide load break, gang operated, oil immersed switch, with eye for hot stick operation.
  - 2. Switch shall be 2-position OFF-ON.
  - 3. Switch shall be stacked deck, spring loaded cam, rotary operated.
- C. High Voltage Fusing:
  - 1. Fuses shall have continuous current ratings sized per manufacturer's recommendations for indicated kVA, impedance, and primary voltage.
  - 2. Current limiting fuses shall be sized for sufficient duty for installation on the campus system.
- D. Provide pentahead enclosure security.

## 2.7 LOW VOLTAGE TERMINATIONS AND EQUIPMENT

- A. Bushings shall be molded epoxy.
- B. Externally clamped, blade type spade terminals with 6 hole NEMA spacing.
- C. Low voltage neutral bushing shall be fully insulated.
  - 1. Connect to adjacent ground pad on tank with detachable strap.
- D. Accessories:
  - 1. Each transformer shall be equipped with the following:
    - a. Dial type thermometer for indicating top liquid temperature.
    - b. Globe valve to serve as drain valve, bottom filler plug connection, and liquid sampling valve.
    - c. Globe valve for top filter plug connection and vacuum pump connection.
    - d. Pressure vacuum gauge.
    - e. Magnetic liquid-level indicator.
    - f. Spare fuse pocket with 1 complete set of fuses.
  - 2. Pressure relief device.
  - 3. Stainless steel nameplate mounted in low-voltage compartment with the following information:
    - a. Serial number and style number.
    - b. Graphic representation of high-voltage and low-voltage connections.



- c. kVA ratings at all cooling class ratings and temperature rises.
  - d. Transformer impedance at 55°C base kVA rating.
  - e. Tap changer positions, voltages and full load currents at each tap setting.
  - f. Low voltage rating and full load current.
  - g. Gallons of liquid in tank and radiators.
  - h. Maximum allowable pressure on tank.
  - i. Transformer weight with and without oil.
  - j. Listing as non-PCB transformer.
- E. Labeling:
- 1. Provide warning label on outside high voltage compartment door and danger label on inside low voltage compartment door.

## **2.8 HARDWARE**

- A. Provide hardware, including bolts, fasteners, caps, plugs, etc. of corrosion resistant materials or plated with corrosion resistant materials.

## **2.9 TESTING**

- A. Report of transformer tests shall be submitted for each transformer:
- B. Complete all tests for liquid filled transformers noted in spec section 26 08 12.
  - 1. Standard ANSI tests.
  - 2. Resistance measurements of windings on rated voltage tap of each transformer and at tap extremes of 1 transformer only of given rating on order.
  - 3. Ratio tests on rated voltage connections and on tap connections.
  - 4. Phase-relation and polarity tests on rated voltage connections.
  - 5. No load losses and excitation current at rated voltage on rated voltage connections.
  - 6. Impedance and load losses at rated current on rated voltage connections of each transformer and on extremes of 1 unit only of given rating on order.
  - 7. Applied and induced potential tests.
  - 8. Regulation and efficiency at rated load and voltage.
  - 9. Insulation resistance tests (high voltage to ground, low voltage to ground, high voltage to low voltage).
- C. Temperature test or tests shall be made on 1 unit only of transformers covered by these specifications of given rating, provided that test data is not available from records of temperature tests on duplicate or essentially duplicate transformer. Tests are to be completed in the field after the transformer has been installed in its final installed location.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

- A. Install components as indicated and in accordance with manufacturer's instructions and recommendations.
- B. Mechanical lugs not permitted for secondary wire connection. Install compression lugs appropriate for wire size used.

- C. Install transformer level and plumb.
- D. Provide means for lifting complete transformer.
- E. Bearing surfaces of lifting means shall be free from sharp edges.
- F. Provide lifting means for untanking transformer.
- G. Base shall permit rolling (or sliding) in directions of both center lines of transformer and provision shall be made for pulling transformer in these directions.
- H. Locate jacking facilities near extreme ends of junction of base segments.
- I. Jack ports or lugs shall be so designed that lifting members of jack can be inserted.
- J. If liquid filling of any part of transformer is required at job site, supplier shall furnish liquid and job site supervision, and shall furnish or make available suitable filter press and vacuum pump.

### **3.2 ACCEPTANCE TESTING**

- A. Testing by Testing Agency
- B. Acceptance testing to be performed in accordance with Section 26 08 12 – Power Distribution Acceptance Tests.

**END OF SECTION 26 12 19**

## **SECTION 26 13 16 - MEDIUM-VOLTAGE FUSIBLE PAD-MOUNTED**

### **SWITCHGEAR PART 1 - GENERAL**

#### **1.1 RELATED WORK**

- A. Section 26 00 00 – General Electrical Requirements
- B. Section 26 05 13.16 – Medium-Voltage, Single-and-Multi-Conductor Cables
- C. Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems
- D. Section 26 05 53 – Electrical Systems Identification
- E. Section 26 05 73 – Overcurrent Protective Device Coordination and Arc Flash Study
- F. Section 26 11 13 – Primary Unit Substations
- G. Section 26 27 13 – Electrical Metering

#### **1.2 REFERENCE**

- A. Work under this section is subject to requirements of the Contract Documents including the General Conditions of the Contract, Supplementary Conditions, and sections under Division 01 General Requirements.

#### **1.3 DESCRIPTION**

- A. Provide medium voltage load interrupter switchgear consisting of 3 pole, 1 throw, dead front, metal enclosed, load interrupter switches, fuses and necessary accessory components, factory assembled and operationally checked.

#### **1.4 REFERENCE STANDARDS**

- A. ANSI/IEEE C37.20.3 - Metal-Enclosed Interrupter Switchgear
- B. ANSI/IEEE C37.20.4 - Indoor AC Medium-Voltage Switches used in Metal-Enclosed Switchgear
- C. ANSI C37.57 - Metal-Enclosed Interrupter Switchgear Assemblies - Conformance Testing
- D. ANSI/IEEE C62.11 (1999) - Metal Oxide Surge Arresters for AC Power Circuits (> 1 kV)
- E. NEMA SG5 - Power Switchgear Assemblies
- F. NEMA SG6 - Power Switching Equipment

#### **1.5 SUBMITTALS**

- A. Shop Drawings:
  - 1. Submit shop drawings for equipment provided under this Section.
- B. Submit time current characteristics curves showing selective coordination of the following components for coordination.
  - 1. Fuses
  - 2. Phase and ground fault relaying

## 1.6 QUALITY ASSURANCE

- A. Obtain switchgear from one source and by single manufacturer.
- B. Regulatory Requirements:
  - 1. Comply with NFPA 70 for components and installation.
  - 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.
- C. Certifications:
  - 1. Furnish Owner Representative with Manufacturer Seismic Qualification Certification: Submit certification that switchgear, accessories, and components will remain internally intact to withstand seismic forces defined in Section 26 0548 – Vibration and Seismic Controls for Electrical Systems. Include the following:
    - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - 2. Furnish Owner’s Representative with Installation Seismic Qualification Certification: Submit certification that switchgear(s), accessories, and components will remain in place without separation of any parts when subjected to the seismic forces defined in Section 26 0548 – Vibration and Seismic Controls for Electrical Systems and will be fully operational after the seismic event. Include the following:
    - a. Detailed description of equipment supports and seismic restraints on which the certification is based and their installation requirements.
    - b. Certification shall bear the seal and signature of an Engineer registered and licensed in the State of California.

## 1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect units from dirt, fumes, water, corrosive substances, construction debris, and traffic. Provide temporary heaters in switchgear as required to prevent condensation.
- B. Deliver switchgear in 48” maximum width shipping splits, individually wrapped for protection, and mounted on shipping skids. Mark crates, boxes, and cartons clearly to identify equipment. Show crate, box, or carton identification number on shipping invoices.
- C. Use factory-installed lifting provisions. Handle carefully to avoid damage to switchboard internal components, enclosure, and finish.

## 1.8 WARRANTY

- A. Refer to Division 01 and Section 26 00 00 – General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1-year warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

## 1.9 MAINTENANCE

- A. Extra Materials: Furnish extra materials described below that match product installed, are packaged with protective covering for storage, and are identified with labels describing contents.
  - 1. Fuses: Equal to 10% of amount installed for each size and type, minimum of 2 of each size and type.

## **PART 2 - PRODUCTS**

### **2.1 MATERIALS**

- A. Acceptable Manufacturers: Eaton Innovative Switchgear Solutions
- B. Provide pad-mounted gear in accordance with the specifications and one-line diagram for the project.

### **2.2 MODEL**

- A. Eaton Innovative Switchgear Solutions Solid Dielectric (ISG-SD). No substitutions permitted.

### **2.3 RATINGS and CONSTRUCTION**

- A. Configuration to match plans and specifications
- B. Construction – 304 Stainless steel tank, enclosure, and control enclosures Munsell 7GY3.29/1.5 Hammertone
- C. Ratings – 15.5 kV 12.5 KA Symmetrical 20kA Asymmetrical 125V BIL.
- D. 600A Ways – Motor Operated, SEL 751 Automation and Protection, 15kV
- E. VIL – 955 CPT, 24v DC power supply with battery backup
- F. Control – Fiber Optic ports for communication and remote operation, push buttons for local motor operation

### **2.4 Eaton Innovative Switchgear (ISG)**

- 1. Pad mounted single sided access – PS532066226-10XA, or campus approved equal

### **2.5 FUSES**

- A. Current limiting type fuses
  - 1. Fuse ampacity and type: as indicated on drawings
  - 2. Fuse Maximum Nominal Voltage Rating: 15kV

### **2.6 SURGE ARRESTERS**

- A. Provide 3 surge arrestors on line side of switchgear.
- B. Surge arresters shall be rated at 15 kV, when required.
- C. Provide fully shielded, dead front, metal-oxide, elbow type surge arrester with resistance-graded gap suitable for plugging into inserts.
- D. Connect primary surge arrestors using manufacturer's jumper cables.

### **2.7 WIRING TERMINATIONS**

- A. Provide wiring, terminal blocks and fuse blocks within vertical section as required.
- B. Label control wiring with wire markers.
- C. Provide wire termination system such that no additional cable bracing, tying or lashing is required to maintain short circuit withstanding rating of assembly.
- D. Equip each cubicle section that contains lugs for incoming and/or outgoing feeders with horizontal cable supports.

## **2.8 NAMEPLATE**

- A. Nameplates:
  - 1. Engraved with 3/16" high black lettering on laminated plastic white background.
  - 2. Secured to switchgear enclosure with screws.
- B. Switchgear Assembly:
  - 1. Provide nameplate indicating:
    - a. Manufacturer's name and drawing number
    - b. Voltage ratings (kV nominal; kV maximum design; kV BIL)
    - c. Main bus continuous rating (amperes)
    - d. Short circuit ratings (amperes, rms symmetrical and Mva 3-phase symmetrical at rated nominal voltage)
    - e. Monetary and fault-closing ratings (amperes, rms asymmetrical)
  - 2. Provide nameplate in each bay indicating:
    - a. Ratings of interrupter switch (amperes continuous and interrupting)
    - b. Maximum rating of power fuse in amperes
    - c. Catalog number of fuse units or refill units
  - 3. Mark control components for identification corresponding to designation on manufacturer's drawings.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Visually inspect to confirm that all items and accessories are in accordance with specifications and drawings.
- B. Verify field measurements are as shown on shop drawings.
- C. Verify that required utilities are available, in proper location, and ready for use.
- D. All work safety requirements apply to inspections.

### **3.2 INSTALLATION**

- A. Install equipment per manufacturer's recommendations and as indicated.
- B. Coordinate final locations of equipment with Owner Representative and review final locations with Owner Representative prior to setting equipment.
- C. Protect equipment during installation to prevent twisting or deformations, exposure to potentially damaging environments, and work of other trades. Maintain protection until completion of construction.

- D. Verify tightness of accessible bolted bus joints with torque wrench prior to energizing switchgear. Tightness shall be in accordance with manufacturer's recommended values.
- E. Conductor Bending
  - 1. Bending of high-voltage cables should be avoided or minimized.
  - 2. Necessary bends should meet minimum radii specified by cable manufacturer.

### **3.3 ACCEPTANCE TESTING**

- A. Testing by Testing Agency
- B. Acceptance testing shall be performed in accordance with Section 26 0812 – Power Distribution Acceptance Tests.
- C. Manufacturer's Field Service:
  - 1. Engage factory-authorized service representative to inspect and adjust field assembled components and equipment installation, including connections.
  - 2. Prior to energization, factory representative shall visually inspect switchgear installation to insure that switches and motor operators are operable and bus connections are complete.
  - 3. Switch operators shall be tested minimum of 1 time after energization.
  - 4. Provide 3copies of manufacturer's representative's certification.

### **3.4 CLEANING**

- A. Switchgear shall be cleaned during construction phase, prior to initial testing and energization of unit, and prior to final punch-list.

### **3.5 TRAINING**

- A. Provide services of factory-trained representative to instruct Owner on maintenance and operation for period of 4 h.

### **END OF SECTION 26 13 16**

## **SECTION 26 22 00 - LOW-VOLTAGE TRANSFORMERS**

### **PART 1 - GENERAL**

#### **1.1 RELATED WORK**

- A. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables
- B. Section 26 05 26 – Grounding and Bonding for Electrical Systems
- C. Section 26 05 29 – Hangers and Supports for Electrical Systems
- D. Section 26 05 33 – Raceway and Boxes for Electrical Systems
- E. Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems
- F. Section 26 05 53 – Electrical Systems Identification
- G. Section 26 08 12 – Power Distribution Acceptance Tests

#### **1.2 REFERENCE**

- A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

#### **1.3 DESCRIPTION**

- A. Section includes dry type distribution and buck-boost transformers rated 600V and less, with capacities up to 500 kVA.

#### **1.4 REFERENCE STANDARDS**

- A. ANSI/NECA 1 – Standard Practices for Good Workmanship in Electrical Contracting
- B. IEE C57.12.91 – Test Code for Dry Type Distribution and Power Transformers
- C. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum)
- D. NEMA ST 1 – Specialty Transformers (except General Purpose Type)
- E. NEMA ST 20 – Dry-Type Transformers for General Applications
- F. NFPA 70 – National Electrical Code
- G. UL 506 – Specialty Transformers
- H. UL 1561 – Dry-Type General Purpose and Power Transformers
- I. 10 CFR 431.196 (a) (2) – Energy Conservation Standards and Their Effective Dates

#### **1.5 SUBMITTALS**

- A. Product Data:
  - 1. Include rated nameplate data, capacities, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.
- B. Shop Drawings:
  - 1. For each transformer size and type:



- a. Physical dimensions, including bolting templates, weight, and center of gravity
  - b. Loads, method of field assembly, components, and location and size of each field connection
  - c. Wiring Diagrams: Power, signal, and control wiring
  - d. kVA rating
  - e. Primary taps
  - f. Insulation class and temperature rise
  - g. Efficiency values measured at 0, 25, 50, 75, and 100% load
  - h. Impedance value – X/R and %Z
  - i. Sound level
  - j. “K” factor listing, where applicable
- C. Submit 1/4” scale electrical room floor plans with transformer locations.
- D. Manufacturer’s Installation Instructions:
- 1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
- E. Test Reports: Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
- F. Output Settings Report: Record output voltages and tap settings.
- G. Closeout Submittals:
- 1. Project Record Documents:
    - a. Record actual locations of transformers.
  - 2. Operation and Maintenance Data:
    - a. Include manufacturer’s recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
    - b. Include manufacturer’s Seismic Qualification Certification, Installation Seismic Qualification Certification, manufacturer’s Ultra Quiet Transformers Sound Level Certification, where applicable, and Output Settings Report.

## 1.6 QUALITY ASSURANCE

- A. Obtain transformers from one source and by single manufacturer.
- B. Regulatory Requirements:
- 1. Comply with NFPA 70 for components and installation.
  - 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.
- C. Certifications:
- 1. Furnish Owner Representative with manufacturer’s Seismic Qualification Certification: Submit certification that transformers, accessories, and components will remain internally intact] to withstand seismic forces defined in Section 26 0548 – Vibration and Seismic Controls for Electrical Systems. Include the following:
    - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.

2. Furnish Owner Representative with Installation Seismic Qualification Certification: Submit certification that transformers, accessories, and components will remain in place without separation of any parts when subjected to the seismic forces defined in Section 26 0548 – Vibration and Seismic Controls for Electrical Systems and will be fully operational after the seismic event. Include the following:
  - a. Detailed description of busway supports and seismic restraints on which the certification is based and their installation requirements.
  - b. Certification shall bear the seal and signature of an Engineer registered and licensed in the State of California.
3. Furnish Owner Representative with manufacturer's Ultra Quiet Transformers Sound Level Certification, where applicable: Submit certification that ultra-quiet transformers have sound level not exceeding 35 dB. Submit for each ultra-quiet transformer. Include the following:
4. Basis for Certification: Indicate whether certification is based on actual test of assembled components or on calculations.

#### **1.7 DELIVERY, STORAGE, AND HANDLING**

- A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris, and traffic.
- B. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

#### **1.8 WARRANTY**

- A. Refer to Division 01 and Section 26 00 00 – General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1-year written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

### **PART 2 - PRODUCTS**

#### **2.1 MANUFACTURERS**

- A. Square D
- B. General Electric
- C. Cutler-Hammer
- D. Or equal

#### **2.2 DISTRIBUTION TRANSFORMERS**

- A. Fabrication:
  1. NEMA ST 20, UL 1561
  2. Factory assembled and tested
  3. Air-cooled, for 60 Hz service

4. Two winding dry type
  5. Coils:
    - a. Continuous wound construction and impregnated with non-hydroscopic, thermosetting varnish.
    - b. Conductors: Continuous windings without splices, except for taps, and encapsulated wire resin compound to seal out moisture and air.
    - c. Materials: Copper
    - d. Separate primary and secondary
    - e. Internal Connections: Braised or pressure type
  6. Cores: High-grade silicon steel, non-aging, with high magnetic permeability, low eddy current losses and low hysteresis. Magnetic flux densities below saturation point. Core laminations clamped with steel members, one leg per phase.
  7. Rubber vibration absorbing mounts to isolate base of enclosure from core and coil assembly.
  8. Transformer neutral visibly grounded to enclosures with flexible grounding conductor.
- B. Enclosure:
1. NEMA 250
  2. Type 2, unless otherwise indicated to comply with environmental conditions at installed location. (Exterior low voltage transformers are to be encapsulated type or non-ventilated type)
  3. Code-gauge steel panel over core and coil.
  4. Ventilated (air-cooled): Louvered openings for convection cooling.
  5. Cooling and terminal chamber access with both sides and rear obstructed.
  6. Manufacturer's lifting eyes or brackets.
  7. Finish: Manufacturer's standard gray enamel over prime coat after being degreased, cleaned, and phosphatized.
- C. Ratings:
1. KVA Rating: As required
  2. Primary Voltage: As required
  3. Secondary Voltage: As required
  4. Insulation Class and Winding Temperature Rise:
    - a. Transformers 15kVA and smaller: Class 185°C, with 115°C temperature rise above 40°C ambient temperature, capable of carrying 15% continuous overload without exceeding 150°C rise.
    - b. Transformers 25kVA – 112.5kVA: Class 220°C, with 115°C temperature rise above 40°C ambient temperature, capable of carrying 15% continuous overload without exceeding 150°C rise.
    - c. Transformers above 112.5kVA: Class 220°C, with 115°C temperature rise above 40°C ambient temperature, capable of carrying 30% continuous overload without exceeding 150°C.
  5. Top of Enclosure Temperature: Maximum 35°C above 40°C ambient temperature at warmest point at full load.
  6. K-Factor Rating: K-4.
- D. Primary Taps:
1. Transformers rated 15kVA and larger: Two 2.5% above and two 2.5% below normal full capacity, minimum of four taps.

- E. Energy Efficiency:
  - 1. Transformers rated 15kVA and larger, except K-rated, quiet type and ultra-quiet type:
    - a. 10 CFR 431.196 (a) (2) compliant
- F. Sound Levels:
  - 1. NEMA ST 20, maximum average sound levels as follows:
    - a. 45 dB for general-purpose transformer sizes less than 51kVA.
    - b. 50 dB for general-purpose transformer sizes 51-150kVA.
    - c. 55 dB for general-purpose transformer sizes 151-300kVA.
  - 2. Minimum of 3 dB less than NEMA ST 20. Maximum average sound levels when factory tested according to IEEE C57.12.91 as follows:
    - a. 42 dB for quiet type transformer sizes less than 51kVA.
    - b. 47 dB for quiet type transformer sizes 51-150kVA.
    - c. 52 dB for quiet type transformer sizes 151-300kVA.
  - 3. Maximum average sound levels, when factory tested according to IEEE C57.12.91, as follows:
    - a. 35 dB for ultra quiet transformers, for all sizes through 300kVA.
- G. Electrostatic Shielding, where indicated: Each winding with an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.
  - 1. Coil leads and terminal strips arranged to minimize capacitive coupling between input and output terminals.
  - 2. Special terminal included for grounding the shield.
  - 3. Shield Effectiveness:
    - a. Capacitance between Primary and Secondary Windings: Not to exceed 33 picofarads over a frequency range of 20 Hz to 1 MHz.
    - b. Common-Mode Noise Attenuation: Minimum of minus 120 dBA at 0.5 to 1.5 kHz; minimum of minus 65 dBA at 1.5 to 100 kHz.
    - c. Normal-Mode Noise Attenuation: Minimum of minus 52 dBA at 1.5 to 10 kHz.

### **2.3 LUGS**

- A. Manufacturer's primary and secondary bolted lugs: labeled for 75°C copper and aluminum conductors for ventilated enclosures
- B. Connections at sides near bottom, accessible from front of cabinet.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine conditions for compliance with enclosure and ambient temperature requirements for each transformer.
- B. Examine areas and surface to receive transformers for compliance with requirements, installation tolerances, and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.
- C. Verify space indicated for transformers' mounting meets code-required working clearances.
- D. Notify Owner Representative of any discrepancies prior to submittal of product data and shop drawings.

- E. Verify that ground connections are in place and requirements in Section 26 0526 – Grounding and Bonding for Electrical Systems have been met.
- F. Verify with manufacturer that “touch-up” paint kit is available for repainting.

### **3.2 INSTALLATION**

- A. Install transformers in accordance with ANSI/NECA 1.
- B. Install level and plumb within 1/2 degree, and at least 6” from the adjacent wall or structure to insure proper ventilation, in accordance with manufacturer’s written instruction, and in compliance with recognized industry practices.
- C. Transformer mounting, seismic restraints, and vibration control:
  - 1. Install transformer anchorage devices, seismic restraints and vibration control based on design by an Engineer registered and licensed in the State of California, and to comply with Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems for seismic criteria.
  - 2. Mount transformers on floor.
  - 3. Floor mounting:
    - a. Secure to floor via isolation pads between floor brackets (per manufacturer recommendations) and transformer.
    - b. Mount on spring isolator.
- D. Install engraved plastic nameplates under provisions of Section 26 0553 – Electrical Systems Identification. No drilling, punching or screwing of nameplates is permitted. Use self adhesive
  - 1. Indicate kVA rating, voltage/phase rating, taps, insulation class and temperature rise, impedance value, sound level, and K-factor listing.
- E. Install conduit per requirements in Section 26 0533 – Raceway and Boxes for Electrical Systems.
- F. Install transformer in dedicated electrical space per NFPA 70 and as shown on drawings. Coordinate with miscellaneous trades for equipment foreign to the electrical installation to be outside of dedicated electrical space.

### **3.3 CONNECTIONS**

- A. Ground transformers according to Section 26 0526 – Grounding and Bonding for Electrical Systems.
- B. Connect wiring according to Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables. Mechanical lugs are not permitted for primary and secondary wiring. Install size specific corresponding compression terminations.

### **3.4 FIELD QUALITY CONTROL**

- A. Inspect transformers for physical damage, proper alignment, anchorage, grounding, connections, and installation.
- B. Test transformers per requirements in Sections 26 08 12 – Power Distribution Acceptance Tests and 26 08 13 – Power Distribution Acceptance Test Tables.
- C. Interpret test results in writing and submit to Owner Representative.
- D. Output Settings Report: Prepare a written report recording output voltages and tap

settings and submit to Owner Representative.

**3.5 REPAINTING**

- A. Remove paint splatters and other marks from surface of equipment.
- B. Touch-up chips, scratches, or marred finishes to match original finish, using manufacturer- supplied paint kit. Leave remaining paint with Owner Representative.

**3.6 ADJUSTING**

- A. Record transformer secondary voltage at each unit for at least 48 h of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10% and not being lower than nameplate voltage minus 3% at maximum load conditions.
- B. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5%, at secondary terminals.

**3.7 CLEANING**

- A. Vacuum dirt and construction debris from interior and exterior of equipment; do not use compressed air to assist in cleaning.

**END OF SECTION 26 22 00**

## **SECTION 26 23 00 - LOW-VOLTAGE SWITCHGEAR**

### **PART 1 - GENERAL**

#### **1.1 RELATED WORK**

- A. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables
- B. Section 26 05 26 – Grounding and Bonding for Electrical Systems
- C. Section 26 05 29 – Hangers and Supports for Electrical Systems
- D. Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems
- E. Section 26 05 53 – Electrical Systems Identification
- F. Section 26 05 73 – Power System Studies
- G. Section 26 08 12 – Power Distribution Acceptance Tests
- H. Section 26 27 13 – Electrical Metering
- I. Section 26 28 13 – Fuses
- J. Section 26 43 00 – Surge Protective Devices

#### **1.2 REFERENCE**

- A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

#### **1.3 DESCRIPTION**

- A. Section includes free-standing, dead-front type, metal-enclosed, low-voltage distribution switchgear.

#### **1.4 REFERENCE STANDARDS**

- A. ANSI/IEEE C37.13 – Low-Voltage AC Power Circuit Breakers Used in Enclosures
- B. IEEE C37.20.1 – Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear
- C. IEEE C37.90 – Relay and Relay Systems Associated with Electric Power Apparatus
- D. IEEE C62.41.1 Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
- E. IEEE C62.41.2 Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits
- F. NFPA 70 – National Electrical Code
- G. NEMA 2250 – Enclosures for Electrical Equipment (1000 Volts Maximum)
- H. UL 486A-486B – Wire Connectors
- I. UL 869A – Reference Standard for Service Equipment
- J. UL 1066 – Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures

K. UL 1558 – Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear

**1.5 SUBMITTALS**

A. Product Data: For switchgear, components and accessories indicated:

1. Include data on features and components and complete description; submit catalog cut sheets showing voltage, size, rating and size of surge protective devices, switching and overcurrent protective devices.
2. Features, characteristics, factory settings and time-current curves of individual protective devices, auxiliary components and ground fault relaying.

B. Shop Drawings:

1. For switchgear specified in this Section:
  - a. General Arrangement:
    - 1) Indicate front, plan, and side views of switchgear; access requirements; overall dimensions and components list; shipping splits and weights.
    - 2) Front elevation indicating location of devices and instruments.
    - 3) Sections through switchgear showing space available for conduits.
  - b. Conduit entrance locations and requirements
  - c. Nameplate legends
  - d. Configuration, size and number of bus bars for each phase and current rating of buses
  - e. Ground bus
  - f. Neutral bus
  - g. Short circuit ratings of switchgear and overcurrent protective devices, and bus withstand rating
  - h. Instrument details; enclosure types and details
  - i. Wiring diagrams: power, signal and control wiring
  - j. Cal Poly metering provisions with indication of approval by Cal Poly
2. Submit 1/4" scale floor plans with switchgear location and required clearances and service space around equipment.

C. Manufacturer's Installation Instructions:

1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

D. Test Reports: Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.

E. Complete review of this specification noting for each paragraph whether proposed equipment complies with project specifications or deviates. Justification must be given for each deviation.

F. Closeout Submittals:

1. Project Record Documents:
  - a. Record actual locations, configurations, and ratings of switchgear and major components on single-line diagrams and plan layouts.
2. Operation and Maintenance Data:
  - a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance



- instructions.
- b. Include manufacturer's written instructions for testing and adjusting overcurrent protective devices.
- c. Include spare parts data listing, source, and current prices of replacement parts and supplies.
- d. Include Manufacturer Seismic Qualification Certification and Installation Seismic Qualification Certification.
- e. Include time-current curves, including selectable ranges for each type of overcurrent protective device.

## 1.6 QUALITY ASSURANCE

- A. Obtain switchgear from one source and by single manufacturer.
- B. Regulatory Requirements:
  - 1. Comply with NFPA 70 for components and installation.
  - 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.
- C. Certifications:
  - 1. Furnish Owner's Representative with Manufacturer Seismic Qualification Certification: Submit certification that switchgear, accessories, and components will remain internally intact to withstand seismic forces defined in Section 26 0548 – Vibration and Seismic Controls for Electrical Systems. Include the following:
    - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - 2. Furnish Owner's Representative with Installation Seismic Qualification Certification: Submit certification that switchgear, accessories, and components will remain in place without separation of any parts when subjected to the seismic forces defined in Section 26 0548 – Vibration and Seismic Controls for Electrical Systems and will be fully operational after the seismic event. Include the following:
    - a. Detailed description of equipment supports and seismic restraints on which the certification is based and their installation requirements.
    - b. Certification shall bear the seal and signature of an Engineer registered and licensed in the State of California.

## 1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect units from dirt, fumes, water, corrosive substances, construction debris, and traffic. Provide temporary heaters in switchgear as required to prevent condensation.
- B. Deliver switchgear in (48") maximum width shipping splits, individually wrapped for protection, and mounted on shipping skids. Mark crates, boxes, and cartons clearly to identify equipment. Show crate, box, or carton identification number on shipping invoices.
- C. Use factory-installed lifting provisions. Handle carefully to avoid damage to

switchboard internal components, enclosure, and finish.

### **1.8 WARRANTY**

- A. Refer to Division 01 and Section 26 00 00 – General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1-year warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

### **1.9 MAINTENANCE**

- A. Extra Materials: Furnish extra materials described below that match product installed, are packaged with protective covering for storage, and are identified with labels describing contents.
  - 1. Potential Transformer Fuses: Equal to 10% of amount installed for each size and type, but no fewer than 2 of each size and type.
  - 2. Control-Power Fuses: Equal to 10% of amount installed for each size and type, but no fewer than 2 of each size and type.

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS**

- A. Square D
- B. Eaton
- C. Or equal

### **2.2 RATINGS**

- A. Nominal system voltage: As indicated on the drawings or scheduled.
- B. Main bus continuous amperes: As indicated on the drawings or scheduled.
- C. Short circuit current rating: as indicated on drawings.
- D. Brace switchgear components to withstand mechanical forces for symmetrical fault current shown.

### **2.3 CONSTRUCTION**

- A. IEEE C37.20.1, UL 1558.
- B. Free-standing, dead-front type; metal-enclosed; side, front and rear panels of one-piece welded or bolted construction; compartments with ventilation louvers in top and bottom sections of front and rear panels; supporting frame: steel angles rigidly fastened together, with same outside dimensions as the enclosure.
- C. Adequate strength and rigidity necessary to resist conditions of use to which it may be subjected and to support equipment, devices and appurtenances contained therein.
- D. Incoming lug locations: Top or bottom, as applicable per drawings.

- E. Environmental Limitations:
  - 1. Ambient temperatures: not exceeding 40°C
  - 2. Altitude: Not exceeding 6,600 ft
  - 3. Temperature rise: Not to exceed 65°C over a 40°C ambient environment, with no derating required.
- F. Device Mounting and Type:
  - 1. Front and rear accessible switchgear: Front and rear aligned
    - a. Main device and feeder devices: Drawout and compartmented power circuit breakers.
- G. Bus:
  - 1. Material: Copper; copper: 98% conductivity.
  - 2. Connections: Accessible from rear only for maintenance.
    - a. Bolted:
      - 1) Not fewer than 4 bolts for each 4" x 4" contact
      - 2) Not fewer than 2 bolts for each 2" x 2" contact
      - 3) Grade 5 bolts and conical spring-type washers
  - 3. Sizing: Standard size, based on 65°C over 40°C; full capacity of the breaker frame size, not the trip setting; fully rated vertical and horizontal bus sections.
  - 4. Main Phase Buses: Three phase, 4 wire; uniform capacity for entire length of switchgear; ampacity as indicated on drawings; rated for the main protective device frame size or main incoming conductors.
  - 5. Bus Arrangement: A-B-C (left to right, top to bottom, front to rear).
- H. Ground Bus: extend length of switchgear.
- I. Neutral Bus: 100 % of the ampacity of phase buses, equipped with pressure connectors for outgoing circuit neutral cables. Bus extensions for busway feeder neutral bus are braced.
- J. Hinged Front Doors: Allow access to metering, accessory, and blank compartments, with latch and padlocking provisions.
- K. Removable, Hinged Rear Doors and Compartment Covers: Secured by captive thumb screws, for access to rear interior of switchgear, with latch and padlocking provisions.
- L. Circuit breaker compartment: Equipped to house drawout type circuit breakers, fitted with hinged outer doors, and segregated from adjacent compartments by steel barriers; equipped with drawout rails, levering out mechanism, primary and secondary contacts; The following functions may be performed without the need to open the circuit breaker door: lever circuit breaker between positions, operate manual charging system, close and open circuit breaker, examine and adjust trip unit, and read circuit breaker rating nameplate.
- M. Section barriers between main circuit breakers compartments: Extended to rear of section; rear compartment barrier between the cable compartment and the main bus; glass polyester barrier between adjacent vertical structures in the cable compartment.
- N. Bus isolation barriers: Arranged to isolate line bus from load bus at each main circuit breaker; separate barriered compartment for current and potential transformers; main and riser buses fully isolated from breaker instrument and auxiliary compartments.
- O. Bus bars connect: Between vertical sections and between compartments. Cable

connections are not permitted.

- P. Safety shutter: To automatically cover line and load stubs to protect against accidental contact.
- Q. Utility Metering Compartment: Fabricated compartment barriered from the rest of the section, with a hinged lockable front cover and removable bus links, complying with Cal Poly's requirements. If separate vertical section is required for metering, match and align with basic switchgear. Metering equipment: Provisions for mounting current transformers and potential transformers; meter base(s), metering conductors and miscellaneous appurtenances required by Cal Poly SLO.
- R. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchgear.
  - 1. Pull Section: Matched and aligned to switchgear
- S. Spare circuit breakers and spaces for future circuit breakers: Allowance in vertical section bus size.
- T. Future Provisions: Fully equip spaces for future devices with bussing, bus connections, rails, mounting brackets, supports, and appurtenances, insulated and braced for short circuit currents, with continuous current rating as indicated on drawings. Extension of phase, neutral, and ground buses from both ends by means of predrilled bolt-holes and connecting links.
- U. Adequate lifting means.
- V. Line and Load Terminations: Mechanical type, labeled for 75°C copper and aluminum conductors; suitable for number, sizes and trip ratings; feeder load terminals: silver-plated copper bus extensions equipped with pressure connectors for outgoing circuit conductors.
- W. Bus-Bar Insulation: Individual bus bars wrapped with factory-applied, flame-retardant tape or spray-applied, flame-retardant insulation, or fluidized epoxy coating. No live connections shall be accessible from the rear, except the breaker load side terminals.
  - 1. Sprayed Insulation Thickness: 3 mils, minimum.
  - 2. Bolted Bus Joints: Insulate with secure joint covers that can easily be removed and reinstalled.
- X. Relays: IEEE C37.90; types and settings as indicated; with test blocks and plugs.
- Y. Enclosure: Steel, NEMA 250, Type 1:
  - 1. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

## **2.4 SERVICE ENTRANCE**

- A. UL 869A
- B. Switchgear labeled as suitable for use as service entrance equipment, where applicable, with incoming line isolation barriers, and a removable neutral bond to switchgear ground for solidly grounded wye systems.

## **2.5 SHORT CIRCUIT CURRENT RATING**

- A. Switchgear with minimum short circuit current rating as indicated on drawings.

- B. Switchgear: Marked with their maximum short circuit current rating at supply voltage.
- C. Switchgear: Fully rated

## **2.6 SURGE PROTECTIVE DEVICES (SPD)**

- A. Furnished under 26 43 00 – Surge Protective Devices
- B. IEEE C62.41.1; integrally mounted, plug-in style, solid-state, parallel-connected, sine-wave tracking suppression and filtering modules.
- C. Per requirements in Section 26 4300 – Surge Protective Devices.

## **2.7 OVERCURRENT PROTECTIVE DEVICES**

- A. Circuit breakers must be able to be installed and removed without manipulating hardware (nuts, bolts, fasteners, etc.) to connect the line side of the circuit breaker to the buss.
- B. Power Circuit Breaker and Accessories: ANSI/IEEE C37.13; UL 1066; metal frame; field interchangeable electrical accessories, including shunt trip, spring release, electrical operator, auxiliary contacts and trip unit.
  - 1. Ratings: As indicated for continuous, interrupting, and short-time current ratings for each circuit breaker; voltage and frequency ratings same as switchgear.
  - 2. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:
    - a. Normal Closing Speed: Independent of both control and operator.
    - b. Slow Closing Speed: Optional with operator for inspection and adjustment.
    - c. Store-Energy Mechanism: Electrically charged, with optional manual charging.
    - d. Means for manual opening and closing.
    - e. Operation counter.
  - 3. Circuit Breakers 400A Frame and Larger: Trip Devices: Electronic (solid-state, microprocessor-based), overcurrent trip-device system consisting of one or two current transformers or sensors per phase, a release mechanism, and the following features:
    - a. Functions: Long-time pickup and delay, short-time pickup and delay, ground-fault pickup and delay and instantaneous-trip functions, independent of each other in both action and adjustment.
    - b. Temperature Compensation: Ensures accuracy and calibration stability from 23°F to 104°F.
    - c. Field-adjustable time-current characteristics.
    - d. Current Adjustability: Dial settings and ratings plugs on trip units or sensors on circuit breakers, or a combination of these methods.
    - e. Three bands, minimum, for long-time- and short-time-delay functions; marked "minimum," "intermediate," and "maximum."
    - f. Pickup Points: Five minimum, for long-time- and short-time-trip functions. Equip short- time-trip function for switchable  $I^2t$  operation.
    - g. Pickup Points: Five minimum, for instantaneous-trip functions.
    - h. Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault.

4. Auxiliary Contacts: For interlocking or remote indication of circuit breaker position, with spare auxiliary switches and other auxiliary switches required for normal circuit breaker operation. Each consists of two type "a" and two type "b" contacts wired through secondary disconnect devices to a terminal block in stationary housing; "a" contacts mimic circuit breaker contacts, "b" contacts operate in reverse of circuit breaker contacts.
5. Drawout Features: Circuit breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in connected, test, and disconnected positions. Include the following features:
  - a. Interlocks: Prevent movement of circuit breaker to or from connected position when it is closed and prevent closure of circuit breaker unless it is in connected, test, or disconnected position.
  - b. Circuit Breaker Positioning: An open circuit breaker may be racked to or from connected, test, and disconnected positions only with the associated compartment door closed unless live parts are covered by a full dead-front shield. An open circuit breaker may be manually withdrawn to a position for removal from the structure with the door open. Status for connection devices for different positions includes the following:
    - 1) Test Position: Primary disconnect devices disengaged, and secondary disconnect devices and ground contact engaged.
    - 2) Disconnected Position: Primary and secondary devices and ground contact disengaged.
6. Arc Chutes: Readily removable from associated circuit breaker when it is in disconnected position and arranged to permit inspection of contacts without removing circuit breaker from switchgear.
7. Padlocking Provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of drawout mechanism.
8. Operating Handle: One for each circuit breaker capable of manual operation.
9. Electric Close Button: One for each electrically operated circuit breaker.
10. Mechanical Interlocking of Circuit Breakers: Uses a mechanical tripping lever or equivalent design and electrical interlocks.
11. Key Interlocks: Arranged so keys are attached at devices indicated. Mountings and hardware are included where future installation of key interlock devices is indicated.
12. Undervoltage Trip Devices: Adjustable time-delay and pickup voltage.
13. Shunt-Trip Devices: Where indicated.
14. Indicating Lights: To indicate circuit breaker is open or closed, for main and bus tie circuit breakers interlocked wither with each other or with exterior devices.
15. Communication Capability: Integral communication module with functions and features compatible with power monitoring and control system specified in Section 26 0913 – Electrical Power Monitoring and Control.
16. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground fault protection function, and/or short time function.
17. Control Voltage: As required
18. Trip Voltage: As required

19. Listed for 100% of breaker's continuous ampere rating.
- C. Circuit Breaker Electronic Trip Units general characteristics:
  1. Circuit breakers, with solid-state microprocessor-based trip units:
    - a. Unit shall consist of current sensors, solid-state trip device, and solid-state adjustable time/current curve shaping elements.
    - b. Trip units shall be removable to allow for field upgrades.
    - c. Trip units shall incorporate "True RMS Sensing."
  2. Solid-state elements shall provide functions as indicated above.
  3. Adjustments shall be made using non-removable, discrete steps.
  4. Sealable transparent cover shall be provided over adjustments.
  5. Adjustable long-time pickup ( $I_r$ ) and delay shall be available in an adjustable rating plug that is UL listed as field-replaceable. Adjustable rating plug shall allow for five minimum long-time pickup settings from 0.4 to 1.0 times the sensor plug ( $I_n$ ). Other adjustable rating plugs shall be available for more precise settings to match the application. Long-time delay settings shall be at least three bands.
  6. Short-time pickup shall allow for five minimum settings from 1.5 to 10 times  $I_r$ . Short-time delay shall be at least three bands with  $I^2t$  ON and OFF.
  7. Instantaneous settings on the trip units shall be available in five minimum bands from 2 to 15 times  $I_n$ . The instantaneous settings shall also have an OFF setting when short-time pickup is provided.
  8. Trip units shall have the capability to electronically adjust the settings locally and remotely to fine increments below the switch settings. Fine increments for pickup adjustments are to be one ampere. Fine increments for delay adjustments are to be one second.
  9. Trip unit shall indicate:
    - a. Long-time fault
    - b. Short-time fault
    - c. Instantaneous fault
    - d. Ground fault, where provided
  10. Trip unit shall provide local trip indication and capability to indicate local and remote reason for trip, i.e., overload, short circuit or ground fault.
  11. Trip unit shall contain means to conduct circuit breaker tests, or via separate test kit.
  12. Breaker shall be equipped with externally accessible test points to be used for field testing.
  13. Trip units shall be available to provide real time metering. Metering functions include current, voltage, power and frequency.
  14. Trip units shall be provided with the following standard features:
    - a. True RMS sensing
    - b. LI
    - c. LSI
    - d. LSIG/Ground-fault trip
    - e. Ground Fault Alarm (no trip), with external relay, where required
    - f. Adjustable rating plugs
    - g. LCD or LED – Long-time pickup
    - h. LCD or LED – Trip indication
    - i. Digital Ammeter

- j. Communications
  - k. LCD dot matrix display
  - l. Advanced user interface
  - m. Protective relay functions
  - n. Neutral protection
  - o. Incremental fine tuning of settings
  - p. Selectable long-time delay bands
  - q. Power measurement
  - r. Maximum peak demand (measure of average power over a 15-minute period) continuously recorded over a one-year period
- D. Ground Fault protection equipment on breakers, where indicated: Integrally mounted relay and trip unit, push-to-test feature and ground fault indicator:
- 1. Ground-fault protection with at least three adjustable short-time-delay settings and three trip- time-delay bands; adjustable current pickup with maximum setting of 1200 A. Arrange to provide protection for the following:
    - a. Three-wire circuit or system
    - b. Four-wire circuit or system
    - c. Four-wire, double-ended substation
  - 2. Trip units shall be capable of the following types of ground-fault protection: source ground return, residual, zero sequence, and modified differential. Ground-fault sensing systems shall be changed in the field.
  - 3. Neutral current transformers shall be provided for 4-wire system.
  - 4. Ground-fault settings for circuit breaker sensor sizes 1200 A or below shall be in nine bands from 0.2 to 1.0 times  $I_n$ . The ground-fault settings for circuit breakers above 1200 A shall be in minimum three bands up to 1200 A.
  - 5. Ground-Fault Relay: UL 1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and 3-phase current transformer/sensor.

## **2.8 CONTROL POWER, COMPONENTS IDENTIFICATION, AND CONTROL WIRING**

- A. Control Circuits: 120 V, supplied through secondary disconnecting devices from control-power transformer: Dry-type transformers in separate compartments for units larger than 3 KVA, including primary and secondary fuses.
- B. Electrically Interlocked Main and Tie Circuit Breakers: Two control-power transformers in separate compartments, with interlocking relays, connected to the primary side of each control- power transformer at the line side of the associated main circuit breaker. 120 V secondaries connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.
- C. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.
- D. Control components mounted within assembly, such as relays, pushbuttons, switches etc.: Suitably marked for identification, corresponding to appropriate designations on manufacturer's wiring diagrams.
- E. Control Wiring: Factory installed, with bundling, lacing, and protection included; flexible conductors for #8 AWG and smaller, for conductors across hinges, and for conductors



for interconnections between shipping units; insulated locking spade terminals for control connections, except where saddle type terminals, integral to a device; current transformer secondary leads, connected to short circuit terminal blocks; terminal blocks with suitable numbering strips for group of control wires leaving switchgear, with wire markers at each end of control wiring.

## **2.9 ACCESSORY COMPONENTS AND FEATURES**

- A. Furnish portable test set to test functions of circuit breakers and solid-state trip devices without removal from switchgear. Include relay and meter test plugs suitable for testing switchgear meters and switchgear class relays.
- B. Furnish accessory set including tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
- C. Furnish one portable, floor-supported, roller-based, elevating carriage arranged for movement of circuit breakers in and out of compartments for present and future circuit breakers.
- D. Furnish overhead circuit-breaker lifting devices, mounted at top front of switchgear, with hoist and lifting yokes matching each drawout circuit breaker.
- E. Furnish set of tools for manually charging circuit breaker stored energy device.
- F. Furnish racking handle to manually move circuit breaker between connected and disconnected positions.
- G. Lockout Devices: Circuit breakers with integral, lockout/tagout devices.

## **2.10 CUSTOMER METERING**

- A. Per requirements in Section 26 27 13 – Electrical Metering.

## **PART 3 - EXECUTION**

### **3.1 COORDINATION**

- A. Instruct manufacturer about the location of incoming lugs, i.e., top or bottom feed based on incoming feeder entrance location.
- B. Coordinate installation of housekeeping concrete pad based on actual equipment supplied:
  - 1. Concrete: Per requirements in Division 03 – Concrete.
  - 2. Dimensions: Per requirements in Section 26 05 29 – Hangers and Supports for Electrical Systems.
- C. Coordinate with miscellaneous trades for equipment foreign to the electrical installation to be outside of dedicated electrical space.
- D. Coordinate Cal Poly metering equipment requirements.
- E. Verify with manufacturer that “touch-up” paint kit is available for repainting.

### **3.2 EXAMINATION**

- A. Examine areas and surface to receive switchgear for compliance with requirements, installation tolerances, and other conditions affecting performance. Proceed with

installation only after unsatisfactory conditions have been corrected.

- B. Verify that space indicated for switchgear mounting meets code-required working clearances.
- C. Notify Owner's Representative of any discrepancies prior to submittal of product data and shop drawings.

### **3.3 INSTALLATION**

- A. Install switchgear in accordance with applicable portions of ANSI/NECA 400.
- B. Switchgear mounting and seismic restraints:
  - 1. Install switchgear anchorage devices and seismic restraints based on design by an Engineer registered and licensed in the State of California, and to comply with Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems for seismic criteria.
  - 2. Bolt switchgear to concrete housekeeping pads, using anchor bolts in accordance with Section 26 05 29 – Hangers and Supports for Electrical Systems. Cast anchor bolt inserts into pads.
  - 3. Install bushing assemblies for anchor bolts for seismic restraints per requirements in Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems.
- C. Install engraved plastic nameplates under provisions of Section 26 0553 – Electrical Systems Identification for switchgear, every instrument, overcurrent protective device and disconnect device. Attach nameplate to exterior of switchgear using small corrosion-resistant metal screws and rivets. Do not use contact adhesive. Indicate switchgear manufacturer's name and drawing number, name, amperage, voltage, phase, number of wires, short circuit current rating (amp, RMS symmetrical and MVA 3-phase symmetrical) and momentary and fault-closing ratings (amp, RMS asymmetrical). For each overcurrent protective device and disconnect device, include circuit, load and area served, voltage/phase rating, and fuse size and type, when applicable.
- D. Provide framed, printed operating instructions for switchgear, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of switchgear.
- E. Install switchgear in dedicated electrical space per NFPA 70, and as indicated on drawings.
- F. Tighten electrical connectors and terminal according to equipment manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- G. Install fuses in fusible switch at job site per requirements in Section 26 2813 – Fuses.
- H. Install surge arrestors in cable termination compartments and connect to each phase of circuit, per requirements in Section 26 43 00 – Surge Protective Devices.
- I. Connect surge protective devices to switchgear bus per requirements in Section 26 4300 – Surge Protective Devices.

- J. Request inspection from the University IOR 10 days prior to planned panel energization. Have all required testing complete and available for inspection.
- K. Install Cal Poly metering equipment, devices and wiring in conformance with Cal Poly requirements.
- L. Tighten electrical connectors and terminals according to equipment manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- M. Apply temporary heat to maintain temperature according to manufacturer's written instructions.

### **3.4 CONNECTIONS**

- A. Ground switchgear according to Section 26 05 26 – Grounding and Bonding for Electrical Systems.
- B. Connect power and control wiring according to Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables.

### **3.5 FIELD QUALITY CONTROL**

- A. Inspect switchgear for physical damage, proper alignment, connections, anchorage, seismic restraints and grounding.
- B. Test continuity of each circuit.
- C. Test switchgear per requirements in Sections 26 08 12 – Power Distribution Acceptance Tests and 26 08 13 – Power Distribution Acceptance Test Tables.
- D. Interpret test results in writing and submit to Owner's Representative.

### **3.6 REPAINTING**

- A. Remove paint splatters and other marks from surface of equipment.
- B. Touch-up chips, scratches or marred finishes to match original finish, using manufacturer- supplied paint kit. Leave remaining paint with Owner's Representative.

### **3.7 ADJUSTING**

- A. Set field-adjustable circuit breakers trip settings, to values indicated on drawings or recommended by the overcurrent protective device coordination study per Section 26 05 73 – Power System Studies.
- B. Field adjustments of trip setting and adjustment or replacement of equipment to comply with Section 26 05 73 – Power System Studies; no additional cost to Owner.

### **3.8 CLEANING**

- A. Clean switchgear during construction phase, prior to initial testing and energization, and prior to final punch list, after other trades have departed. Cleaning procedures shall be as follows:

1. Vacuum dirt and construction debris from interior and exterior of equipment; do not use compressed air to assist in cleaning.
2. Rack out circuit breakers and remove arc chutes.
3. Wipe down surfaces, including arc chutes and circuit breakers with Endust or equivalent.
4. Use paintbrush to dust small, hard-to-reach crevices.

### **3.9 DEMONSTRATION**

- A. Provide training session by manufacturer for one workday at a job location, to train the Owner's personnel in the operation and maintenance of switchgear.

**END OF SECTION 26 23 00**

## **SECTION 26 24 13 -**

### **SWITCHBOARDS PART 1 -**

#### **GENERAL**

##### **1.1 RELATED WORK**

- A. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables
- B. Section 26 05 26 – Grounding and Bonding for Electrical Systems
- C. Section 26 05 29 – Hangers and Supports for Electrical Systems
- D. Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems
- E. Section 26 05 53 – Electrical Systems Identification
- F. Section 26 05 73 – Power System Studies
- G. Section 26 08 12 – Power Distribution Acceptance Tests
- H. Section 26 27 13 – Electrical Metering
- I. Section 26 28 13 – Fuses
- J. Section 26 43 00 – Surge Protective Devices

##### **1.2 REFERENCE**

- A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

##### **1.3 DESCRIPTION**

- A. Section includes free-standing, dead-front type low-voltage distribution switchboards.

##### **1.4 REFERENCE STANDARDS**

- A. ANSI/IEEE C37.13 – Low-Voltage AC Power Circuit Breakers Used in Enclosures
  - B. ANSI/NECA 400 – Recommended Practice for Installing and Maintaining Switchboards
  - C. IEEE C62.41.1 Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
  - D. IEEE C62.41.2 Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits
  - E. NFPA 70 – National Electrical Code
  - F. NEMA AB 1 – Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures
  - G. NEMA AB 3 – Molded-Case Circuit Breakers and Their Applications
  - H. NEMA FU 1 – Low-Voltage Cartridge Fuses
  - I. NEMA KS 1 – Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts
- SWITCHBOARDS

Maximum)

- J. NEMA PB 2 – Dead-Front Distribution Switchboards
- K. NEMA PB 2.1 – General Instructions for Proper Handling, Installation and Maintenance of Dead- Front Distribution Switchboards Rated 600 Volts or Less
- L. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)
  
- M. UL 98 – Enclosed and Dead-Front Switches
- N. UL 486A-486B – Wire Connectors
- O. UL 489 – Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
- P. UL 869A – Reference Standard for Service Equipment
- Q. UL 891 – Dead-Front Switchboards
- R. UL 1053 – Ground-Fault Sensing and Relaying Equipment
- S. UL 1066 – Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures

### 1.5 SUBMITTALS

- A. Product Data: For each switchboard, components and accessories indicated:
  - 1. Include data on features and components and complete description; submit catalog cut sheets showing voltage, size, rating and size of surge protective devices, switching and overcurrent protective devices.
  - 2. Features, characteristics, factory settings and time-current curves of individual protective devices, auxiliary components and ground fault relaying.
- B. Shop Drawings:
  - 1. For each switchboard specified in this Section:
    - a. General Arrangement:
      - 1) Indicate front, plan, and side views of switchboards; access requirements (front, side, rear); overall dimensions and components list; shipping splits and weights.
      - 2) Front elevation indicating location of devices and instruments.
      - 3) Sections through switchboard showing space available for conduits.
    - b. Conduit entrance locations and requirements.
    - c. Nameplate legends.
    - d. Configuration, size and number of bus bars for each phase and current rating of buses.
    - e. Ground bus.
    - f. Neutral bus.
    - g. Short circuit ratings of switchboards and overcurrent protective devices, and bus withstand rating.
    - h. Instrument details; enclosure types and details.
    - i. Wiring diagrams: power, signal and control wiring.
    - j. Utility company's metering provisions with indication of approval by utility company.
    - k. Descriptive documentation of optional barriers specified for electrical

- insulation and isolation.
- I. UL listing for series rating of installed devices.
- 2. Contractor to submit 1/4" scale floor plans with switchboard locations and required clearances and service space around equipment.
- C. Manufacturer's Installation Instructions:
  - 1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
- D. Test Reports: Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
- E. Complete review of this specification noting for each paragraph whether proposed equipment complies with project specifications or deviates. Justification must be given for each deviation.
- F. Closeout Submittals:
  - 1. Project Record Documents:
    - a. Record actual locations, configurations, and ratings of switchboard and major components on single-line diagrams and plan layouts.
  - 2. Operation and Maintenance Data:
    - a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
    - b. Include manufacturer's written instructions for testing and adjusting overcurrent protective devices.
    - c. Include spare parts data listing, source, and current prices of replacement parts and supplies.
    - d. Include Manufacturer Seismic Qualification Certification and Installation Seismic Qualification Certification.
    - e. Include time-current curves, including selectable ranges for each type of overcurrent protective device.

## 1.6 QUALITY ASSURANCE

- A. Obtain switchboards from one source and by single manufacturer.
- B. Regulatory Requirements:
  - 1. Comply with NFPA 70 for components and installation.
  - 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.
- C. Certifications:
  - 1. Furnish Owner Representative with Manufacturer Seismic Qualification Certification: Submit certification that switchboards, accessories, and components will remain internally intact to withstand seismic forces defined in Section 26 0548 – Vibration and Seismic Controls for Electrical Systems. Include the following:
    - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Furnish Owner Representative with Installation Seismic Qualification Certification: Submit certification that switchboards, accessories, and components will remain in place without separation of any parts when subjected to the seismic forces defined in Section 26 0548 – Vibration and Seismic Controls for Electrical Systems and will be fully operational after the seismic event. Include the following:
  - a. Detailed description of equipment supports and seismic restraints on which the certification is based and their installation requirements.
  - b. Certification shall bear the seal and signature of an Engineer registered and licensed in the State of California.

### **1.7 DELIVERY, STORAGE, AND HANDLING**

- A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect units from dirt, fumes, water, corrosive substances, construction debris, and traffic. Provide temporary heaters in switchboards as required to prevent condensation.
- B. Deliver switchboards in (48") maximum width shipping splits, individually wrapped for protection, and mounted on shipping skids. Mark crates, boxes, and cartons clearly to identify equipment. Show crate, box, or carton identification number on shipping invoices.
- C. Handle switchboards in accordance with NEMA PB 2.1 and ANSI/NECA 400. Use factory- installed lifting provisions. Handle carefully to avoid damage to switchboard internal components, enclosure, and finish.

### **1.8 WARRANTY**

- A. Refer to Division 01 and Section 26 00 00 – General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1-year warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

### **1.9 MAINTENANCE**

- A. Extra Materials: Furnish extra materials described below that match product installed, are packaged with protective covering for storage, and are identified with labels describing contents.
  1. Potential Transformer Fuses: Equal to 10% of amount installed for each size and type, but no fewer than 2 of each size and type.
  2. Control-Power Fuses: Equal to 10% of amount installed for each size and type, but no fewer than 2 of each size and type.

### **1.10 UNIVERSITY STANDARDS**

- A. Switchboards and Panel boards
  1. All switchboards, panel boards, distribution boards, etc. that have a rating above 225A or a phase to ground voltage above 150V shall use distribution breakers that can be installed and removed without the manipulation of line side hardware



- (Nuts, Bolts or Screws) on the line side of the circuit breaker. The manipulation of any one circuit breaker must not disturb or interrupt the operation of any other or adjacent circuit breaker in the assembly
2. Provide 20% of the panel board, switchboard or distribution board breaker mounting space as spare space.
  3. All low voltage distribution equipment, panel boards, switchboards, distribution boards, etc. are to be located inside the building or structure. Outdoor distribution equipment is not permitted.
  4. All electrical distribution equipment shall be located in an electrical room or similar occupancy that is not accessible to the general public.
  5. All electrical distribution equipment shall be provided with locking covers or provisions for padlocks.
  6. All circuit breakers that carry a rating over 70A 1, 2 or 3 pole shall have permanently installed provisions to lock the breakers in the off position.
  7. Flush mounted panel boards shall have (1) .75 inch conduit stubbed into the accessible ceiling space above the panel per 3 available circuit breaker spaces.
  8. All circuit breakers that have trip or protection parameters that are adjustable will have facilities to seal of and protect these parameters from further tampering or adjustment.
  9. Circuit breaker will be fully rated for the fault current that they will encounter in their installation. The use of series rated devices to achieve a system that is of sufficient fault current duty for the installation conditions is not acceptable.
  10. Perform 3rd party acceptance testing for switchboards and panelboards per the current NETA ATS. Test each breaker 400A 3 pole or greater using NETA ATS.
  11. Low voltage transformers are to have an energy rating of CSL3 or higher.
  12. Perform 3rd party acceptance testing for transformers per the current NETA ATS.
  13. Motor starters that require overload protection shall use solid state current sensing type overload protection. Thermal element overload protection is not acceptable.

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS**

- A. Square D
- B. Eaton

### **2.2 RATINGS**

- A. Nominal system voltage: As indicated on the drawings or scheduled.
- B. Main bus continuous amp: As indicated on the drawings or scheduled.
- C. Short circuit current rating: As indicated on drawings.

- D. Brace switchboard components to withstand mechanical forces for symmetrical fault current shown.

### 2.3 CONSTRUCTION

- A. NEMA PB 2, UL 891
- B. Free-standing, dead-front type; vertical sections bolted together; sides and rear covered with removable bolt-on covers; adequate ventilation within enclosure; supporting frame: steel angles rigidly fastened together, with same outside dimensions as the enclosure.
- C. Adequate strength and rigidity necessary to resist conditions of use to which it may be subjected and to support equipment, devices and appurtenances contained therein.
- D. Incoming lug locations: Top or bottom, as applicable per drawings.
- E. Environmental Limitations:
  - 1. Ambient temperatures: Not exceeding 40°C.
  - 2. Altitude: Not exceeding 500 feet
  - 3. Temperature rise: Not to exceed 65°C over a 40°C ambient environment, with no derating required.
- F. Bus:
  - 1. Material: Copper; copper: 98% conductivity. The bus bars shall have sufficient cross-sectional area to meet UL 891 temperature rise requirements through actual tests. The bus bars shall be standard density rated for 1000 amperes per square inch copper.
  - 2. Connections:
    - a. Bolted:
      - 1) Not fewer than 4 bolts for each 4" x 4" contact.
      - 2) Not fewer than 2 bolts for each 2" x 2" contact.
      - 3) Grade 5 bolts and conical spring-type washers.
      - 4) Clamp joints are not allowed.
    - 3. Sizing: Standard size, based on 65°C over 40°C.
    - 4. Main Phase Buses: Three phase, 4 wire; fully rated; uniform capacity for entire length of switchboard; ampacity as indicated on drawings; rated for the main protective device frame size or main incoming conductors.
    - 5. All feeder device line and load connection straps: Rated to carry current rating of device frame (not trip rating).
    - 6. Support for Buses: Mounted on high-impact, non-tracking insulated supports; joints in the vertical bus are not permitted.
    - 7. Bus arrangement: A-B-C (left to right, top to bottom, front to rear).
  - G. Ground Bus: extend length of switchboard.
    - 1. 1/4" x 2" minimum-size, hard-drawn copper of 98% conductivity, equipped with pressure connectors for feeder ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection.
  - H. Neutral Bus: 100% of the ampacity of phase buses, equipped with pressure connectors for outgoing circuit neutral cables. Bus extensions for busway feeder

neutral bus are braced.

- I. Main incoming compartment.
- J. Hinged Front Doors: Allow access to metering and accessory compartments; concealed hinges; fastened by head bolts.
- K. Cable Supports: For each vertical section.
- L. Vertical Insulating Barrier: Between the device compartment and bus compartment.
- M. Vertical Insulating Barrier: Between the bus compartment and cable compartment.
- N. Barriers: Between adjacent sections.
- O. Hinged Front Doors: Over device compartments, with concealed hinges and fastened by hex head bolts.
- P. Hinged Rear Doors and Compartment Covers: With concealed hinges and fastened by hex head bolts.
- Q. Bus Connections: Extend from load side of devices into rear compartment for connections to outgoing cables.
- R. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.
  - 1. Pull Section: Matched and aligned with basic switchboard
- S. Future Provisions: Fully equip spaces for future devices with bussing, mounting brackets, supports, and appurtenances, insulated and braced for short circuit currents, with continuous current rating as indicated on drawings. Extension of phase, neutral, and ground buses from both ends.
- T. Adequate lifting means.
- U. Dimensions: 90" maximum height, excluding floor sills, lifting members and pull boxes.
- V. Line and Load Terminations: Mechanical type accessible from front only of switchboard, suitable for conductor materials and sizes as indicated on drawings suitable for number, size and trip ratings.
- W. Enclosure: Steel, NEMA 250, Type 1:
  - 1. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray Finish over a rust-inhibiting primer on treated metal surface.

## **2.4 SHORT CIRCUIT CURRENT RATING**

- A. Each switchboard with minimum short circuit current rating as indicated on drawings.
- B. Switchboards: Marked with their maximum short circuit current rating at supply voltage.
- C. Switchboards: Fully rated. Series rated switchboards are not acceptable.

## **2.5 SURGE PROTECTIVE DEVICES (SPD)**

- A. Furnished under 26 43 00 – Surge Protective Devices
- B. IEEE C62.41.1; integrally mounted, plug-in style, solid-state, parallel-connected, suppression and filtering modules
- C. Per requirements in Section 26 43 00 – Surge Protective Devices

## 2.6 OVERCURRENT PROTECTIVE DEVICES

- A. Circuit breakers must be able to be installed and removed without manipulating hardware (nuts, bolts, fasteners, etc.) to connect the line side of the circuit breaker to the buss.
- B. Molded-Case Circuit Breaker: NEMA AB 1, NEMA AB 3, UL 489; lockable handle; interrupting capacity to meet available fault current:
  - 1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit breaker frame sizes 225 A and below.
  - 2. Electronic (solid-state microprocessor based) trip unit circuit breakers: digital true RMS sensing trip units; interchangeable in the field within the frame size (field-replaceable rating plug to determine the breaker trip rating), field-adjustable settings and the following trip functions for circuit breaker frame sizes 250 A - 1200 A:
    - a. Instantaneous trip
    - b. Long- and short-time pickup levels
    - c. Long- and short-time time delay adjustments with  $I^2t$  response
    - d. Ground-fault pickup level, time delay, and  $I^2t$  response
  - 3. Current-Limiting Circuit Breakers: No fusible element, frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
  - 4. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with current-limiting fuses; trip activation on fuse opening or on opening of fuse compartment door.
  - 5. Listed for 100% of breaker's continuous ampere rating.
- C. Circuit Breaker Electronic Trip Units general characteristics:
  - 1. Circuit breakers, with solid-state microprocessor-based trip units:
    - a. Unit shall consist of current sensors, solid-state trip device, and solid-state adjustable time/current curve shaping elements.
    - b. Trip units shall be removable to allow for field upgrades.
    - c. Trip units shall incorporate "True RMS Sensing."
  - 2. Solid-state elements shall provide functions as indicated above.
  - 3. Adjustments shall be made using non-removable, discrete steps.
  - 4. Sealable transparent cover shall be provided over adjustments.
  - 5. Adjustable long-time pickup ( $I_r$ ) and delay shall be available in an adjustable rating plug that is UL listed as field-replaceable. Adjustable rating plug shall allow for five minimum long-time pickup settings from 0.4 to 1.0 times the sensor plug ( $I_n$ ). Other adjustable rating plugs shall be available for more precise settings to match the application. Long-time delay settings shall be at least three bands.
  - 6. Short-time pickup shall allow for five minimum settings from 1.5 to 10 times  $I_r$ . Short-time delay shall be at least three bands with  $I^2t$  ON and OFF.
  - 7. Instantaneous settings on the trip units shall be available in five minimum bands from 2 to 15 times  $I_n$ . The instantaneous settings shall also have an OFF setting when short-time pickup is provided.
  - 8. Trip units shall have the capability to electronically adjust the settings locally and

- remotely to fine increments below the switch settings. Fine increments for pickup adjustments are to be one ampere. Fine increments for delay adjustments are to be one second.
9. Trip unit shall indicate:
    - a. Long-time fault
    - b. Short-time fault
    - c. Instantaneous fault
    - d. Ground fault, where provided
  10. Trip unit shall provide local trip indication and capability to indicate local and remote reason for trip, i.e., overload, short circuit or ground fault.
  11. Trip unit shall contain means to conduct circuit breaker test, or via separate test kit.
  12. Breaker shall be equipped with externally accessible test points to be used for field testing.
  13. Trip units shall be available to provide real time metering. Metering functions include current, voltage, power and frequency.
  14. Trip units shall be provided with the following standard features:
    - a. True RMS sensing
    - b. LI
    - c. LSI
    - d. LSIG/Ground-fault trip
    - e. Ground Fault Alarm (no trip), with external relay, where required
    - f. Adjustable rating plugs
    - g. LCD or LED – Long-time pickup
    - h. LCD or LED – Trip indication
    - i. Digital Ammeter
    - j. Communications
    - k. LCD dot matrix display
    - l. Advanced user interface
    - m. Protective relay functions
    - n. Neutral protection
    - o. Incremental fine tuning of settings
    - p. Selectable long-time delay bands
    - q. Power measurement
    - r. Maximum peak demand (measure of average power over a 15-minute period) continuously recorded over a one-year period.
- D. Ground Fault protection equipment on breakers, where indicated: Integrally mounted relay and trip unit, push-to-test feature and ground fault indicator:
1. Ground-fault protection with at least three adjustable short-time delay settings and three trip- time delay bands; adjustable current pickup with maximum setting of 1200 amps. Arrange to provide protection for the following:
    - a. Three-wire circuit or system
    - b. Four-wire circuit or system
    - c. Four-wire, double-ended substation
  2. Trip units shall be capable of the following types of ground-fault protection: source ground return, residual, zero sequence, and modified differential. Ground fault sensing systems shall be changed in the field.
  3. Neutral current transformers shall be provided for 4-wire system.

4. Ground-fault settings for circuit breaker sensor sizes 1200 A or below shall be in nine bands from 0.2 to 1.0 times  $I_n$ . The ground-fault settings for circuit breakers above 1200 A shall be in minimum three bands up to 1200 A.
5. Ground-Fault Relay: UL 1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and 3-phase current transformer/sensor.

## **2.7 CONTROL POWER, COMPONENTS IDENTIFICATION, AND CONTROL WIRING**

- A. Control Circuits: 120 V, supplied through secondary disconnecting devices from control-power transformer.
- B. Electrically Interlocked Main and Tie Circuit Breakers: Two control-power transformers in separate compartments, with interlocking relays, connected to the primary side of each control- power transformer at the line side of the associated main circuit breaker. 120 V secondaries connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.
- C. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.
- D. Control components mounted within assembly, such as relays, pushbuttons, switches, etc.: Suitably marked for identification, corresponding to appropriate designations on manufacturer's wiring diagrams.
- E. Control Wiring: Factory installed, with bundling, lacing, and protection included; flexible conductors for #8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units; insulated locking spade terminals for all control connections, except where saddle type terminals, integral to a device; current transformer secondary leads, connected to short circuit terminal blocks; terminal blocks with suitable numbering strips for group of control wires leaving switchboard, with wire markers at each end of control wiring.

## **2.8 ACCESSORY COMPONENTS AND FEATURES**

- A. Furnish 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.
- B. Furnish accessory set including tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
- C. Furnish one portable, floor-supported, roller-based, elevating carriage arranged for movement of circuit breakers in and out of compartments for present and future circuit breakers.
- D. Furnish overhead circuit breaker lifting devices, mounted at top front of switchboard, with hoist and lifting yokes matching each drawout circuit breaker.
- E. Furnish set of tools for manually charging circuit breaker stored energy device.
- F. Lockout Devices: Circuit breakers with integral, lockout/tagout devices.

## **2.9 CUSTOMER METERING**

- A. Per requirements in Section 26 27 13 – Electrical Metering.

## **PART 3 - EXECUTION**

### **3.1 COORDINATION**

- A. Instruct manufacturer about the location of incoming lugs, i.e., top or bottom feed based on incoming feeder entrance location.
- B. Coordinate installation of housekeeping concrete pad based on actual equipment supplied:
  - 1. Concrete: Per requirements in Division 03 – Concrete.
  - 2. Dimensions: Per requirements in Section 26 05 29 – Hangers and Supports for Electrical Systems.
- C. Coordinate with miscellaneous trades for equipment foreign to the electrical installation to be outside of dedicated electrical space.
- D. Coordinate utility company metering equipment requirements.
- E. Verify with manufacturer that “touch-up” paint kit is available for repainting.

### **3.2 EXAMINATION**

- A. Examine areas and surface to receive switchboards for compliance with requirements, installation tolerances, and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Verify that space indicated for switchboard mounting meets code-required working clearances.
- C. Notify Owner Representative of any discrepancies prior to submittal of product data and shop drawings.

### **3.3 INSTALLATION**

- A. Install switchboard in accordance with NEMA PB 2.1 and ANSI/NECA 400.
- B. Switchboard mounting and seismic restraints:
  - 1. Install switchboard anchorage devices and seismic restraints based on design by an Engineer registered and licensed in the State of California, and to comply with Section 26 0548 – Vibration and Seismic Controls for Electrical Systems for seismic criteria.
  - 2. Bolt switchboards to concrete housekeeping pads, using anchor bolts in accordance with Section 26 05 29 – Hangers and Supports for Electrical Systems. Cast anchor bolt inserts into pads.
  - 3. Install bushing assemblies for anchor bolts for seismic restraints per requirements in Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems.
- C. Install engraved plastic nameplates under provisions of Section 26 05 53 – Electrical Systems Identification for each switchboard, every instrument, overcurrent protective

device and disconnect device. Attach nameplate to exterior of each switchboard using small corrosion-resistant metal screws and rivets. Do not use contact adhesive. Indicate switchboard manufacturer's name and drawing number, name, amperage, voltage, phase, number of wires, short circuit current rating (amp, RMS symmetrical and MVA 3-phase symmetrical) and momentary and fault-closing ratings (amp, RMS asymmetrical). For each overcurrent protective device and disconnect device, include circuit, load and area served, voltage/phase rating, and fuse size and type, when applicable Request inspection from the University IOR 10 days prior to planned panel energization. Have all required testing complete and available for inspection.

- D. Provide framed, printed operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of switchboards.
- E. Install switchboards in dedicated electrical space per NFPA 70, and as indicated on drawings.
- F. Tighten electrical connectors and terminal according to equipment manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- G. Install fuses in fusible switch at job site per requirements in Section 26 28 13 – Fuses.
- H. Install surge arrestors in cable termination compartments and connect to each phase of circuit, per requirements in Section 26 43 00 – Surge Protective Devices.
- I. Connect surge protective devices to switchboard bus per requirements in Section 26 43 00 – Surge Protective Devices.
- J. Install utility company metering equipment, devices and wiring in conformance with serving utility requirements.
- K. Tighten electrical connectors and terminals according to equipment manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- L. Apply temporary heat to maintain temperature according to manufacturer's written instructions.

### **3.4 CONNECTIONS**

- A. Ground switchboards according to Section 26 05 26 – Grounding and Bonding for Electrical Systems.
- B. Connect power and control wiring according to Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables.

### **3.5 FIELD QUALITY CONTROL**

- A. Inspect switchboards for physical damage, proper alignment, connections, anchorage, seismic restraints and grounding.
- B. Test continuity of each circuit.
- C. Test switchboards per requirements in Sections 26 08 12 – Power Distribution Acceptance Tests.



- D. Interpret test results in writing and submit to Owner Representative.
- E. Test switch operators once after energizing.

**3.6 REPAINTING**

- A. Remove paint splatters and other marks from surface of equipment.
- B. Touch-up chips, scratches or marred finishes to match original finish, using manufacturer- supplied paint kit. Leave remaining paint with Owner Representative.

**3.7 ADJUSTING**

- A. Set field-adjustable circuit breakers trip settings or change the trip settings to values indicated on drawings or recommended by the overcurrent protective device coordination study per Section 26 05 73 – Power System Studies.
- B. Field adjustments or changing of trip setting and adjustment or replacement of equipment to comply with Section 26 05 73 – Power System Studies; no additional cost to Owner.

**3.8 CLEANING**

- A. Vacuum dirt and construction debris from interior and exterior of equipment; do not use compressed air to assist in cleaning.

**3.9 DEMONSTRATION**

- A. Provide training session by manufacturer for one workday at a job location, to train the Owner’s personnel in the operation and maintenance of switchboards.

**END OF SECTION 26 24 13**

## **SECTION 26 24 16.13 - LIGHTING AND APPLIANCE PANELBOARDS**

### **PART 1 - GENERAL**

#### **1.1 RELATED WORK**

- A. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables
- B. Section 26 05 26 – Grounding and Bonding for Electrical Systems
- C. Section 26 05 29 – Hangers and Supports for Electrical Systems
- D. Section 26 05 33 – Raceway and Boxes for Electrical Systems
- E. Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems
- F. Section 26 05 53 – Electrical Systems Identification
- G. Section 26 05 73 – Power System Studies
- H. Section 26 08 12 – Power Distribution Acceptance Tests
- I. Section 26 08 13 – Power Distribution Acceptance Test Tables
- J. Section 26 27 13 – Electrical Metering

#### **1.2 REFERENCE**

- A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

#### **1.3 DESCRIPTION**

- A. Section includes circuit breaker type lighting and appliance branch circuit panelboards as shown on drawings and as scheduled. Panels covered in this section are between 0-225A ratings. See "Distribution Boards" spec section 26 24 16.16 for ratings above 225A.

#### **1.4 REFERENCE STANDARDS**

- A. NECA 407 - Recommended Practice for Installing and Maintaining Panelboards
- B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)
- C. NEMA AB 1 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures
- D. NEMA PB 1 - Panelboards
- E. NEMA PB 1.1 - General Instructions for Proper Installation, Operation, and Maintenance of Panelboards Rated 600 Volts or Less

- F. NFPA 70 - National Electrical Code

- G. UL 50 - Enclosures for Electrical Equipment
- H. UL 67 - Panelboards
- I. UL 486A-486B - Wire Connectors
- J. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures
- K. UL 869A - Reference Standard for Service Equipment

### **1.5 SUBMITTALS**

- A. Product Data:
  - 1. Submit catalog data showing specified features of standard products. Eliminate extraneous catalog data.
- B. Shop Drawings:
  - 1. Submit for review prior to manufacture. Include complete description, front view, dimensions, voltage, main bus ampacity, circuit breaker arrangement and sizes, short circuit current rating, and factory settings of individual protective devices.
  - 2. Submit 1/4" scale electrical room floor plans with panelboard locations.
- C. Partial Submittals:
  - 1. Panelboards shall be submitted for review together. Partial submittals of panelboards are not acceptable and will be rejected.
- D. Manufacturer's Installation Instructions:
  - 1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
- E. Test Reports:
  - 1. Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
- F. Closeout Submittals:
  - 1. Project Record Documents:
    - a. Record actual locations of panelboards and record actual circuiting arrangements.
  - 2. Operation and Maintenance Data:
    - a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
    - b. Include manufacturer's written instructions for testing and adjusting overcurrent protective devices.
    - c. Include time-current curves and selectable ranges for each type of overcurrent protective device.
    - d. Include spare parts data listing, source, and current prices of replacement parts and supplies.
    - e. Include manufacturer's Seismic Qualification Certification and Installation Seismic Qualification Certification.

### **1.6 QUALITY ASSURANCE**

- A. Obtain panelboards, overcurrent protective devices, components, and accessories from one

source and by single manufacturer.

B. Regulatory Requirements:

1. Comply with NFPA 70.
2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

C. Certifications:

1. Furnish Owner's Representative with manufacturer's Seismic Qualification Certification: Submit certification that panelboards, overcurrent protective devices, accessories, and components will remain internally intact to withstand seismic forces defined in Section 26 0548 – Vibration and Seismic Controls for Electrical Systems. Include the following:
  - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
2. Furnish Owner's Representative with Installation Seismic Qualification Certification: Submit certification that panelboards, overcurrent protective devices, accessories, and components will remain in place without separation of any parts when subjected to the seismic forces defined in Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems and will be fully operational after the seismic event. Include the following:
  - a. Detailed description of panelboard anchorage devices and seismic restraints on which the certification is based, and their installation requirements.
  - b. Certification shall bear the seal and signature of an Engineer registered and licensed in the State of California.

### 1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris, and traffic.
- B. Comply with NEMA PB 1.1 and manufacturer's written instructions.

### 1.8 WARRANTY

- A. Refer to Division 01 and Section 26 00 00 – General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1-year written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

### 1.9 MAINTENANCE

- A. Extra Materials:
  1. Furnish Owner's Representative with two keys per panelboard.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Square D

- B. Eaton
- C. Or equal

## **2.2 LIGHTING AND APPLIANCE BRANCH CIRCUIT PANELBOARDS**

- A. NEMA PB 1, UL 67
- B. Fabrication:
  - 1. Factory assembled.
  - 2. Door-in-door construction.
  - 3. Incoming feeder lugs: copper conductors.
  - 4. Multiple lugs to match number of conductors per phase.
  - 5. Sub-feed (double) lugs, or feed-through lugs where indicated.
  - 6. Filler plates.
  
  - 7. Wiring terminals for field installed conductors: Pressure wire connectors, except wire-binding screws for #10 AWG or smaller conductors.
- C. Panelboard Buses:
  - 1. Copper
  - 2. Ampere rating as scheduled
  - 3. Ground bus: uninsulated, bonded to panelboard cabinet
  - 4. Insulated neutral bus: 100% of phase bus rating
- D. Molded-Case Circuit Breakers:
  - 1. NEMA AB 1, UL 489
  - 2. Panelboards operating at a voltage over 150V phase to ground must employ circuit breakers that can installed and removed without manipulating hardware (nuts, bolts, fasteners, etc.) to connect to the line side of the circuit breaker to panelboard buss.
  - 3. Panelboards operating at a voltage less than 150V phase to ground must employ circuit breakers that have positive trip indication on circuit breakers sized 5-100A. Positive trip indication and contrasting LED, contrasting flag, or indicating window that changes color when the circuit breaker is in the tripped position. This indication must not be visible or illuminated when the circuit breaker is in the "on" or "off" state.
  - 4. Quick-make, quick-break, with thermal-magnetic trip.
  - 5. Common internal trip on multi-pole breakers. Handle-ties are not permitted.
  - 6. Ampere rating as scheduled.
  - 7. Listed as Type SWD for lighting circuits.
  - 8. Listed as Type HACR for air conditioning equipment circuits.
  - 9. Bussing, device mounting hardware, and steel knockouts in dead front where "space" is indicated.
  - 10. Tandem circuit breakers are not acceptable.
  - 11. Locks on trip handles where indicated.
  - 12. Ground fault equipment protection (GFEP), rated 30 mA trip, to provide equipment protection for branch circuits feeding electrical heat tracing, where indicated.
  - 13. Ground fault circuit interrupter (GFCI), rated at 4-6 mA trip for protection of personnel, where indicated.
- E. Cabinet

1. NEMA 250, UL 50
2. NEMA Type 1, Type 3R (outdoor locations) enclosure.
3. Front (trim) flush and surface mounted with door in front with concealed self-adjusting trim clamps, and complete with cylinder-type lock and catch.
4. Same height matching trim, where two cabinets are mounted adjacent to one another in finished areas.
5. All sections of panelboards have the same size, where oversize cabinets are required for one section of multi-section panelboard.
6. Boxes and fronts made of code-gauge galvanized steel.
7. Manufacturer's standard gray enamel finish over prime coat] [Manufacturer's prime coat finish for cabinets mounted in finished areas for field paint to match wall color by others and manufacturer standard gray enamel finish over prime coat for cabinets mounted in unfinished areas. For field painted panels, door hinges shall be concealed inside panel.

### **2.3 METERS**

- A. Provide separate metering compartments with digital meter in accordance with Section 26 2713 - Electrical Metering.

### **2.4 SHORT CIRCUIT CURRENT RATING**

- A. Each panelboard with minimum short circuit current rating as indicated on drawings.
- B. Panelboards marked with their maximum short circuit current rating at supply voltage.
- C. Panelboards: Fully rated. Series-rated panelboards are not acceptable.

### **2.5 SURGE PROTECTIVE DEVICES (SPD)**

- A. Furnished under 26 43 00 – Surge Protective Devices
- B. Per requirements in Section 26 43 00 – Surge Protective Devices.

### **2.6 SPARE CONDUITS**

- A. Spare conduits per requirements in Section 26 05 33 – Raceway and Boxes for Electrical Systems.

## **PART 3 - EXECUTION**

### **3.1 COORDINATION WITH MANUFACTURER**

- A. Instruct manufacturer about the location of additional wiring gutter space when required (i.e., top, bottom, right, left, or combination).
- B. Instruct manufacturer about the location of main lugs or main circuit breaker (i.e., top or bottom feed based on incoming feeder entrance location).
- C. Instruct manufacturer to provide multiple lugs where conductors in parallel or sub-feed (double) lugs or feed-through lugs are indicated.
- D. Instruct manufacturer on the size of cross-connection cables for panelboards fed via

sub-feed (double) lugs or feed-through lugs. Make cable size with ampacity equal to incoming feeder.

- E. Verify that "touch-up" paint kit is available for repainting.
- F. Coordinate painting of cabinets in finished areas with work performed under Division 09 - Finishes.

### **3.2 EXAMINATION**

- A. Verify that space indicated for panelboard mounting meets code-required working clearances and dedicated equipment space.
- B. Notify Owner's Representative of any discrepancies prior to submittal of product data and shop drawings.

### **3.3 INSTALLATION**

- A. Install panelboards in accordance with NECA 407 and NEMA PB 1.1.
- B. Install panelboards plumb and rigid without distortion of box, in accordance with manufacturer's written instructions, and in compliance with recognized industry practices.
- C. Panelboard mounting and seismic restraints:
  - 1. Install panelboard anchorage devices and seismic restraints based on design by an Engineer registered and licensed in the State of California and to comply with Section 26 0548 – Vibration and Seismic Controls for Electrical Systems for seismic criteria.
  - 2. Fasten panelboards firmly to walls and structural surfaces, ensuring they are permanently and mechanically anchored.
  - 3. Anchor and fasten panelboards and their supports to building structural elements (wood, concrete, masonry, hollow walls and nonstructural building surfaces) by the methods described in Section 26 05 29 – Hangers and Supports for Electrical Systems.
  - 4. Install two rows of steel slotted channel, with a minimum of 4 attachment points, for each panelboard section.
  - 5. When not located directly on wall, provide support frame of steel slotted channel anchored to floor and ceiling structure.
- D. Install top breaker handle a maximum of 6'-7" above finished floor or working platform with handle in its highest position.
- E. Tighten electrical connectors and terminals according to equipment manufacturer's published torque- tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A – 486B.
- F. Install as-built typewritten circuit directory in directory frame (to indicate installed circuit loads) mounted inside each panelboard door. Include description of connected loads, room number, room name, area, or item served for each branch circuit. Indicate motor names and horsepower as applicable. Cover circuit directory with colorless plastic. Coordinator with Owner's Representative and Architect to ensure that room numbers used in panel directory

are final numbers assigned by Owner's Representative.

- G. Install engraved plastic nameplates under provisions of Section 26 05 53 – Electrical Systems Identification. Attach nameplate to exterior of each panelboard using small metal screws or rivets. Do not use contact adhesive.
- H. 1. Include panelboard name, amperage, voltage, phase, and number of wires. Label spare circuits as SPARE. Leave spare breakers in OFF position.
- I. Room numbers used shall be those used by Owner's Representative except as otherwise directed by Owner's Representative.
- J. Install panelboard in dedicated electrical space per NFPA 70 and as shown on drawings. Coordinate with miscellaneous trades for equipment foreign to the electrical installation to be outside of dedicated electrical space.
- K. Install filler plates in unused spaces.
- L. Install three 3/4" spare conduits stubbed into accessible ceiling space or space designated to be ceiling space in the future for all flush-mounted panelboards. Install conduits in accordance with requirements in Section 26 05 33 – Raceway and Boxes for Electrical Systems.
- M. Install three 3/4" spare conduits stubbed into ceiling space above and below for panelboards that serve loads on levels other than that where the panelboard is located. Install conduits in accordance with requirements in Section 26 05 33 – Raceway and Boxes for Electrical Systems.

### **3.4 CONNECTIONS**

- A. Ground panelboards according to Section 26 05 26 – Grounding and Bonding for Electrical Systems.
- B. Connect wiring according to Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables.

### **3.5 FIELD QUALITY CONTROL**

- A. Inspect for physical damage, proper alignment, anchorage, and grounding.
- B. Maintain proper phasing for multi-wire circuits.
- C. Test main circuit breakers in accordance with requirements in Sections 26 08 12 – Power Distribution Acceptance Tests and 26 08 13 – Power Distribution Acceptance Test Tables.
- D. Interpret test results in writing and submit to Owner's Representative.
- E. Check phase-to-phase and phase-to-ground insulation resistance levels prior to energization of panelboards. Request inspection from the University IOR 10 days prior to planned panel energization. Have all required testing complete and available for IOR's inspection.
- F. Check panelboards for electrical continuity of circuits and for short-circuits prior to energization.
- G. Submit ammeter readings for all panelboard feeders indicating normal operating



load and phase balance.

- H. Balancing Loads: After Substantial Completion, but not more than 2 months after Final Acceptance, conduct load-balancing measurements and make circuit changes as follows:
1. Perform measurements during period of normal working load as advised by Owner's Representative.
  2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility. Make special arrangements with Owner's Representative to avoid disrupting critical 24-hour services, such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
  3. Recheck loads after circuit changes during normal load period. Record all load readings before and after changes and submit test records.
  4. Tolerance: Difference exceeding 10% between phase loads, within a panelboard, is not acceptable.
  5. Reconnect or redistribute circuits or circuit breakers to achieve balanced condition. Revise circuit directory to reflect circuiting changes required to balance phase loads.

### **3.6 REPAINTING**

- A. Remove paint splatters or other marks from surface of panelboards.
- B. Touch-up chips, scratches, or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint with Owner's Representative.

### **3.7 ADJUSTING**

- A. Adjust fronts, covers, hinges, and locks.

### **3.8 CLEANING**

- A. Clean panelboard interiors and exteriors prior to final inspection. Remove paint splatters and other spots, dirt and debris.

**END OF SECTION 26 24 16.13**

## **SECTION 26 24 16.16 - DISTRIBUTION**

### **PANELBOARDS PART 1 - GENERAL**

#### **1.1 RELATED WORK**

- A. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables
- B. Section 26 05 26 – Grounding and Bonding for Electrical Systems
- C. Section 26 05 29 – Hangers and Supports for Electrical Systems
- D. Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems
- E. Section 26 05 53 – Electrical Systems Identification
- F. Section 26 05 73 – Power System Studies
- G. Section 26 08 12 – Power Distribution Acceptance Tests
- H. Section 26 27 13 – Electrical Metering

#### **1.2 REFERENCE**

- A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

#### **1.3 DESCRIPTION**

- A. Section includes circuit breaker type and fusible switch type power distribution panelboards as shown on drawings and as scheduled. Distribution Panelboards included in this section are panelboards operating over 225A.

#### **1.4 REFERENCE STANDARDS**

- A. NECA 407 - Recommended Practice for Installing and Maintaining Panelboards
- B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)
- C. NEMA AB 1 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures
- D. NEMA FU 1 - Low-Voltage Cartridge Fuses
- E. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)
- F. NEMA PB 1 - Panelboards
- G. NEMA PB 1.1 - General Instructions for Proper Installation, Operation, and Maintenance of Panelboards Rated 600 Volts or Less
- H. NFPA 70 - National Electrical Code
- I. UL 50 - Enclosures for Electrical Equipment
- J. UL 67 - Panelboards
- K. UL 486A – 486B - Wire Connectors

- L. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures
- M. UL 512 - Fuseholders
- N. UL 869A - Reference Standard for Service Equipment

### **1.5 SUBMITTALS**

- A. Product Data:
  - 1. Submit catalog data showing specified features of standard products. Eliminate extraneous catalog data.
- B. Shop Drawings:
  - 1. Submit for review prior to manufacture. Include complete description, front view, dimensions, voltage, main bus ampacity, circuit breaker arrangement and sizes, short circuit current rating, and factory settings of individual protective devices.
  - 2. Submit 1/4" scale electrical room floor plans with panelboard locations.
- C. Partial Submittals:
  - 1. Panelboards shall be submitted for review together. Partial submittals of panelboards are not acceptable and will be rejected.
- D. Manufacturer's Installation Instructions:
  - 1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
- E. Test Report:
  - 1. Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
- F. Closeout Submittals:
  - 1. Project Record Documents:
    - a. Record actual locations of panelboards and record actual circuiting arrangements.
  - 2. Operation and Maintenance Data:
    - a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
    - b. Include manufacturer's written instructions for testing and adjusting overcurrent protective devices.
    - c. Include time-current curves and selectable ranges for each type of overcurrent protective device.
    - d. Include spare parts data listing, source, and current prices of replacement parts and supplies.
    - e. Include manufacturer's Seismic Qualification Certification and Installation Seismic Qualification Certification.

### **1.6 QUALITY ASSURANCE**

- A. Obtain panelboards, overcurrent protective devices, components, and accessories from one source and by a single manufacturer.
- B. Regulatory Requirements:
  - 1. Comply with NFPA 70.
  - 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as

suitable for purpose specified and indicated.

C. Certifications:

1. Furnish Owner Representative with manufacturer's Seismic Qualification Certification: Submit certification that panelboards, overcurrent protective devices, and components will remain internally intact to withstand seismic forces defined in Section 26 0548 – Vibration and Seismic Controls for Electrical Systems. Include the following:
  - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
2. Furnish Owner Representative with Installation Seismic Qualification Certification: Submit certification that panelboards, overcurrent protective devices, accessories, and components will remain in place without separation of any parts when subjected to the seismic forces defined in Section 26 0548 – Vibration and Seismic Controls for Electrical Systems and will be fully operational after the seismic event. Include the following:
  - a. Detailed description of panelboard anchorage devices and seismic restraints on which the certification is based, and their installation requirements.
  - b. Certification shall bear the seal and signature of an Engineer registered and licensed in the State of California.

**1.7 DELIVERY, STORAGE, AND HANDLING**

- A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris, and traffic.
- B. Comply with NEMA PB 1.1 and manufacturer's written instructions.

**1.8 WARRANTY**

- A. Refer to Division 01 and Section 26 00 00 – General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1-year written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

**1.9 MAINTENANCE**

- A. Extra Materials:
  1. Furnish Owner Representative with two keys per panelboard.

**PART 2 - PRODUCTS**

**2.1 MANUFACTURERS**

- A. Square D
- B. General Electric

- C. Cutler Hammer
- D. or equal

## 2.2 POWER DISTRIBUTION PANELBOARDS

- A. NEMA PB 1, UL 67.
- B. Distribution panelboards must be mounted in equipment enclosures that are 32" wide or larger.
- C. Distribution panelboards rated 225A or greater shall have circuit breakers that can be installed and removed without manipulating hardware (nuts, bolts, fasteners, etc.) to connect the line side of the circuit breaker to the distribution panelboard buss.
- D. Fabrication:
  - 1. Factory assembled
  - 2. Individualized breaker dead-front cover door-in-door construction
  - 3. Incoming feeder lugs: copper conductors
  - 4. Multiple lugs to match number of conductors per phase
  - 5. Sub-feed (double) lugs, or feed-through lugs where indicated
  - 6. Filler plates
  - 7. Wiring terminals for field installed conductors: Pressure wire connectors, except wire-binding screws for #10 AWG or smaller conductors.
- E. Panelboard Buses:
  - 1. Copper
  - 2. Ampere rating as scheduled
  - 3. Ground bus: uninsulated, bonded to panelboard cabinet
  - 4. Insulated neutral bus where applicable: 100% of phase bus rating
- F. Molded-Case Circuit Breakers:
  - 1. NEMA AB 1, UL 489
  - 2. Bolt-on or I-line type, labeled for 75°C copper and aluminum conductors.
  - 3. Quick-make, quick-break, with thermal-magnetic trip and electronic (solid-state microprocessor-based) trip.
  - 4. Equipped with individually insulated, braced, and protected connectors
  - 5. Common internal trip on multi-pole breakers. Handle-ties are not permitted.
  - 6. Ampere rating as scheduled.
  - 7. Front face flush with each other.
  - 8. Large, permanent, individual circuit numbers affixed to each breaker in uniform position.
  - 9. Tripped indication clearly shown by breaker handle taking position between "ON" and "OFF."
  - 10. Listed as Type HACR for air conditioning equipment circuits.
  - 11. Bussing, device mounting hardware, and steel knockouts in dead front where "space" is indicated.
  - 12. For 100A frame size and below: thermal-magnetic trip.
  - 13. For 100A frame size and above: electronic trip units interchangeable in the field within the frame size and field-adjustable long time pick-up, long time delay, short time pick-up, short time delay, and instantaneous current settings. Each adjustment shall have discrete settings and shall be independent of all other adjustments.

14. Locks on trip handles where indicated.
15. Breakers 400A frame size and larger to be microprocessor controlled with LSI or LSIg trip functions.

G. Cabinet

1. NEMA 250, UL 50
2. NEMA Type 1, Type 3R (outdoor locations) enclosure.
3. Four-piece front (trim) surface mounted with door over the front, with concealed self-adjusting trim clamps, and complete with cylinder-type lock and catch except omit door in fusible switch panelboard.
4. Same height matching trim, where two cabinets are mounted adjacent to one another in finished areas.
5. All sections of panelboards have the same size, where oversize cabinets are required for one section of multi-section panelboard.
6. Boxes and fronts made of code-gauge galvanized steel.

**2.3 METERS**

- A. Provide separate metering compartments with digital meter in accordance with Section 26 27 13  
- Electrical Metering.

**2.4 SHORT CIRCUIT CURRENT RATING**

- A. Each panelboard with minimum short circuit current rating as indicated on drawings.
- B. Panelboards marked with their maximum short circuit current rating at supply voltage.
- C. Panelboards: Fully rated. Series-rated panelboards are not acceptable.

**2.5 SURGE PROTECTIVE DEVICES (SPD)**

- A. Furnished under 26 43 00 – Surge Protective Devices
- B. Per requirements in Section 26 43 00 – Surge Protective Devices.

**PART 3 - EXECUTION**

**3.1 COORDINATION WITH MANUFACTURER**

- A. Instruct manufacturer about the location of additional wiring gutter space when required, i.e. top, bottom, right, left, or combination.
- B. Instruct manufacturer about the location of main lugs or main circuit breaker (i.e., top or bottom feed based on incoming feeder entrance location).
- C. Instruct manufacturer to provide multiple lugs where conductors in parallel or sub-feed (double) lugs or feed-through lugs are indicated.
- D. Instruct manufacturer on the size of cross-connection cables for panelboards fed via sub-feed (double) lugs or feed-through lugs. Make cable size with ampacity equal to incoming feeder.
- E. Verify that "touch-up" paint kit is available for repainting.

### **3.2 EXAMINATION**

- A. Verify that space indicated for panelboard mounting meets code-required working clearances and dedicated equipment space.
- B. Notify Owner Representative of any discrepancies prior to submittal of product data and shop drawings.

### **3.3 INSTALLATION**

- A. Install panelboards in accordance with NECA 407 and NEMA PB 1.1.
- B. Install panelboards plumb and rigid without distortion of box, in accordance with manufacturer's written instructions, and in compliance with recognized industry practices.
- C. Panelboard mounting and seismic restraints:
  - 1. Install panelboard anchorage devices and seismic restraints based on design by an Engineer registered and licensed in the State of California, and to comply with Section 26 0548 – Vibration and Seismic Controls for Electrical Systems for seismic criteria.
  - 2. Fasten panelboards firmly to walls and structural surfaces, ensuring they are permanently and mechanically anchored.
  - 3. Anchor and fasten panelboards and their supports to building structural elements (wood, concrete, masonry, hollow walls and nonstructural building surfaces) by the methods described in Section 26 05 29 – Hangers and Supports for Electrical Systems.
  - 4. Install two rows of steel slotted channel, with a minimum of four attachment points, for each panelboard section.
  - 5. When not located directly on wall, provide support frame of steel slotted channel anchored to floor and ceiling structure.
- D. Install top breaker handle a maximum of 6'-7" above finished floor or working platform, with handle in its highest position.
- E. Tighten electrical connectors and terminals according to equipment manufacturer's published torque tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A –486B.
- F. Install as-built typewritten circuit directory in directory frame (to indicate installed circuit loads before completing load balancing) mounted inside each panelboard door. Include description of connected loads, room number, room name, area, or item served for each branch circuit. Indicate motor names and horsepower as applicable. Cover circuit directory with colorless plastic. Coordinate with Owner Representative and Architect to ensure that room numbers used in panel directory are final numbers assigned by Owner Representative.
- G. Install engraved plastic nameplates under provisions of Section 26 05 53 – Electrical Systems Identification. Attach nameplate to exterior of each panelboard using small, corrosion-resistant metal screws or rivets. Do not use contact adhesive.
  - 1. Indicate panelboard name, amperage, voltage, phase, and number of wires.

- H. Label spare circuits as SPARE. Leave spare breakers in OFF position.
- I. Room numbers used shall be those used by Owner Representative except as otherwise directed by Owner Representative.
- J. Install panelboard in dedicated electrical space per NFPA 70 and as shown on drawings. Coordinate with miscellaneous trades for equipment foreign to the electrical installation to be outside of dedicated electrical space.
- K. Install filler plates in unused spaces.
- L. Install fuses in fusible switches, per requirements in Section 26 28 13 – Fuses.
- M. Request inspection from the University IOR 10 days prior to planned panel energization. Have all required testing complete and available for IOR inspection.

### **3.4 CONNECTIONS**

- A. Ground panelboards according to Section 26 05 26 – Grounding and Bonding for Electrical Systems.
- B. Connect wiring according to Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables.

### **3.5 FIELD QUALITY CONTROL**

- A. Inspect for physical damage, proper alignment, anchorage, and grounding.
- B. Test circuit breakers per requirements in Sections 26 08 12 – Power Distribution Acceptance Tests.
- C. Interpret test results in writing and submit to Owner Representative.
- D. Check phase-to-phase and phase-to-ground insulation resistance levels prior to energizing panelboards.
- E. Check panelboards for electrical continuity of circuits and for short-circuits prior to energizing.
- F. Submit ammeter readings for all panelboard feeders indicating normal operating load and phase balance.
- G. Balancing Loads: After Substantial Completion, but not more than 2 months after Final Acceptance, conduct load-balancing measurements and make circuit changes as follows:
  - 1. Perform measurements during period of normal working load as advised by Owner Representative.
  - 2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility. Make special arrangements with Owner Representative to avoid disrupting critical 24-hour services, such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
  - 3. Recheck loads after circuit changes during normal load period. Record all load readings before and after changes and submit test records.
  - 4. Tolerance: Difference exceeding 10% between phase loads, within a panelboard, is not acceptable.



5. Reconnect or redistribute circuits or circuit breakers to achieve balanced condition. Revise circuit directory to reflect circuiting changes required to balance phase loads.

### **3.6 REPAINTING**

- A. Remove paint splatters or other marks from surface of panelboards.
- B. Touch-up chips, scratches, or marred finishes to match original finish, using manufacturer- supplied paint kit. Leave remaining paint to Owner Representative.

### **3.7 ADJUSTING**

- A. Adjust fronts, covers, hinges, and locks.
- B. Circuit Breakers: Set field-adjustable trip settings or change the trip settings recommended by the overcurrent protective device coordination study per Section 26 05 73 – Power System Studies.

### **3.8 CLEANING**

- A. Clean panelboard interiors and exteriors prior to final inspection. Remove paint splatters and other spots, dirt and debris.

**END OF SECTION 26 24 16.16**

## **SECTION 26 27 13 - ELECTRICAL**

### **METERING PART 1 - GENERAL**

#### **1.1 RELATED WORK**

- A. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables
- B. Section 26 05 26 – Grounding and Bonding for Electrical Systems
- C. Section 26 05 29 – Hangers and Supports for Electrical Systems
- D. Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems
- E. Section 26 05 53 – Electrical Systems Identification
- F. Section 26 08 12 – Power Distribution Acceptance Tests
- G. Section 26 11 13 – Primary Unit Substations
- H. Section 26 13 16 – Medium-Voltage Fusible Interrupter Switchgear
- I. Section 26 13 19 – Medium-Voltage Vacuum Interrupter Switchgear
- J. Section 26 13 23 – Medium-Voltage Pad-Mounted Switchgear
- K. Section 26 23 00 – Low-Voltage Switchgear
- L. Section 26 24 13 – Switchboards
- M. Section 26 28 13 – Fuses
- N. Section 26 43 00 – Surge Protective Devices

#### **1.2 REFERENCE**

- A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

#### **1.3 DESCRIPTION**

- A. Section includes equipment for energy and demand metering by Owner. It also includes options that provide for monitoring or automatic control of demand at a remote location.

#### **1.4 REFERENCE STANDARDS**

- A. ANSI C12.1 – Code for Electricity Metering
- B. ANSI C12.7 – Requirements for Watthour Meter Sockets
- C. ANSI C12.9 – Test Switches for Transformer-Rated Meters
- D. ANSI C12.10 – Watthour Meters
- E. ANSI C12.11 – Instrument Transformers for Revenue Metering, 10 kV BIL Through 350 kV BIL (0.6 kV NSV Through 69 kV NSV)
- F. ANSI C12.18 – Protocol Specification for ANSI Type 2 Optical Port
- G. ANSI C12.19 – Utility Industry End Device Data Tables

- H. ANSI C12.20 – Electricity Meters-0.2 and 0.5 Accuracy Classes
- I. ANSI C39.1 – Requirements, Electrical Analog Indicating Instruments
- J. IEEE C37.90.1 – Standard Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
- K. IEEE C57.13 – Standard Requirements for Instrument Transformers
- L. IEEE C62.11 – Metal-Oxide Surge Arresters for Alternating Current Power Circuits
- M. IEEE C62.41.1 – Guide on the Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits
- N. IEEE C62.41.2 – Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits
- O. IEEE C62.45 – Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits
- P. NECA 1 – Standard Practices for Good Workmanship in Electrical Contracting
- Q. NECA 400 – Recommended Practice for Installing and Maintaining Switchboards
- R. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum)
- S. NEMA AB 1 – Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures
- T. NEMA AB 3 – Molded-Case Circuit Breakers and Their Applications
- U. NEMA EI 21.1 – Instrument Transformers for Revenue Metering (110KV BIL and Less)
- V. NEMA KS 1 – Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)
- W. NEMA LA 1 – Surge Arresters
- X. NEMA PB 2 – Dead-Front Distribution Switchboard
- Y. NFPA 70 – National Electrical Code
- Z. UL 50 – Standard for Enclosures for Electrical Equipment (1995)
- AA. UL 98 – Enclosed and Dead-Front Switches
- BB. UL 414 – Standard for Meter Sockets (1999)
- CC. UL 467 – Grounding and Bonding Equipment
- DD. UL 486A-486B – Wire Connectors
- EE. UL 489 – Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures
- FF. UL 891 – Dead-Front Switchboards
- GG. ASTM D1535 – Standard Practice for Specifying Color by the Munsell System

## 1.5 SUBMITTALS

- A. Product Data: For metering equipment, components and accessories indicated:
  - 1. Include data on features, components, and complete description; submit catalog cut sheets showing electrical characteristics and ratings.
  - 2. Include construction details, material descriptions, dimensions of individual

components and profiles, and finishes. Describe operating sequences, both automatic and manual.

- B. Shop Drawings:
  - 1. Dimensioned plans and sections or elevation layouts.
  - 2. Wiring Diagrams: Power, signal, and control wiring. Identify terminals and wiring designations and color codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field installed wiring, and show circuit protection features.
- C. Manufacturer's Installation Instructions:
  - 1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
- D. Test Reports: Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
- E. Closeout Submittals:
  - 1. Project Record Documents:
    - a. Record actual locations and ratings of metering equipment on single-line diagrams and plan layouts.
  - 2. Operation and Maintenance Data:
    - a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
    - b. Include manufacturer's written instructions for testing.
    - c. Include spare parts data listing, source, and current prices of replacement parts and supplies.
    - d. Include manufacturer's Seismic Qualification Certification and Installation Seismic Qualification Certification.

## 1.6 QUALITY ASSURANCE

- A. Obtain metering equipment from one source and by single manufacturer.
- B. Regulatory Requirements:
  - 1. Comply with NFPA 70 for components and installation.
  - 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.
- C. Certifications:
  - 1. Furnish Owner's Representative with manufacturer's Seismic Qualification Certification: Submit certification that metering equipment, accessories, and components will remain internally intact to withstand seismic forces defined in Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems. Include the following:
    - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Furnish Owner's Representative with Installation Seismic Qualification Certification: Submit certification that metering equipment, accessories, and components will remain in place without separation of any parts when subjected to the seismic forces defined in Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems. Include the following:
  - a. Detailed description of equipment supports and seismic restraints on which the certification is based and their installation requirements.
  - b. Certification shall bear the seal and signature of an Engineer registered and licensed in the State of California.

### **1.7 DELIVERY, STORAGE, AND HANDLING**

- A. Receive, store, and handle modular meter center as specified in NECA 400. Use factory installed lifting provisions. Handle carefully to avoid damage to assembly internal components, enclosure, and finish.

### **1.8 WARRANTY**

- A. Refer to Division 01 and Section 26 00 00 – General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1-year warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

### **1.9 MAINTENANCE**

- A. Extra Materials: Furnish extra materials described below that match product installed, are packaged with protective covering for storage, and are identified with labels describing contents.
  1. Potential Transformer Fuses: Equal to 10% of amount installed for each size and type, minimum of 2 of each size and type.
  2. Control-Power Fuses: Equal to 10% of amount installed for each size and type, minimum of 2 of each size and type.
  3. Fuses for Fused Switches: Equal to 10% of amount installed for each size and type, minimum of 3 of each size and type.

### **1.10 UNIVERSITY STANDARDS**

- A. The campus has specified some equipment as a "Sole Source Justification" to match the existing infrastructure in functionality. Note references to specific manufactures in the following section.
- B. Instrumentation and Control for Electrical Systems
  1. The campus uses a SCADA system for the control and monitoring of the campus high and medium voltage system as well as the acquisition of power meter data back to Facility Service's automated recharge system.
  2. All electric meters will be connected to the SCADA system for remote monitoring of total energy usage as well as real time data. Consult a University representative about current power meters in use that may be applied to the specific project.

Consult a University Representative for compunctions options which will include either a mod bus connection or an Ethernet connection. Provide necessary hardware and cabling to facilitate meter connection and integration.

3. Connect control power to power meters at 120V or less AC or DC

## **PART 2 - PRODUCTS**

### **2.1 EQUIPMENT FOR ELECTRICAL METERING FOR CALIFORNIA POLYTECHNIC STATE UNIVERSITY**

- A. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four- wire systems and with the following features:
  1. Manufacturers:
    - a. Square D
    - b. Schweitzer Engineering Labs (SEL).
    - c. Approved equal
  2. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
    - a. Phase Currents, Each Phase: +/-0.5%
    - b. Phase-to-Phase Voltages, Three Phase: +/-1%
    - c. Phase-to-Neutral Voltages, Three Phase: +/-1%
    - d. Megawatts: +/-2%
    - e. Megavars: +/-2%
    - f. Power Factor: +/-2%
    - g. Frequency: +/-0.5%
    - h. Megawatt Demand: +/-2%; demand interval programmable from 5 to 60 minutes
    - i. Accumulated Energy, Megawatt Hours: +/-2%. Accumulated values unaffected by power outages up to 72 hours
    - j. Maximum demand (measure of average power demand over a 15-minute period) continuously recorded over a one-year period.
    - k. Total Harmonic Distortion, Amperes
    - l. Total Harmonic Distortion, Volts
    - m. Individual Amperage Harmonics through the 63<sup>rd</sup>
    - n. Integral Communications Port
  3. Mounting: Display and control unit flush or semi-flush, mounted in instrument compartment door.
- B. Instrumentation:
  1. Manufacturers:
    - a. Square D
    - b. General Electric
    - c. Siemens
    - d. Cutler-Hammer
    - e. Approved equal
  2. Instrument Transformers: NEMA EI 21.1, IEEE C57.13, and the following:
    - a. Potential Transformers: Secondary voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.

- 1) 600 V and below: external PTs not required; fused potential connection.
  - b. Current Transformers: Bar type; ratios shall be as indicated with accuracy class and burden suitable for connected relays, meters, and instruments; shorting test blocks: 10 poles – 4 potential and 6 current, mounted with meter or in accessible location.
  - c. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kV.
  - d. 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.
- C. Data Communications:
1. Means to transmit data to central control and monitoring system.
    - a. Provide meter with Onboard TCIP connectivity.
    - b. Keypad and scrollable display for local reading of measured values.
  2. Kilowatt-Hour/Demand Meter: Electronic three-phase meters, measuring electricity use and demand.
    - a. Voltage and Phase Configuration: Designed for use on circuits with voltage rating and phase configuration indicated for its application.
    - b. Display: Digital liquid crystal, indicating accumulative kilowatt hours, current time and date, current demand, historic peak demand, and time and date of historic peak demand.
    - c. Demand Signal Communication Interface: Match signal to building automation system input and arrange to convey the instantaneous, integrated, demand level measured by meter to provide data for processing and possible programmed demand control action by destination system.
    - d. Programmable Contact Module: Unit shall have push-button switches and a display for setting the demand level at which an integral set of Form C contacts shall be operated to initiate indicated action.
    - e. Enclosure: NEMA 250, Type 1 minimum, with hasp for padlocking or sealing.
    - f. Identification: Comply with Section 26 05 53 – Electrical Systems Identification.
    - g. Memory Backup: Self-contained to maintain memory throughout power outages of 72 hours, minimum.
    - h. Sensors: Current-sensing type, with current or voltage output, selected for optimum range and accuracy for ratings of circuits indicated for this application.
      - 1) Type: Split and solid core.
    - i. Meter Accuracy: Nationally recognized testing laboratory certified to comply with ANSI C12.1.
    - j. Current-Transformer Cabinet: Listed or recommended by metering equipment manufacturer for use with sensors indicated.
    - k. Solid State Breakers for Energy Monitoring (provided under other specification sections). Identified breakers shall monitor energy use and report to the building automation system.

## **PART 3 - EXECUTION**

### **3. 1 COORDINATION**

- A. Coordinate adjustment and programming of metering equipment with manufacturer.
- B. Instruct manufacturer about the location of incoming lugs (i.e., top or bottom feed based on incoming feeder entrance location).
- C. Coordinate with miscellaneous trades for equipment foreign to electrical installation to be outside of dedicated electrical space.
- D. Verify with manufacturer that "touch-up" paint kit is available for repainting.
- E. Coordinate meter data transmission with Supervisory Control and Data Acquisition (SCADA) System to integrate electrical system metering data with SCADA GUI and Energy Code reporting requirements.

### **3.2 EXAMINATION**

- A. Examine areas and surface to receive modular meter center for compliance with requirements, installation tolerances, and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Verify that space indicated for modular meter center mounting meets code-required working clearances.
- C. Notify Owner's Representative of any discrepancies prior to submittal of product data and shop drawings.

### **3.3 INSTALLATION**

- A. Comply with installation requirements in NECA 1.
- B. Connect all energy meter to the campus SCADA system. Coordinate with University to integrate into the current SCADA HMI and database system.
- C. Install current transformer cabinets, meter cabinets or meter sockets to comply with requirements of electrical power utility company. Install empty conduits for metering leads and extend grounding connections as required by utility company.
- D. Install modular meter center in accordance with NECA 400.
- E. Modular meter center mounting and seismic restraints:
  - 1. Install modular meter center anchorage devices and seismic restraints based on design by an Engineer registered and licensed in the State of California, and to comply with Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems for seismic criteria.
  - 2. Bolt modular meter center to concrete housekeeping pad, using anchor bolts in accordance with Section 26 05 29 – Hangers and Supports for Electrical Systems. Cast anchor bolt inserts into pad.
  - 3. Install bushing assemblies for anchor bolts for seismic restraints per requirements in Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems.
- F. Install engraved plastic nameplates under provisions of Section 26 0553 - Electrical



Systems Identification for modular meter center, every instrument, overcurrent protective device, and disconnect device. Attach nameplate to exterior of modular meter center using small corrosion-resistant metal screws and rivets. Do not use contact adhesive. Indicate modular meter center manufacturer's name and drawing number, name, amperage, voltage, phase, number of wires, short circuit current rating (amp, RMS symmetrical and MVA three-phase symmetrical), and momentary and fault-closing ratings (amp, RMS asymmetrical). For each overcurrent protective device and disconnect device, include tenant name, load served, voltage/phase rating, and fuse size and type, when applicable.

- G. Install modular meter center in dedicated electrical space per NFPA 70, and as indicated on drawings.
- H. Tighten electrical connectors and terminal according to equipment manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- I. Install fuses in fusible switch at job site per requirements in Section 26 2813 – Fuses.
- J. Mount meters in the locations indicated on the drawings. Mounting height: 5'-6" or less from finished floor.

### **3.4 FIELD WIRING**

- A. Install field wiring to complete the electricity metering installation.
  - 1. Transformer-rated meter:
    - a. Current transformer wiring shall be #12 AWG minimum size. Where distance to meter exceeds 22 ft, increase wire size to #10 AWG to reduce the burden on the metering circuit.
    - b. Potential wiring shall be #14 AWG.
    - c. Color coding: Same for current and potential wiring. A phase – black; B phase – red; C phase – blue; Neutral – white; Ground – green. Identify all wiring with plastic sleeve wire markers. Cloth markers are not acceptable.
    - d. Neatly train and lace wiring for metering installation within pad-mounted transformer compartment and meter socket enclosure using nylon cable ties.
  - 2. Transformer-rated meter:
    - a. Field wiring for building automation system (BAS) connection to solid-state electricity meter:
      - 1) Conduit: Install a 3/4" conduit routed underground from meter to BAS panel in the building; terminate conduit within 12" of BAS panel.
      - 2) Communications Wiring: In the 3/4" conduit, install a 3-conductor communications cable as recommended by meter manufacturer. Connect one end to cable lead from meter KYZ pulse initiator module. Leave 4 ft excess cable coiled at opposite end for connection to BAS panel.

### **3.5 CONNECTIONS**

- A. Ground metering equipment according to Section 26 05 26 – Grounding and

Bonding for Electrical Systems.

- B. Connect power and control wiring according to Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables.
- C. Bond meter socket enclosure to grounding facilities as required. Grounding equipment per UL 467 requirements.

### **3.6 FIELD QUALITY CONTROL**

- A. Test continuity of each circuit.
- B. Test metering equipment per requirements in Sections 26 08 12 – Power Distribution Acceptance Tests.
- C. Interpret test results in writing and submit to Owner's Representative.
- D. Test Owner's electricity-metering installation for proper operation, accuracy, and usability of output data.
  - 1. Connect a load of known kilowatt rating, 1.5 hp minimum, to a circuit supplied by metered feeder.
  - 2. Turn off circuits supplied by metered feeder and secure them in off condition.
  - 3. Run test load continuously for 8 h, minimum, or longer to obtain a measurable meter indication. Use test load placement and setting that ensures continuous, safe operation.
  - 4. Check and record meter reading at end of test period and compare with actual electricity used based on test load rating, duration of test, and sample measurements of supply voltage at test load connection. Record test results.
  - 5. Repair or replace deficient or malfunctioning metering equipment, or correct test setup; then retest. Repeat for each meter in installation until proper operation of entire system is verified.
- E. Inspect modular meter center for physical damage, proper alignment, connections, anchorage, seismic restraints and grounding.
- F. Verify that correct multiplier is indicated on face of meter.
- G. Verify that current transformer secondary circuits are intact.
- H. Inspect indicating devices for proper operation.

### **3.7 REPAINTING**

- A. Remove paint splatters and other marks from surface of equipment.
- B. Touch-up chips, scratches or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint with Owner's Representative.

### **3.8 ADJUSTING**

- A. Adjustment and programming of metering equipment: By factory-authorized representative.
- B. Compare meter display readings with readings taken with clamp on ammeter and hand-held volt-meter.

- C. Make adjustments as necessary.

### **3.9 CLEANING**

- A. Vacuum dirt and construction debris from interior and exterior of equipment; do not use compressed air to assist in cleaning.

### **3.10 DEMONSTRATION**

- A. Provide training session by manufacturer for up to 8 h at a job location, to train the Owner's personnel in the operation and maintenance of metering equipment.

**END OF SECTION 26 27 13**

## **SECTION 26 27 26 - WIRING**

### **DEVICES PART 1 - GENERAL**

#### **1.1 RELATED WORK**

- A. Section 26 05 26 - Grounding and Bonding for Electrical Systems
- B. Section 26 05 53 - Electrical Systems Identification

#### **1.2 REFERENCE**

- A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

#### **1.3 DESCRIPTION**

- A. Section includes general-use snap switches, wall-box dimmers, fan speed controls, receptacles, hazardous (classified) location receptacles, pendant cord-connector devices, cord and plug sets and device cover plates.

#### **1.4 REFERENCE STANDARDS**

- A. IEEE C62.41.2 – Characterization of Surges in Low-Voltage (1000V and less) AC Power Circuits
- B. IEEE C62.45 – Surge Testing for Equipment Connected to Low-Voltage (1000V and less) AC Power Circuits
- C. NECA 1 – Good Workmanship in Electrical Contracting
- D. NFPA 70 – National Electrical Code
- E. NFPA 99 –Health Care Facilities
- F. NEMA FB 11 – Plugs, Receptacles, and Connectors of the Pin and Sleeve Type for Hazardous Locations
- G. NEMA WD-1 – General Color Requirements for Wiring Devices
- H. NEMA WD-6 – Wiring Devices - Dimensional Requirements
- I. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum)
- J. UL 20 – General-Use Snap Switches
- K. UL 498 – Attachment Plugs and Receptacles
- L. UL 943 – Ground-Fault Circuit-Interrupters
- M. UL 1010 – Receptacle-Plug Combinations for Use in Hazardous (Classified) Locations
- N. UL 1436 – Outlet Circuit Testers and Similar Indicating Devices
- O. UL 1449 – Transient Voltage Surge Suppressors
- P. UL 1472 – Solid-State Dimming Controls
- Q. UL 1917 – Solid-State Fan Speed Controls

### **1.5 SUBMITTALS**

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.
- C. Samples: One for each type of device and wall plate specified, in each color specified.
- D. Manufacturer's Installation Instructions:
  - 1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
- E. Test Reports: Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
- F. Closeout Submittals:
  - 1. Project Record Documents:
    - a. Record actual locations and ratings of wiring devices.
  - 2. Operation and Maintenance Data:
    - a. Include in manufacturers' packing label warnings and instruction manuals with labeling conditions.
    - b. Include source and current prices of replacement parts and supplies.

### **1.6 QUALITY ASSURANCE**

- A. Obtain wiring devices from one source and by single manufacturer.
- B. Regulatory Requirements:
  - 1. Comply with NFPA 70 for components and installation.
  - 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

### **1.7 DELIVERY, STORAGE, AND HANDLING**

- A. Store in clean, dry space. Maintain factory unopened packaging until ready for installation.

### **1.8 WARRANTY**

- A. Refer to Division 01 and Section 26 00 00 – General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1-year warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

### **1.9 MAINTENANCE**

- A. Extra Materials: Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.

## **PART 2 - PRODUCTS**

## 2.1 MANUFACTURERS

- A. Cooper Wiring Devices; a division of Cooper Industries, Inc.
- B. Hubbell Incorporated; Wiring Device-Kellems
- C. Leviton Manufacturing Company, Inc.
- D. Pass & Seymour/Legrand; Wiring Devices & Accessories
- E. Or equal

## 2.2 GENERAL-USE SNAP SWITCHES

- A. Comply with NEMA WD 1 and UL 20.
- B. Switches: Heavy-duty (specification grade); back and side wired; flush or surface mounting; Body and Handle: thermoplastic with rocker handle; for connection to copper or copper-clad conductors:
  - 1. Ratings:
    - a. Voltage: 120-277V, AC
    - b. Current: 20 A
  - 2. Single pole
  - 3. Double pole
  - 4. Three-way
  - 5. Four-way
  - 6. Locator Light: Lighted handle type switch (single pole with red neon-lighted handle, illuminated when switch is "OFF.")
  - 7. Pilot Light: Indicator light switch (single pole with red neon-lighted handle, illuminated when switch is "ON.")
  - 8. Locking Type: Designed to prevent tampering and unauthorized switching.
  - 9. Key-Operated: Single pole, with factory-supplied key in lieu of switch handle.
  - 10. Single-Pole, Double-Throw, Momentary Contact, Center-Off: For use with mechanically held lighting contactors.
  - 11. Key-Operated, Single-Pole, Double-Throw, Momentary Contact, Center-Off: For use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.
  - 12. Pendant and Through-cord: For field installation on flexible cord and provided with one "ON" and one "OFF" position.
  - 13. Weatherproof: Toggle switch.
- C. Wiring devices will accept stranded wire without the use of a wire prep device (stake on or similar).

## 2.3 FAN SPEED CONTROLS

- A. Comply with UL 1917
- B. Modular, 120V, full-wave, solid-state units with integral, quiet on-off switches and audible frequency and EMI/RFI filters.
  - 1. Continuously adjustable slider, 5A.

## 2.4 RECEPTACLES

- A. Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL498.
- B. Receptacles: 125 V, 20A, heavy-duty (specification grade); back and side wired; flush or surface mounted; straight blade; 2 pole, 3 wire grounding; thermoplastic body; duplex as indicated on drawings.
  - 1. Ground Fault Circuit Interrupter (GFCI):
    - a. Additional compliance with UL 943 Class A.
    - b. Leakage current trip level: 4 to 6 mA.
    - c. Trip time: .025 seconds nominal.
    - d. Non-feed through type
    - e. Reverse line-load function to prevent GFCI from functioning if wired incorrectly.
    - f. Indicator Light: Lighted when device is tripped.
  - 2. Twist-locking:
    - a. NEMA WD 6 configuration as indicated on drawings.
  - 3. Dedicated: Labeled "Dedicated."
  - 4. Plug-Tail type devices are permissible where an angled connector is use and connector conductors have 6" of slack before splice into circuit.
  - 5. Special Purpose Receptacles: Specification grade, rated for voltage, amperage and NEMA configuration as noted on drawings.
- C. Wiring devices will accept stranded wire without the use of a wire prep device (stake on or similar).

## **2.5 HAZARDOUS (CLASSIFIED) LOCATION RECEPTACLES**

- A. Comply with NEMA FB 11 and UL 1010
- B. Manufacturers:
  - 1. Cooper Crouse-Hinds
  - 2. EGS/Appleton Electric
  - 3. Killark; a division of Hubbell, Inc.
  - 4. Or equal

## **2.6 DEVICE COVER PLATES**

- A. Single and combination types to match corresponding wiring devices:
  - 1. Attachment: Metal screws with head color to match plate finish.
  - 2. Material for Finished Spaces: Coordinate with Owner's Representative.
  - 3. Material for Unfinished Spaces: Galvanized steel.
  - 4. Material for Damp Locations: Thermoplastic with while-in-use hinged cover and listed and labeled for use in "wet locations."
- B. Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant thermoplastic with weatherproof while-in-use hinged cover.
- C. Lockable Cover:
  - 1. Hinged steel cover with cylinder lock.
  - 2. Keyed all the same.

## **2.7 FINISHES**

- A. Color:
  - 1. Switch handles, receptacle faceplates, and device cover plates: Coordinate with

Owner's Representative except as follows:

- a. Switch handles and receptacle faceplates connected to Emergency or Standby Power System: Red; labeled "Emergency."
- b. UPS Receptacles: Gray

### **PART 3 - EXECUTION**

#### **3.1 COORDINATION**

- A. Special Purpose Receptacles: Coordinate final selections of NEMA configuration (locking, straight, blade, etc.) with configuration of plug on utilization equipment.
- B. Receptacles for Owner-furnished equipment and equipment furnished under other divisions of specifications: Match plug configurations.
- C. Cord and Plug Sets: Match equipment requirements.
- D. Coordination with Other Trades:
  1. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers guided by riding against outside of the boxes.
  2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
  3. Install device boxes in brick or block walls so that the device cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
  4. Install wiring devices after all wall preparation, including painting, is complete.

#### **3.2 EXAMINATION**

- A. Verify location of wiring devices with architectural interior elevation drawings, prior to rough-in.
- B. Verify outlet boxes are installed at proper height.
- C. Verify wall openings are neatly cut and completely covered by wall plates.
- D. Verify branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.

#### **3.3 PREPARATION**

- A. Clean debris from outlet boxes.

#### **3.4 INSTALLATION**

- A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise scheduled or indicated on drawings. Indicated dimensions are to center of device.
- B. Conductors:
  1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
  2. Strip insulation evenly around the conductor using tools designed for the



- purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. Length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
  4. Do not place bare stranded conductors directly under device screws. Use crimp on fork terminals for device terminations.
- C. Device Installation:
1. Replace all devices that have been in temporary use during construction or show signs of installation prior to completion of building finishing operations.
  2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
  3. Do not remove surface protection, such as plastic film and smudge covers, until last possible moment.
  4. Connect devices to branch circuits using pigtails that are not less than 6" in length.
  5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
  6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
  7. When conductors larger than #12 AWG are installed on 15A or 20A circuits, splice #12 AWG pigtails for device connections.
  8. Tighten unused terminal screws on the device.
  9. When mounting into metal boxes, remove fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.
  10. Install devices plumb, level with finished surfaces and free from blemishes.
  11. Install lighting switches vertically on latch side of door within 6" of frame edge.
  12. Install devices above counters, 2" to the bottom of device above countertop or backsplash.
  13. Install all devices at same height above any one counter or fixed cabinet.
  14. Install special purpose receptacles and switches according to shop and rough-in drawings furnished by trade(s) producing such equipment. Verify locations prior to rough-in.
  15. Install weatherproof GFCI receptacles:
    - a. Within 25'-0" of roof-mounted mechanical equipment
    - b. Outdoors
    - c. As indicated on drawings
  16. Group adjacent switches under single, multi-gang wall plates.
  17. Connect wiring device grounding terminal to outlet box with bonding jumper and branch circuit equipment grounding conductor. Ground per requirements in Section 26 0526 – Grounding and Bonding for Electrical Systems.
- D. Installation Orientations:
1. Install ground pin of vertically mounted receptacles down, and on horizontally mounted receptacles to the right.
  2. Install switches with handle operating vertically, with "ON" position up.
  3. Unless otherwise indicated or where space problem occurs, mount devices flush,

with long dimension vertical.

- E. Device Cover Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.
- F. Arrangement of Devices:
  - 1. Unless otherwise indicated or where space problem occurs, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multi-gang wall plates.

### 3.5 IDENTIFICATION

- A. Comply with Section 26 05 53 – Electrical Systems Identification.
  - 1. Switches and Receptacles: No engraved cover plates shall be used. Provide engraved legends that are glued to standard plates per the identification standard. Include panel and circuit number only. Example: LA-12
    - a. Receptacles: Label shall indicate receptacle voltage, phase, and amperage for receptacles other than 20A, 120 V, at top of cover plate, and panel and circuit number at bottom of cover plate.
    - b. Switches: Label shall indicate switch voltage, phase, and amperage at top of cover plate, and panel, circuit number and switch designation at bottom of cover plate.
  - 2. Engrave cover plates on all Owner-furnished equipment and equipment furnished under other divisions of these specifications with panelboard, circuit number and “emergency” (where applicable) as specified in this section. This includes headwalls, gas columns and booms, patient consoles, medical rail systems, custom casework with electrical devices, etc.

### 3.6 FIELD QUALITY CONTROL

- A. Inspect wiring devices for defects.
- B. Operate wall switches with circuits energized and verify proper operation.
- C. Verify receptacle device is energized.
- D. Perform tests and prepare test reports:
  - 1. Test receptacle devices for proper polarity:
    - a. Test every receptacle with receptacle circuit tester. Tester shall test for open ground, reverse polarity, open hot, open neutral, hot and ground reversed, hot or neutral and hot open. Rewire receptacles with faults and retest.
  - 2. Test each GFCI receptacle device for proper operation:
    - a. Perform testing using an instrument specifically designed and manufactured for testing ground-fault circuit interrupters. Apply the test to the receptacle. “TEST” button operation will not be acceptable as a substitute for this test. Replace receptacles that do not shut off power with 5/1000 A within 1/40 second and retest.
  - 3. Test Instruments: Use instruments that comply with UL 1436.
  - 4. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital

readout or illuminated LED indicators of measurement.

- E. Tests for Convenience Receptacles:
  - 1. Line Voltage: Acceptable range is 105 V to 132 V.
  - 2. Percent Voltage Drop under 15A Load: A value of 5% or higher is not acceptable.
  - 3. Ground Impedance: Values of up to 2 ohms are acceptable.
  - 4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
  - 5. Using the test plug, verify that the device and its outlet box are securely mounted.
  - 6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.
- F. Test straight blade for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz.
- G. Operational Tests: Demonstrate the operation of each switch with the systems fully energized and operating. Each switch shall be demonstrated three times.
- H. Interpret test results in writing and submit to Owner's Representative.

### **3.7 ADJUSTING**

- A. Adjust devices and wall plates to be flush and level.

### **3.8 CLEANING**

- A. Remove excess plaster from interior of outlet boxes.
- B. Clean devices and cover plates after painting is complete. Replace stained or improperly painted devices and cover plates.

**END OF SECTION 26 27 26**

## **SECTION 26 28 13 -**

### **FUSES PART 1 -**

#### **GENERAL**

##### **1.1 RELATED WORK**

- A. Section 26 05 73 - Power System Studies
- B. Section 26 24 13 - Switchboards
- C. Section 26 24 16.16 - Distribution Panelboards
- D. Section 26 28 16 - Enclosed Switches and Circuit Breakers
- E. Section 26 29 13 - Enclosed Controllers

##### **1.2 REFERENCE**

- A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and section under Division 01 General Requirements.

##### **1.3 DESCRIPTION**

- A. Section includes nonrenewable cartridge fuses, rated 600V and less, for use in low-voltage power distribution system and spare fuse cabinet.

##### **1.4 REFERENCE STANDARDS**

- A. NEMA FU 1 - Low Voltage Cartridge Fuses
- B. UL 248-1 - Low Voltage Fuses - Part 1: General Requirements
- C. UL 248-4 - Low-Voltage Fuses - Part 4: Class CC Fuses
- D. UL 248-5 - Low-Voltage Fuses - Part 5: Class G Fuses
- E. UL 248-8 - Low-Voltage Fuses - Part 8: Class J Fuses
- F. UL 248-10 - Low-Voltage Fuses - Part 10: Class L Fuses
- G. UL 248-12 - Low-Voltage Fuses - Part 12: Class R Fuses
- H. UL 248-15 - Low-Voltage Fuses - Part 15: Class T Fuses
- I. UL 512 - Fuseholders

##### **1.5 SUBMITTALS**

- A. Product Data:
  - 1. Submit the following for each fuse type and size indicated:
    - a. Manufacturer's technical data on features, performance, electrical characteristics, ratings, and dimensions.
    - b. Time-current curves, coordination charts and tables, and related data.
    - c. Let-through current curves for fuses with current-limiting characteristics.
    - d. Fuse size for each elevator disconnect switch.

- B. Closeout Submittals:
  - 1. Project Record Documents:
    - a. Record actual class, size, and location of fuses.

**1.6 QUALITY ASSURANCE**

- A. Obtain fuses from one source and by single manufacturer.
- B. Comply with NFPA 70 for components and installation.

**1.7 MAINTENANCE**

- A. Extra Materials:
  - 1. Furnish to the Owner’s Representative a quantity of spare fuses equal to 25% of the total quantity of each fuse class and size installed, minimum of 3 of each fuse class and size.
  - 2. Furnish 2 fuse pullers for each size fuse.

**PART 2 - PRODUCTS**

**2.1 MANUFACTURERS**

- A. Cooper Bussmann
- B. Mersen
- C. Littelfuse
- D. Edison Fusegear
- E. Or equal

**2.2 CARTRIDGE FUSES**

- A. NEMA FU 1, UL 248-1.
- B. Characteristics: nonrenewable current-limiting cartridge fuse; current rating and class, as specified or indicated, and voltage rating consistent with circuit voltage.
- C. Miscellaneous data:

UL Standard	Classes	Volts	Amperage	Interrupting Rating (Amp RMS Sym.)
248-4	CC	600	0-30	200,000
248-8	J	600	0-600	200,000
248-10	L	600	601-6000	200,000
248-12	RK1	250 or 600	0-600	200,000
248-12	RK5	250 or 600	0-600	200,000

### **2.3 FUSEBLOCKS**

- A. UL 512
- B. Thermoplastic base with UL flammability 94VO
- C. Clip reinforcing springs – 100A and above
- D. 200,000 A RMS Sym withstand rating
- E. Copper or aluminum connections

### **2.4 TOUCH SAFE FUSEHOLDERS**

- A. UL 512
- B. Thermoplastic base with UL flammability 94VO
- C. Cover over fuses
- D. Neon indicator lamp: "ON" when fuse opens

### **2.5 SPARE FUSE CABINET**

- A. Wall-mounted sheet metal cabinet with shelves, suitably sized to store spare fuses and fuse pullers specified with 10% capacity minimum.
- B. Doors shall be hinged, with hasp for Owner's padlock.
- C. Finish shall be gray enamel.
- D. Cabinet shall have nameplate engraved "Spare Fuses" in 1/2" letters on door.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

### **3.2 INSTALLATION**

- A. Verify proper fuse locations, sizes, and characteristics.
- B. Install fuses in fusible devices (specified in Sections 26 23 00 – Low-Voltage Switchgear, 26 24 13 – Switchboards, 26 24 16.13 - Lighting and Appliance Panelboards, 26 24 16.16 – Distribution Panelboards, 26 24 19 – Motor Control Centers, 26 28 16 – Enclosed Switches and Circuit Breakers, and 26 29 13 – Enclosed Controllers) at job site.
- C. Arrange fuses so manufacturer, class, and size are readable without removing fuse.
- D. Install typewritten labels on inside door of each fused device, indicating fuse replacement information.
- E. Install spare fuse cabinet as directed by Cal Poly.

### **3.3 APPLICATION**

- A. Motor Branch Circuits: Class RK5.

- B. Other Branch Circuits: Class CC, Class J, Class RK1, Class RK5.

### **3.4 CLEANING**

- A. Clean fuses and tighten connections prior to energizing of equipment.

**END OF SECTION 26 28 13**

## **SECTION 26 28 16 - ENCLOSED SWITCHES AND CIRCUIT**

### **BREAKERS PART 1 - GENERAL**

#### **1.1 RELATED WORK**

- A. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables
- B. Section 26 05 26 – Grounding and Bonding for Electrical Systems
- C. Section 26 05 29 – Hangers and Supports for Electrical Systems
- D. Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems
- E. Section 26 05 53 – Electrical Systems Identification
- F. Section 26 05 73 – Power System Studies
- G. Section 26 08 12 – Power Distribution Acceptance Tests
- H. Section 26 28 13 – Fuses

#### **1.2 REFERENCE**

- A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

#### **1.3 DESCRIPTION**

- A. Section includes fusible and non-fusible disconnect switches and circuit breakers in individual enclosures.

#### **1.4 REFERENCE STANDARDS**

- A. ANSI//NECA 1 - Standard Practices for Good Workmanship in Electrical Contracting
- B. NEMA AB 1 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breakers Enclosures
- C. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)
- D. NFPA 70 - National Electrical Code
- E. UL 98 - Enclosed and Dead Front Switches
- F. UL 486A - 468B - Wire Connectors
- G. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures
- H. UL 869A - Reference Standard for Service Equipment

#### **1.5 SUBMITTALS**

- A. Product Data:
  - 1. Submit catalog cut sheet indicating voltage, amperage, HP ratings, enclosure type, and dimension, fuse clip features, terminal lugs and all accessories including interlock devices, short circuit current ampere rating and factory settings of



individual protective devices.

- B. Manufacturer's Installation Instructions:
  - 1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
- C. Test Reports:
  - 1. Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
- D. Closeout Submittals:
  - 1. Project Record Documents:
    - a. Record actual locations of disconnect switches and ratings of installed fuses.
    - b. Record actual locations and continuous current ratings of enclosed circuit breakers.
  - 2. Operation and Maintenance Data:
    - a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
    - b. Include spare parts data listing, source, and current prices of replacement parts and supplies.
    - c. Include Manufacturer's Seismic Qualification Certification and Installation Seismic Qualification Certification.

## 1.6 QUALITY ASSURANCE

- A. Obtain disconnect switches and enclosed circuit breakers from one source and by single manufacturer.
- B. Regulatory Requirements:
  - 1. Comply with NFPA 70 for components and installation.
  - 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.
- C. Certifications:
  - 1. Furnish Owner's Representative with Manufacturer's Seismic Qualification Certification: Submit certification that disconnect switches and enclosed circuit breakers, accessories, and components will remain internally intact to withstand seismic forces defined in Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems. Include the following:
    - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
  - 2. Furnish Owner's Representative with Installation Seismic Qualification Certification: Submit certification that disconnect switches and enclosed circuit breakers, accessories, and components will remain in place without separation of any parts when subjected to the seismic forces defined in Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems and will be fully operational after the seismic event. Include the following:
    - a. Detailed description of disconnect switches and enclosed circuit breakers anchorage devices and seismic restraints on which the certification is based

and their installation requirements.

- b. Certification shall bear the seal and signature of an Engineer registered and licensed in the State of California.

### 1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris, and traffic.
- B. Comply with manufacturer's written instructions.

### 1.8 WARRANTY

- A. Refer to Division 01 and Section 26 00 00 – General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1-year written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Square D
- B. Cutler-Hammer
- C. Or equal

### 2.2 DISCONNECT SWITCHES

- A. NEMA KS 1, UL 98
- B. Load interrupter enclosed knife switch, heavy-duty type.
- C. Fusible type as indicated.
- D. Switch Interiors:
  - 1. Switch blades that are visible in "OFF" position when switch door is open.
  - 2. Plated current carrying parts.
  - 3. Removable arc suppressors to permit easy access to line side lugs.
- E. Switch Mechanism:
  - 1. Quick-make, quick-break, with visible blades and externally operable handle.
  - 2. Lockable only in "OFF" position and accept three industrial type, heavy-duty padlocks.
  - 3. Dual cover interlock to prevent unauthorized opening of switch door when handle is in "ON" position, and to prevent closing of switch mechanism with door open.
  - 4. Defeater mechanism to bypass interlock.
  - 5. Operating handle integral part of enclosure.
  - 6. Handle to physically indicate "ON" and "OFF" position.
- F. Ratings:
  - 1. Ampacity as indicated on drawings.
  - 2. Horsepower rated.

- G. Fusible Switches:
  - 1. Rejection clips for Class R fuses specified.
  - 2. Provisions for Class J or Class L fuses, as applicable.
  - 3. Fuses: Per requirements in Section 26 2813 – Fuses.

### **2.3 ENCLOSED CIRCUIT BREAKERS**

- A. NEMA AB 1, UL 489.
- B. Enclosed molded-case circuit breakers:
  - 1. Tripped indication clearly shown on breaker handle taking position between "ON" and "OFF."
  - 2. 100A frame size and below: thermal-magnetic trip.
  - 3. 100A frame size and above: electronic (solid-state microprocessor-based) trip units  
  
interchangeable in the field within the frame size and field-adjustable long time pick-up, long time delay, short time pick-up, short time delay, and instantaneous current settings. Each adjustment shall have discrete settings and shall be independent of other adjustments.
  - 4. Locks on trip handles where indicated.
  - 5. Molded-case switch in lieu of thermal-magnetic molded-case circuit breaker, where indicated.
  - 6. Shunt trip, where indicated.
- C. Breaker Mechanism:
  - 1. Quick-make, quick-break.
- D. Ratings:
  - 1. Ampacity as indicated on drawings.
  - 2. Listed as Type HACR for air conditioning equipment circuits.
  - 3. Listed as Type SWD for lighting circuits.

### **2.4 LUGS**

- A. Front removable lugs.
- B. Labeled for 75°C copper and aluminum conductors.
- C. Multiple lugs to match number of conductors per phase.
- D. Termination of field installed conductors: Pressure wire connectors, except wire-binding screws for #10 AWG or smaller conductors.

### **2.5 ACCESSORIES:**

- A. Solid neutral assembly, where required.
- B. Equipment ground kit.
- C. Blown fuse indicators on fused disconnect switches.
- D. Factory installed fuse puller on fused disconnect switches.
- E. One set of normally open (NO) auxiliary contacts, where disconnect switch is installed at a remote motor served by variable frequency drive (VFD).

### **2.6 ENCLOSURES**

- A. NEMA KS 1, NEMA AB 1, UL 98, UL 489, as applicable.
- B. NEMA Type 1, Type 3R (outdoor locations) enclosure.
- C. Code-gauge galvanized steel.
- D. Manufacturer's standard gray enamel finish over prime coat.
- E. Surface-mounted.

## **2.7 SHORT CIRCUIT CURRENT RATING**

- A. Each circuit breaker shall have minimum short circuit current rating as indicated on drawings.

## **PART 3 - EXECUTION**

### **3.1 COORDINATION WITH MANUFACTURER**

- A. Instruct manufacturer about the location of incoming lugs, i.e., top or bottom feed based on incoming feeder entrance location.
- B. Verify that "touch-up" paint kit is available for repainting.

### **3.2 EXAMINATION**

- A. Examine areas and surface to receive disconnect switches and enclosed circuit breakers for compliance with requirements, installation tolerances, and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Verify that space indicated for disconnect switches and enclosed circuit breakers mounting meets code-required working clearances.
- C. Notify Owner's Representative of any discrepancies prior to submittal of product data and shop drawings.

### **3.3 INSTALLATION**

- A. Install disconnect switches and/or enclosed circuit breakers in accordance with ANSI/NECA 1.
- B. Install disconnect switches and/or enclosed circuit breakers level and plumb, in accordance with manufacturer's written instruction.
- C. Disconnect switches and enclosed circuit breakers mounting and seismic restraints:
  - 1. Install disconnect switches and enclosed circuit breakers anchorage devices and seismic restraints based on design by an Engineer registered and licensed in the State of California, and to comply with Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems for seismic criteria.
  - 2. Fasten disconnect switches and enclosed circuit breakers firmly to walls and structural surfaces, ensuring they are permanently and mechanically anchored.
  - 3. Anchor and fasten disconnect switches and enclosed circuit breakers and their supports to building structural elements (wood, concrete, masonry, hollow walls and nonstructural building surfaces) by the methods described in Section 26 05 29 – Hangers and Supports for Electrical Systems.

4. Install two rows of steel slotted channel, with a minimum of four attachment points, for each disconnect switch and enclosed circuit breaker.
  5. When not located directly on wall, install support frame of steel slotted channel anchored to floor and ceiling structure.
- D. Do not support disconnect switches and/or enclosed circuit breakers by raceway.
- E. Install top disconnect switch and/or enclosed circuit breaker handle a minimum of 3'-6" and maximum of 6'-6" above finished floor.
- F. Tighten electrical connectors and terminals according to equipment manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A - 486B.
- G. Install engraved plastic nameplates under provisions of Section 26 05 53 – Electrical Systems Identification. Attach nameplate to exterior of each switch and/or enclosed circuit breaker using small corrosion-resistant metal screws or rivets. Do not use contact adhesive.
1. Include switch and/or enclosed circuit breaker name, amperage, voltage, phase, and number of wires.
- H. Install fuses in fusible switches at job site per requirements in Section 26 28 13 – Fuses.

### **3.4 CONNECTIONS**

- A. Ground equipment according to Section 26 05 26 – Grounding and Bonding for Electrical Systems.
- B. Connect wiring according to Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables.

### **3.5 FIELD QUALITY CONTROL**

- A. Inspect for physical damage, proper alignment connections, anchorage, and grounding.
- B. Correct malfunctioning units on-site and retest to demonstrate compliance. Remove and replace with new units and retest.
- C. Test disconnect switches and/or enclosed circuit breakers per requirements in Sections 26 08 12 – Power Distribution Acceptance Tests and 26 08 13 – Power Distribution Acceptance Test Tables.
- D. Interpret test results in writing and submit to Owner's Representative.

### **3.6 REPAINTING**

- A. Remove paint splatters and other marks from surface of equipment.
- B. Touch-up chips, scratches, or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint with Owner's Representative.

### **3.7 ADJUSTING**

- A. Circuit Breakers: Set field-adjustable trip settings or change the trip settings recommended by the overcurrent protective device coordination study per Section

26 05 73 – Power System Studies.

**3.8 CLEANING**

- A. Vacuum dirt and construction debris from interior and exterior of equipment; do not use compressed air to assist in cleaning.

**END OF SECTION 26 28 16**

## **SECTION 26 29 13 - ENCLOSED**

### **CONTROLLERS PART 1 - GENERAL**

#### **1.1 RELATED WORK**

- A. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables
- B. Section 26 05 26 – Grounding and Bonding for Electrical Systems
- C. Section 26 05 29 – Hangers and Supports for Electrical Systems
- D. Section 26 05 33 – Raceway and Boxes for Electrical Systems
- E. Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems
- F. Section 26 05 53 – Electrical Systems Identification
- G. Section 26 08 13 – Power Distribution Acceptance Test Tables
- H. Section 26 28 13 – Fuses

#### **1.2 REFERENCE**

- A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

#### **1.3 DESCRIPTION**

- A. Section includes enclosed manual and magnetic motor controllers and enclosed contactors.
- B. Motors shown on the drawings or specified in other Divisions of these specifications shall be provided with motorized equipment and connected under this section. Provide motor controllers and power circuit disconnect devices for all motors, unless shown or specified to be furnished with motorized equipment under other Divisions of these specifications, and/or by others, for installation by this contract.
- C. Variable-frequency controllers furnished by Division 20 for installation by Division 26.
- D. Motor Voltage Information:
  - 1. Voltages available are: 208 and 480 V, 3-phase and 120, 208 and 277V single phase. Circuits are designed for motors with voltage ratings as follows:
    - a. Smaller than 1/2 hp motors: 115 V, single phase.
    - b. 1/2 hp motors and larger: 200 and 460 V, 3-phase.

#### **1.4 REFERENCE STANDARDS**

- A. ANSI/NECA 1 – Standard Practices for Good Workmanship in Electrical Contracting
- B. NEMA AB 1 – Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breakers Enclosures
- C. NEMA 250 – Enclosures for Electrical Equipment (1000 V Maximum)
- D. NEMA ICS 2 – Industrial Control and Systems: Controllers, Contactors and Overload Relays, Rated Not More Than 2000 VAC or 750 VDC

- E. NEMA ICS 4 – Industrial Control and Systems: Terminal Blocks
- F. NEMA ICS 5 – Industrial Control and Systems: Control Circuit and Pilot Devices
- G. NEMA ICS 6 – Industrial Control and Systems: Enclosures
- H. NEMA KS 1 – Enclosed and Miscellaneous Distribution Equipment Switches (600 V Maximum)
- I. NEMA MG 1 – Motors and Generators
- J. NFPA 70 – National Electrical Code
- K. UL 98 – Enclosed and Dead Front Switches
- L. UL 486A-486B – Wire Connectors
- M. UL 489 – Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breakers Enclosures
- N. UL 508 – Industrial Control Equipment

### 1.5 SUBMITTALS

- A. Product Data:
  - 1. Motor controllers: Submit catalog cut sheets showing voltage, size, rating and size of switching and overcurrent protective devices, dimensions, and enclosure details.
  - 2. Contactors: Submit catalog cut sheets showing voltage, size, current rating, dimensions, and enclosure details.
  - 3. Factory settings and time-current curves of individual protective devices.
  - 4. Confirm motor sizes and voltages with submittals of other Divisions of specifications, and/or by others, prior to Section submittals.
- B. Manufacturer's Installation Instructions:
  - 1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and/or starting of product.
- C. Test Reports: Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
- D. Closeout Submittals:
  - 1. Project Record Documents:
    - a. Record actual locations and ratings of enclosed motor controllers and enclosed contactors.
  - 2. Operation and Maintenance Data:
    - a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
    - b. Include spare parts data listing, source, and current prices of replacement parts and supplies.
    - c. Include Manufacturer Seismic Qualification Certification and Installation Seismic Qualification Certification.

### 1.6 QUALITY ASSURANCE

- A. Obtain motor controllers, and contactors from one source and by single manufacturer.
- B. Regulatory Requirements:
  - 1. Comply with NFPA 70 for components and installation.
  - 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable



for purpose specified and indicated.

C. Certifications:

1. Furnish Owner's Representative with Manufacturer Seismic Qualification Certification: Submit certification that motor controllers, contactors, accessories and components will remain internally intact to withstand seismic forces defined in Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems. Include the following:
  - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Furnish Owner's Representative with Installation Seismic Qualification Certification: Submit certification that motor controllers, contactors, accessories and components will remain in place without separation of any parts when subjected to the seismic forces defined in Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems and will be fully operational after the seismic event. Include the following:
  - a. Detailed description of equipment supports and seismic restraints on which the certification is based and their installation requirements.
3. Certification shall bear the seal and signature of an Engineer registered and licensed in the State of California.

**1.7 DELIVERY, STORAGE, AND HANDLING**

- A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect units from dirt, water, construction debris, and traffic.

**1.8 WARRANTY**

- A. Refer to Division 01 and Section 26 00 00 – General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1-year warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

**1.9 MAINTENANCE**

- A. Extra Materials: Furnish extra materials described below that match product installed, are packaged with protective covering for storage, and are identified with labels describing contents.
  1. Spare pilot lights: Furnish 1 spare lamp for every 5 installed units, but not less than 1 set of 3 of each kind.

**PART 2 - PRODUCTS**

**2.1 MANUFACTURERS**

- A. Square D
- B. Cutler-Hammer
- C. Siemens
- D. Allen Bradley

## 2.2 MANUAL MOTOR CONTROLLERS

- A. Description: NEMA ICS 2, AC general-purpose, Class A, manually operated, full-voltage controller for small motors, with bimetal type overload relay, red pilot light, (NO) (NC) auxiliary contact, and pushbutton operator.

## 2.3 FRACTIONAL-HORSEPOWER MANUAL CONTROLLERS

- A. Description: NEMA ICS 2, AC general-purpose, Class A, manually operated, full-voltage controller for fractional horsepower induction motors, with bimetal type overload relay, (red) (green) pilot light, and toggle operator.

## 2.4 MOTOR STARTING SWITCHES

- A. Description: NEMA ICS 2, AC general-purpose Class A manually operated, full-voltage controller for fractional horsepower induction motors, without thermal overload unit, with red pilot light, and toggle operator.

## 2.5 FULL-VOLTAGE NON-REVERSING MAGNETIC MOTOR CONTROLLERS

- A. Description: NEMA ICS 2, AC general-purpose, Class A, magnetic controller for induction motors rated in horsepower, three-phase and single-phase, as scheduled, except where single-phase motors scheduled to be provided with built-in overload elements:
  - 1. Size 1 minimum
  - 2. Control Voltage: 120 V, 60 Hz
  - 3. Overload Relays: NEMA ICS 2, solid-state bimetal, 1 overload relay per phase:
    - a. Solid-state type:
      - 1) Class 10, 20, inverse-time tripping characteristics.
      - 2) Non-volatile operating memory.
      - 3) 3:1 current adjustment range.
      - 4) Phase loss/phase unbalance protection.
      - 5) Ambient temperature insensitive.
      - 6) Self-powered.
      - 7) Manual reset. Automatic recent not acceptable.
      - 8) Manual trip.
      - 9) Visible trip indication.
      - 10) One normally open and 1 normally closed isolated auxiliary contract.
      - 11) Class II ground fault protection.
      - 12) Jam/stall protection.
    - b. Bimetallic type:
      - 1) Class 10, 20, [30] inverse-time tripping characteristics.
      - 2) Manual reset.
      - 3) Ambient temperature compensated bimetallic
      - 4) One normally open and one normally closed isolated auxiliary contract.
  - 4. Features:
    - a. Auxiliary Contacts: NEMA ICS 2, 2 each normally open and normally closed field- convertible contacts in addition to seal-in contact.
    - b. Pushbuttons: Unguarded type.
    - c. Pilot Lights NEMA ICS 5: push-to-test LED type.
    - d. Hand-Off-Auto (H-O-A) Selector Switches: Rotary type.

- e. Control Power Transformers: 120V secondary, adequate capacity to operate connected pilot, indicating and control devices, plus 100% spare capacity in each motor controller, but not less than 100VA. Fused primary and secondary, and unfused leg of secondary bonded to enclosure.
- f. Terminals: NEMA ICS 4.
- g. Other accessories detailed or required by drawings.

## 2.6 COMBINATION CONTROLLERS

- A. Factory-assembled motor controllers with externally operable disconnect, molded-case circuit breaker type, in common enclosure; means for locking disconnect handle and means for defeating cover interlock.
  - 1. Molded-case circuit breakers: NEMA AB 1 and UL 489; quick-make, quick-break with thermal- magnetic trip electronic (solid-state microprocessor-based) trip instantaneous trip (motor circuit protector); lockable with two padlocks and interlocked with cover in closed position.
    - a. Thermal-magnetic trip: 100A frame and below.
    - b. Electronic trip: Interchangeable in the field within the frame size and field-adjustable [long time pick-up and delay], [short time pick-up and delay] and [instantaneous] current settings: 100A frame size and above. Each adjustment shall have discrete settings and shall be independent of all other adjustments.
    - c. Instantaneous trip (motor circuit protector): Field adjustable, short circuit trip coordinated with motor locked-rotor amperes; will open the circuit at current exceeding 1300% or 1700% of motor full-load current.

## 2.7 MOTOR CONTROLLER ACCESSORIES

- A. Factory installed devices in controller enclosure, unless otherwise indicated, as follows:
  - 1. "On-Off" and "Start-Stop" pushbutton stations, pilot lights, selector switches: NEMA ICS 2, heavy duty, oiltight type.
  - 2. 120 V control circuits and pilot light, unless noted otherwise.
  - 3. Red pilot light to indicate motor operation.
  - 4. Green pilot light to indicate motor stopped.
  - 5. Minimum wire size for control circuits: #14 AWG.
  - 6. Stop and Lockout Pushbutton Station: Momentary-break pushbutton station with a factory- applied has arranged so a padlock can be used to lock pushbutton in depressed position with control circuit open, where indicated.
  - 7. Control Relays: Auxiliary and adjustable time-delay relays, where indicated:
    - a. Phase-Failure and Undervoltage Relays: Solid-state sensing circuit with isolated output contacts for hardwired connection, with adjustable undervoltage setting.
- B. Control services: As scheduled on motor schedule or indicated.

## 2.8 GENERAL PURPOSE MAGNETIC CONTACTORS

- A. Description: NEMA ICS 2, same as magnetic controllers, except without overload protection.
- B. Poles: To match circuit configuration and control function.
- C. Configuration: Mechanically held.

- D. Contact Rating: Match branch circuit overcurrent protection.

### **2.9 LIGHTING MAGNETIC CONTACTORS**

- A. Description: NEMA ICS 2, same as magnetic controller, except without overload protection.
- B. Poles: To match circuit configuration and control function.
- C. Configuration: Mechanically held.
- D. Contact Rating: Match branch circuit overcurrent protection.

### **2.10 LUGS**

- A. Labeled for 75°C copper and aluminum conductors.
- B. Multiple lugs to match number of conductors per phase.
- C. Termination of field installed conductors: Pressure wire connectors, except wire-binding screws for #10 AWG or smaller conductors.
- D. For equipment specified in this section and for equipment furnished under other Divisions of this specification and/or by others.

### **2.11 MOTOR CONTROLLERS AND CONTACTOR ENCLOSURES**

- A. NEMA 250, NEMA 1CS 6.
- B. NEMA Type 1, Type 3R (outdoor locations) enclosure.
- C. Code-gauge galvanized steel.
- D. Manufacturer's standard gray enamel finish over prime coat.
- E. Surface-mounted.

## **PART 3 - EXECUTION**

### **3.1 COORDINATION**

- A. Coordinate motor control wiring with Division 23 of these specifications.
- B. Coordinate motor sizes and voltages with submittals of other Divisions of these specifications and/or by others.
- C. Verify with manufacturer that "touch-up" paint kit is available for repainting.

### **3.2 EXAMINATION**

- A. Examine areas and surface to receive motor controllers and contactors for compliance with requirements, installation tolerances, and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Verify that space indicated for motor controllers and contactors mounting meets code-required working clearances.
- C. Notify Owner's Representative of any discrepancies prior to submittal of product data.

### **3.3 INSTALLATION**

- A. Install motor controllers and contactors in accordance with ANSI/NECA 1.

- B. Install level and plumb, in accordance with manufacturer's written instruction.
- C. Motor controllers and contactors mounting and seismic restraints:
  - 1. Install motor controllers and contactors anchorage devices and seismic restraints based on design by an Engineer registered and licensed in the State of California, and to comply with Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems for seismic criteria.
  - 2. Fasten motor controllers and contractors firmly to walls and structural surfaces, ensuring they are permanently and mechanically anchored.
  - 3. Anchor and fasten motor controllers and contactors and their supports to building structural elements (wood, concrete, masonry, hollow walls and nonstructural building surfaces) by the methods described in Section 26 05 29 – Hangers and Supports for Electrical Systems.
  - 4. Install two rows of steel slotted channel, with minimum of four attachment points, for each motor controller and contactor.
  - 5. When not located directly on wall, install support frame of steel slotted channel anchored to floor and ceiling structure.
  - 6. Do not support motor controllers and contactors only by raceway.
- D. Tighten electrical connectors and terminals according to equipment manufacturer's published torque-tightening valves. Where manufacturer's torque valves are not indicated, use those specified in UL 486A-486B.
- E. Install engraved plastic nameplates under provisions of Section 26 0553 – Electrical Systems Identification. Attach nameplate to exterior of each motor controller and contactor, using small corrosion resistant metal screws or rivets. Do not use contact adhesive:
  - 1. Indicate motor served, nameplate horsepower, full load amperes, code letter, service factor, voltage/phase rating, and fuse size and type, when applicable.
- F. Connect each motor terminal box to rigid conduit system with maximum 18" of flexible liquid-tight metal conduit. Install conduit per requirements in Section 26 05 33 – Raceway and Boxes for Electrical Systems.
- G. Check for proper rotation and phase relationship of each motor.
- H. Install fuses in fusible switch at job site pre requirements in Section 26 28 13 – Fuses.
- I. Control Wiring Installation:
  - 1. Install wiring between motor control devices according to Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables.
  - 2. Install motor control wiring in accordance with control wiring diagrams and in raceways where indicated or required by contract drawings.
  - 3. Bundle, train, and support wiring in enclosures.
  - 4. Connect hand-off-automatic switch and other automatic-control devices where applicable.
    - a. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.
    - b. Connect selector switches with motor-control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high- temperature cutouts, and motor overload protectors.

### **3.4 APPLICATION**

- A. Select features of each motor controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, and configuration of pilot device and control circuit affecting controller functions.

### **3.5 CONNECTIONS**

- A. Provide green wire ground through flexible conduit to interconnect motor frame and rigid conduit system.
- B. Ground and bond motor controller and contactor enclosures according to Section 26 05 26 – Grounding and Bonding for Electrical Systems.
- C. Connect power and control wiring according to Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables.
- D. Connect control wiring for operation, control and supervision of motorized equipment as shown on drawings and/or specified in this and other Divisions of these specifications.

### **3.6 FIELD QUALITY CONTROL**

- A. Inspect motor controllers and contactors for physical damage, proper alignment, connections, anchorage, seismic restraints and grounding.
- B. Correct malfunctioning motor controllers and contactors on-site and retest to demonstrate compliance. Remove and replace with new units and retest.
- C. Test continuity of each circuit.
- D. Test motor controllers per requirements in Sections 26 08 12 – Power Distribution Acceptance Tests and 26 08 13 – Power Distribution Acceptance Test Tables.
- E. Interpret test results in writing and submit to Owner's Representative.

### **3.7 REPAINTING**

- A. Remove paint splatters and other marks from surface of equipment.
- B. Touch-up chips, scratches or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint with Owner's Representative.

### **3.8 ADJUSTING**

- A. Set field-adjustable circuit breakers trip settings or change the trip settings as indicated on drawings.
- B. Adjust motor circuit protectors.

### **3.9 CLEANING**

- A. Vacuum dirt and construction debris from interior and exterior of equipment; do not use compressed air to assist in cleaning.

## **END OF SECTION 26 29 13**

## **SECTION 26 32 13 - ENGINE GENERATORS**

### **PART 1 - GENERAL**

#### **1.1 RELATED WORK**

- A. Section 26 00 00 – General Electrical Requirements
- B. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables
- C. Section 26 05 26 – Grounding and Bonding for Electrical Systems
- D. Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems
- E. Section 26 08 12 – Power Distribution Acceptance Tests
- F. Section 26 36 23 – Automatic Transfer Switches

#### **1.2 REFERENCE**

- A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

#### **1.3 DESCRIPTION OF SYSTEM**

- A. Section describes complete package generator set, unit-mounted radiator cooling system microprocessor-based control and monitoring panel, battery and charger, Building Management System (BMS) communications module, remote annunciator, drop over sound attenuated enclosure.
- B. Package generator set rated for standby duty.
- C. Engine fuel system:
  - 1. Sub-base fuel tank
- D. Discuss with University Representative direction for fuel burning generator for specific requirements.

#### **1.4 REFERENCE STANDARDS**

- A. NEMA MG-1 – Motors and Generators
- B. IEEE446 – Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
- C. NFPA 37 - Standard for Installation and Use of Stationary Combustion Engines and Gas Turbines
- D. NFPA 110 – Standard for Emergency and Standby Power Systems
- E. UL 2200 – Stationary Engine Generator Assemblies
- F. IEC8528 Part 4 – Control Systems for Generator Sets
- G. UL 142 – Steel Aboveground Tanks for Flammable and Combustible Liquids
- H. UL 2085 – Protected Aboveground Tanks for Flammable and Combustible Liquids

## 1.5 SUBMITTALS

### A. Shop Drawings

1. Submit for engineering review and approval prior to production release. Include the following for engine-generator:
  - a. Outline drawings of equipment showing weights
  - b. Overall dimensions including bolting template and earthquake restraints
  - c. Right hand, left hand, end, and top views of proposed assembly
  - d. Battery, battery rack, battery charger, and wiring diagrams
  - e. Vibration isolation bases, mounts, and hangers
  - f. Exhaust silencer and flexible fittings
  - g. Stub ups for fuel
  - h. Power and control wiring entrance locations
  - i. Main circuit breaker size, location, and required clearance
  - j. Lug sizes and locations
  - k. Engine-generator control panel drawings showing devices to be provided, with each device referenced to material list with complete description for device.
  - l. Weather protective enclosure installation drawings, structural calculations, lighting fixture catalog cut, conduit, and wiring.
  - m. Enclosure sound performance data
  - n. Muffler characteristics
  - o. Calculations for starting based on step loads outlined in Paragraph 2.2, B.5.
  - p. Factory certified prototype test report indicating fuel efficiency and emission levels
2. Information on engine characteristics:
  - a. Make, type, and number of cylinders
  - b. Brake horsepower (bhp) available
  - c. Jacket water heat rejection
  - d. Cooling pump characteristics
  - e. Exhaust flow rate and temperature at 25, 50, 75, and 100% rated load
  - f. Ventilation requirements
  - g. Combustion air requirements
  - h. Fuel consumption rates at 25, 50, 75, and 100% rated load
  - i. Liquid refill capacities
  - j. Exhaust backpressure limitation
  - k. Type and manufacturer of governor
  - l. Alternator size to limit voltage dip to 10%
3. Information on generator characteristics:
  - a. Make and type
  - b. Type of construction and overspeed capabilities
  - c. Temperature rise
  - d. Regulation characteristics
  - e. Ventilation requirements
  - f. Type of winding insulation
  - g. KW power factor
  - h. Type of exciter and voltage regulator
4. Manufacturer seismic qualifications: Submit certification that engine-generator set, batteries, battery rack, accessories, and components will withstand seismic forces defined in Section 26 05 48 - Vibration and Seismic Controls for Electrical Systems.



- B. Interconnection detail drawing showing control and power connections in complete standby system. Control connections between components are to be labeled with identical nomenclature. Coordinate with generator manufacturer.
- C. Accessories including fuel lines, flexible exhaust couplings, exhaust flange, and other exhaust system components.
- D. Complete review of this specification, noting for each paragraph whether or not proposed equipment complies with project specifications, or deviates in some fashion. Justification must be provided for each deviation.
- E. Complete test specification detailing testing procedure to be used to verify performance of equipment provided.
- F. Recommended spare parts lists.
- G. Test Reports:
  - 1. Submit certified factory tests report on engine-generator delivery. Alarms, sensors, and meters must be tested and certified.
  - 2. Submit, upon completion of installation and testing of engine-generator sets, certified test reports from load tests for each engine-generator.

#### **1.6 DELIVERY, STORAGE, AND HANDLING**

- A. Handle equipment in accordance with manufacturer's written instructions. One copy of instructions is to be included with equipment at time of shipment. Maintain factory bracing, packaging, and wrapping.

#### **1.7 OPERATION AND MAINTENANCE MANUALS**

- A. Refer to Section 01 77 00 - Closeout Procedures and herein below.
- B. Submit Operation and Maintenance (O&M) manuals to Owner's Representative for review 60 days prior to acceptance of unit.
- C. Installation, maintenance, and operating instruction manuals shall include, but not limited to, the following:
  - 1. 100% accurate system "as-installed" drawings, interconnect diagrams, schematic diagrams, wiring diagrams, individual sub-system component manuals, operation procedures, system description with theory of operation, maintenance schedules and procedures, original programmed settings and parameters, and other information necessary for the Owner's Representative to maintain, operate, test, and troubleshoot system.
  - 2. The O&M manual shall contain step-by-step instructions for startup and shutdown. The first page shall contain name, address, and phone number of local representative to be called for service or parts. Follow with complete parts lists by actual ordering catalog numbers. O&M manual also shall contain four copies each of test record forms and service record forms for Owner's Representative use. Forms shall show proper interval for testing, servicing, and replacing of components, lubrication, filters, antifreeze, etc., including recommended specifications and fluid levels for lubricants.
  - 3. Recommended spare parts list (with pricing) for 2 years of operation.

- D. O&M manuals shall not solely rely on sub-component manuals. Thorough consolidation of operating and maintenance information shall be available in system overview guide. Include major components of system in overview.
- E. Turn final reviewed manuals over to Owner's Representative prior to conducting training of Owner personnel.
- F. Seal single copy of service record forms, recommended operation and service practices for unit in plastic and wall mount in weather-protective enclosure.

## **PART 2 - PRODUCTS**

### **2.1 MATERIALS**

- A. Acceptable Manufacturers:
  - 1. Engine Generator Set - Caterpillar, Cummins, MTU Onsite Energy, Kohler
  - 2. Exhaust Silencer – Maxim, Nelson, or approved equal
  - 3. Isolation equipment
  - 4. Battery charger – Sens, La Marche, Charles Industries
  - 5. Or equal

### **2.2 RATINGS AND PERFORMANCE**

- A. Engine Generator Set
  - 1. Generator kW Output: As shown on drawings
  - 2. Altitude 500 ft above sea level in ambient temperature of 104°F
  - 3. Stable frequency regulation
- B. Alternator
  - 1. As shown on drawings kVA, .8 Power Factor
  - 2. As required for the project.
  - 3. Stable voltage regulation 0-full load less than or equal to  $\pm 0.5\%$ .
- C. Transient Performance
  - 1. Engine
    - a. Start and load in 10 seconds per NFPA 110
    - b. Accept 100% block load per NFPA 110
  - 2. Frequency regulation [ $\pm .25\%$  no load to full load  $\pm 0.25\%$  steady state.
  - 3. Alternator
    - a. 15% Voltage dip
    - b. Step Load Requirements
    - c. AC waveform output contains <5% total harmonic distortion (THD) at full linear load when measured from line to neutral with <3% in any single harmonic, and no third- order harmonics or their multiples.
    - d. Telephone influence factor < 40
    - e. Telephone harmonic factor < 3
- D. Factory Prototype Test Certified
  - 1. Harmonic Distortion Levels
    - a. Demonstrate
  - 2. Airflow Restriction tests
    - a. Demonstrate controlled shutdown after overheating

3. Unit tested with enclosure
    - a. UL 2200 listed
  4. 30 Degree Water Spray Unit Rain Test
    - a. Demonstrate no water leakage into electrical boxes
  5. Overload Test
    - a. Demonstrate 10% overload with no damage to engine
  6. Air Filter Test
    - a. Demonstrate engine contains engine backfire explosion
- E. Factory Production Test Certified
1. Alternator Impedance to Ground
  2. Dielectric Testing
    - a. At 1000 V and 2-times rated voltage
  3. Maximum kW Rating
  4. Engine Response Time
  5. Alternator Construction Testing
    - a. Impedance Balance Tested
  6. Alternator Insulation Testing
    - a. Surge Tested

## 2.3 FABRICATION AND MANUFACTURER

- A. Engine:
1. Type: Inline or vee
  2. Four-stroke cycle diesel compression ignition at 1800RPM consistent with engine durability.
  3. Aspiration: Turbo Charged
  4. Horsepower
    - a. Brake Horsepower Rule of thumb =  $1.6 \times \text{kW}$
  5. Water cooled
  6. Fuel Type: No. 2 domestic diesel fuel oil.
  7. Engine accessories:
    - a. Fuel filter
    - b. Lube oil filter
    - c. Intake air filter
    - d. Lube oil cooler
      - 1) Suitable for operation of generator set at full rated load in ambient temperature specified.
    - e. Fuel transfer pump
    - f. Fuel priming pump
      - 1) Engine driven positive displacement, mechanical, full pressure.
    - g. Gear driven water pump.
    - h. Electronic direct fuel injection or have suitable emission control equipment.
    - i. Electric speed sensing governor capable of isochronous regulation.
    - j. Safety-shut-offs for:
      - 1) High water temperature
      - 2) Low oil pressure
      - 3) Overspeed
      - 4) Overcranking
  8. EPA Certified Tier 4
- B. Cooling System:

1. Engine skid mounted, engine-driven radiator with blower type fan, sized to maintain safe operation at 122°F ambient temperature.
  2. Arrange liquid-cooled prime movers for NFPA level 1 applications for closed-loop cooling.
  3. Provide radiator with:
    - a. Motor-driven fan with voltage same as generator
    - b. Motor Starter
    - c. Initiating contacts to actuate on generator startup
    - d. Connect to generator distribution system
    - e. Core guard
    - f. Fan guard
    - g. Mounting hardware
    - h. Direct adapter flange. Ductwork with flexible connection between radiator and exhaust plenum to be provided by Division 23. Coordinate with Division 23.
    - i. Flexible pipe connections at engine and radiator.
    - j. Supply power for fans and pumps on remote radiators from a tap at generator output terminals or ahead of first load circuit overcurrent protective device.
    - k. Heat exchangers
  4. Block Heater
    - a. Water Jacket Heater
    - b. Maintain engine jacket water to 110°F in ambient temperature of 30°F
    - c. Heater to be equipped with thermostatic switch.
    - d. Single phase 208V
    - e. Provide two heaters, 4500 W each minimum.
  5. Fill engine cooling system with solution of 50/50 mix ethylene glycol at initial fill.
  6. Ductwork with flexible connection between radiator and exhaust dampers to be provided by others. Refer to Section 23 3113 – Facility Fuel Oil Piping.
- C. Exhaust System:
1. Furnish critical type exhaust silencer:
    - a. Sized according to manufacturer's recommendations
    - b. Mount so weight is not supported by engine
    - c. Flexible exhaust fitting
    - d. Installation inside drop over enclosure
  2. Condensate Traps
    - a. Drain plug at low point of muffler
  3. Thermal Expansion
    - a. Stainless steel exhaust flex to accommodate thermal growth and vibration isolation.
  4. Exhaust Blankets
    - a. 1" high temperature fiberglass cloth wrap
    - b. Coordinate with weather protective enclosure.
  5. Thimble
    - a. Pipe and wall of compatible construction
  6. Acceptable Back Pressure
    - a. Size silencer and exhaust pipe so exhaust back pressure does not exceed maximum limitations specified by generator set manufacturer.

7. Exhaust clearing area
- D. Starting System
  1. Provide DC electric starting system with positive engagement drive. Provide DC voltage recommended by manufacturer.
  2. Provide fully automatic start-stop controls.
  3. Provide cycle cranking to open and lock out start circuit after 3 attempts to start failed engine start.
  4. Batteries
    - a. Provide sealed lead-acid storage battery set:
      - 1) Heavy duty diesel starting type
      - 2) Voltage compatible with starting system voltage
      - 3) Capacity to provide for 1-1/2 minutes total cranking time at 0°F without recharging. In accordance with NFPA Level 1.
    - b. Provide vinyl coated steel battery rack.
    - c. Provide starting battery heater:
      - 1) Heater plate under battery
      - 2) Heater type blanket around battery case
      - 3) Thermal switch - heater control relay
      - 4) 120 VAC input
    - d. Battery cables and clamps
  5. Battery Charger
    - a. Four Rate Battery Charger
      - 1) Constant current, constant voltage, high rate taper, and float equalized.
    - b. Dual Rate Battery Charger
      - 1) Constant current, and float equalized
    - c. Charger Accessories:
      - 1) Overload protection
      - 2)  $\pm 0.5\%$  line and load regulation
      - 3) Electronic current limit output 105%
      - 4) DC ammeter and voltmeter digital meter with  $\pm 2\%$  volt accuracy,  $\pm 5\%$  amp accuracy.
      - 5) UL 1236 listed and meets NFPA 110 requirements
      - 6) Output protection
      - 7) Temperature compensation
      - 8) Enclosed in NEMA 1 aluminum or stainless-steel enclosure
      - 9) Form C contacts for the following alarms
        - a) AC fail
        - b) Low battery volts
        - c) High battery volts
        - d) Charger fail
        - e) Battery fault
  6. AC input voltage: 208 V
  7. When installed on the engine generator set, mount on vibration isolators.
- E. Speed Control
  1. Electronic: Isochronous
- F. Alternator:
  1. Maximum temperature rise is 135°C at 40°C ambient

2. Synchronous type
3. Self-ventilated
4. Drip-proof construction
5. Directly connected to engine flywheel housing with a flex coupling
6. Capable of sustaining 300% overcurrent for 10 seconds under a 3 Ph symmetrical short circuit
7. 120 V Anti-Condensation heater
8. Subtransient Reactance limited to 12%
9. Insulation
  - a. Complies with NEMA (MG1-33.4)
  - b. Class H Insulation Systems
    - 1) UL 1449 recognized
    - 2) Vacuum impregnated with epoxy varnish
    - 3) Fungus resistant
10. Permanent magnet brushless excitation (PMG).
  - a. PMG shall derive excitation current from pilot exciter mounted on the rotor shaft. It is to be able to sustain 300% of rated current for ten seconds during a fault condition.
  - b. Self-excited system to be brushless and consist of a 3 Ph armature and a 3 Ph full wave bridge rectifier mounted on the rotor shaft. Include surge suppressors to protect the diodes from voltage spikes.
11. Rotor
  - a. 4 pole
  - b. Winding
    - 1) Random
  - c. Varnish process
    - 1) Epoxy based material applied to each layer of magnet wire
  - d. Coil supports
    - 1) Driven through flexible coupling to ensure permanent alignment.
  - e. End winding spacing
  - f. Amortisseur windings
  - g. Bearings
    - 1) Sealed
    - 2) Single
12. Stator
  - a. 3 Ph winding
  - b. Laminations
  - c. Cooling air passages and fan
    - 1) Provide space heater to keep alternator free of moisture. Space heater to be 1500 W, 120 VAC, 1 Ph.
  - d. Welded laminations to prevent cutting of wires
  - e. Skewed stack to minimize slot ripple on output voltage and produce smooth voltage waveform.
  - f. Pitch – Skewed design to optimize efficiency and minimize total harmonic distortion.
  - g. Varnish process
    - 1) 2 dips and bakes using Class A impregnating varnish
13. Alternator Components

- a. Solid state design digital voltage regulator:
  - 1) Performance
    - a) Microprocessor based.
    - b) Programmable
    - c) Regulation:  $\pm 0.25\%$  at any constant load for any load from 0% to 100% of pf rating.
    - d) 3 Ph, true RMS sensing
    - e) PMG input, engine unloading
    - f) Design insensitive to severe, load induced wave shape distortion from SCR or thyrister circuits such as those used in battery charging, UPS, and motor speed control equipment loads.
    - g) Controls to limit build-up of AC generator voltage to provide a linear rise and limit overshoot.
    - h) Digital adjustments for out voltage adjustment gain, damping and frequency rate-off.
    - i) System setup controls and fault alarms.
  - 2) Protection
    - a) Over-excitation protection
    - b) Electronic voltage buildup protection
    - c) Loss of sensing protection
    - d) Temperature compensation
    - e) Limitation of voltage overshoot on startup
  - 3) Features
    - a) Parallel support
    - b) VAR/PF control
  - 4) Environmentally sealed
  - 5) UL 508A listing
- b. Output Circuit Breaker(s)
  - 1) Two 100% thermal magnetic rated circuit breaker
  - 2) Adjustable long time, long time delay, short time, and short time delay curve shaping elements
  - 3) Shunt Trip for integration with load bank controls
  - 4) Solid state trip fixed mounted insulated case generator mounted circuit breaker
  - 5) NEC required access in front of breaker
  - 6) Ground fault alarm only: Monitoring relay for breaker 1000A and above. Relay to be adjustable from 3.8 – 1200A and include an adjustable time delay of 0- 10S.

G. Controls:

- 1. NFPA 110 listed
- 2. Micro-processor based solid state controls to automatically start, protect and monitor engine- generator set with panel illuminating lighting and digital display.
- 3. Control panel includes:
  - a. Solid state trip main circuit breaker
  - b. Motor starting switch
  - c. Electrically operated fuel control

- d. Relay to disconnect battery charger during cranking
- e. Switching lamps and meters to be oil tight and dust tight. All active components to be installed within a NEMA 3R enclosure. There shall be no exposed components with door open operating 750 V.
- f. Protective relays to open main circuit breaker and shut down and lockout engine on abnormal conditions including:
  - 1) Overspeed
  - 2) Operation of Remote Stop
  - 3) Overcrank (alarm only when generator serves a fire pump)
  - 4) Low lube oil pressure (alarm only when generator serves a fire pump)
  - 5) High Engine Temp (alarm only when generator serves a fire pump)
  - 6) Low coolant level (alarm only when generator serves a fire pump)
  - 7) Fail to crank (alarm only when generator serves a fire pump)
  - 8) Dead battery (alarm only when generator serves a fire pump)
- g. Monitoring items shall include but is not limited to the following items and control:
  - 1) Coolant temperature
  - 2) Oil pressure
  - 3) Battery voltage
  - 4) RPM
  - 5) Voltmeter, 3-1/2" dual type, 0.5% accuracy with selector switch
  - 6) Ammeter, 3-1/2" dual type, 0.05% accuracy with selector switch
  - 7) Frequency meter, 55-65 Hz  $\pm$ 0.125 Hz.
  - 8) Running Time Meter (hours and 1/10 hours)
  - 9) AC power metering to be 0.5% accuracy and include frequency, phase, selector switch with real time power metering including, kW, kVA, kVAR, kWh, PF, % of rated load.
- h. Control Items:
  - 1) Voltage level adjustment rheostat
  - 2) Overspeed level adjustment
  - 3) Overvoltage level adjustment
  - 4) Undervoltage level adjustment
  - 5) Overfrequency level adjustment
  - 6) Underfrequency level adjustment
  - 7) Position function switch(es) marked AUTO, MANUAL RUN, OFF/RESET and STOP
  - 8) 4 NO and 4 NC dry contacts for local and remote alarms, wired to terminal strips.
  - 9) Emergency off mushroom button
  - 10) Automatic remote start capability. Engine cranking system to permit minimum 4 cranking attempts of 10 seconds (adjustable) duration with rest of periods of 10 seconds (adjustable).
    - a) Overcrack lockout shall occur after 4 cranking attempts.
- i. In accordance with NFPA 110, Level 1, control panel shall furnish battery-powered individual visual alarm indicator functions at battery voltage and visual and audible pre- alarm:
  - 1) Overcrank
  - 2) Low water temperature
  - 3) High engine temperature pre-alarm



- 4) High engine temperature
- 5) Low lube oil pressure pre-alarm
- 6) Low lube oil pressure
- 7) Overspeed
- 8) Low fuel main tank
- 9) Low coolant level
- 10) EPS supplying load
- 11) Control switch not in automatic position
- 12) High battery voltage
- 13) Low cranking voltage
- 14) Low voltage in battery
- 15) Battery charger ac failure
- 16) Lamp test
- 17) Contacts for local and remote common alarm
- 18) Low starting air pressure
- 19) Low starting hydraulic pressure
- 20) Air shutdown damper
- j. Engine shut down, with audible alarm:
  - 1) Low oil pressure
  - 2) High engine temperature
  - 3) Overcrank
  - 4) Overspeed
  - 5) Remote Emergency Stop
  - 6) Low-coolant level
- k. Status report:
  - 1) Engine running
  - 2) Circuit breaker open
  - 3) Circuit breaker closed
4. Visual alarm resettable only after fault condition has been corrected.
5. Audible alarm shall include silencing circuit, which, after activation, will permit annunciation of subsequent failures.
6. Control Panel mounting:
  - a. Mounted on engine generator set in NEMA 1 enclosure on shock isolators
  - b. Wall mounted in NEMA 1 enclosure
  - c. Free standing in NEMA 1 enclosure
7. Provide remote annunciator panel
  - a. Compliant with NFPA Level 1 requirements.
- H. Isolate engine generator set from building structure and from connecting services.
  1. Separately derived grounding system. Connect generator ground as shown on drawings to grounding electrode system.
- I. Termination Bars and Connections:
  1. Silver- or tin-plated copper bus bars for terminating cables.
  2. Standard NEMA standard bolt hole spacing, for 3 Ph and neutral, within generator connection box with gasketed bolt on cover.
  3. Engine-generator set control interfaces to other system components to be made on a permanently labeled terminal block assembly. Provide labels describing connection points.
    1. Connections to engine-generator set: Flexible or isolation type connections.

Include electrical, fuel, exhaust, and ventilation connections.

J. Equipment Bases:

1. Mount complete unit on a structural steel sub-base, rectangular in shape, with sufficient rigidity to maintain alignment of generator set. Provide perimeter beams with minimum depth equal to 1/10 of longest dimension of base, except beam depth need not exceed 14" provided that deflection and misalignment are kept within acceptable limits as determined by manufacturer. Engine-generator set to be statically and dynamically balanced at factory. Peak-to-peak amplitude of vibration velocity in horizontal, vertical, and axial direction shall not exceed 0.65" per second at main structural components.
2. Engine-generator set weight distribution is to be considered to provide uniform deflections.
2. Bases shall provide equipment alignment and assure uniform weight distribution. Provide side brackets on bases to contain isolating mounts and reduce total installed heights of equipment.

K. Vibration Isolators:

1. Prevent equipment vibrations from being transmitted to enclosure.
2. Required between the structural steel sub-base and concrete housekeeping pad.
3. Steel or cast-iron top and bottom housings incorporating 1 or more steel springs with built-in leveling bolts and built-in resilient chocks to control oscillation and withstand lateral forces in all directions.

L. Outdoor Weather Protective Drop-Over Enclosure:

1. Rated NEMA 3R
2. Attenuation:
  - a. Provide engine-generator set with sound-attenuated enclosure. Enclosure will reduce sound level of engine-generator set while operating at full rated load and ventilation running to maximum of 85 dBA at 1 meter or 77 dBA at 7 meters from engine-generator set in free-field environment.
3. Overall Size:
  - a. Drawings show generator footprint, which is maximum allowed for available space.
  - b. Air intake requirements are to be taken into consideration and shall not prevent enclosure from operating within space limitations indicated above.
4. Construction:
  - a. Construction to be welded, 14 ga galvanized steel to ASTM A-446.
  - b. Package listed to UL 2200
  - c. Lockable doors
  - d. Minimum 100A accessory distribution panel to power items listed in Paragraph 2.2, D.
  - e. Interior lights
  - f. Remote mounted emergency stop button
  - g. Lifting lugs
  - h. Refer to Paragraph 2.3.N for fuel system.
5. Ventilation:
  - a. Intake: Complete with gravity damper, hood with silencer, flex connections, and 1/2" x 1/2", 16 ga galvanized bird screen to protect against ice and snow.

- b. Discharge: Complete with gravity-type damper with discharge duct, hood with silencer, flex connector, and 1/2" x 1/2", 16 ga galvanized bird screen.
      - c. Discharge: Vertical
    - 6. Paint:
      - a. Clean surfaces to SSPC-SP1, seal seams, prime with industrial phenolic primer to 1.5 mils D.F.T. Top coat exterior with Clovacoat epoxy enamel to 2.0 mils D.F.T.
    - 7. Power Coat Paint. Selections to include white, beige, ASA61 gray, and manufacturer factory standard. Owner's Representative to select.
  - M. Provide an Active Particulate filter that requires no subsequent preventive maintenance or cleaning.
  - N. Fuel System
    - 1. Sub-base Fuel Tank and Appurtenances
      - a. Capacity: 24 hours at full load
      - b. Rating: UL 142 Listed Check with AHJ
      - c. Double Wall Construction
      - d. Flex fuel lines (NFPA 110 construction)
      - e. Epoxy lined to prevent corrosion
      - f. Tank Exterior: Chemically treated, primed, and painted in factory standard.
      - g. Tank Accessories
        - 1) Overfill prevention valve on tank fill inlet
        - 2) Visual dial type fuel level gauge
        - 3) Manual gauge port with stick gauge
        - 4) Fuel supply and return ports
        - 5) Atmospheric vent port and mushroom type UL-listed flame arrester vent to be installed onto vent pipe by others
        - 6) Containment tank emergency vent port and pressure relief cap.
        - 7) Primary tank emergency vent port and pressure relief cap.
        - 8) Digital tank monitor/overfill control panel with pilot warning lights, audible alarm, output contactors, and press to silence/test/reset feature equal to Pneumercator TMS 2000. Provide with analog output option for use by Building Automation System. (Mounted near tank indoors.)
        - 9) Overfill panel with pilot warning light, audible alarm and press to silence/test/reset feature (mounted near tank indoors). Panel shall interface to digital tank monitor.
        - 10) Fill spill box
        - 11) Leak detection
        - 12) Required internal piping and wiring
        - 13) Decals and signs required by code and authority having jurisdiction.
      - h. UL 2085 prototype test requirements:
        - 1) Submit certified prototype test report that includes the following tests:
          - a) Fire Tests. In full-scale fire test, tank is placed in furnace where temperature is quickly raised to 2000°F to simulate fire of pooled fuel beneath tank. During test, maximum temperature inside tank must not exceed 260°F above ambient temperature (for example,

if ambient temperature is (60°F), tank's internal temperature must not exceed 320°F). At no time may tank's internal temperature exceed 400°F. Immediately following fire test, tank is subjected to hose stream test, then tested for leakage.

- b) Impact Tests. Steel plate, one square foot, is attached 18" (457 mm) above ground level to truck. Truck is driven at 16 kph (10 mph) into point of tank that, according to its construction and design, is most vulnerable to impact, exerting a force of 12000 lbs (5455 kg). Following impact, tank must again pass leakage test. Test simulates an accident that might occur during filling of tank.
  - c) Projectile Tests. Tank is again attacked at its most vulnerable point, according to design and manufacture. Five closely grouped shots are fired at that area from a .30-06 rifle firing M-2 ball ammunition at a range of 100' (30.5 m). Following projectile test, tank is again subjected to leakage test.
- i. UL 142 prototype test requirements:
    - 1) Submit certified prototype test report that includes the following tests:
      - a) Fire Tests. In full-scale fire test, tank is placed in furnace where temperature is quickly raised to 2000°F to simulate fire of pooled fuel beneath tank. During test, maximum temperature inside tank must not exceed 260°F above ambient temperature (for example, if ambient temperature is 60°F, tank's internal temperature must not exceed 320°F). At no time may tank's internal temperature exceed 400°F. Immediately following fire test, tank is subjected to hose stream test, then tested for leakage.
    - 2. System shall comply with local codes and permitting requirements.

## **2.4 SEISMIC CAPABILITY**

- A. Engine-generator set and components shall meet requirements of Seismic Zone of project's location without additional external bracing to building structure. Frequency modifying devices are not allowed.

## **2.5 INTERFACE WITH UNIVERSITY POLICE DEPARTMENT (UPD) VIA FIRE ALARM SYSTEM**

- A. Interface shall be as follows:
  - 1. Control panel shall incorporate communication module with digital communication port connection to UPD via Fire Alarm system.
  - 2. Communications shall be for the following:

TYP E	CONDITION/DESCRIPTION	RANGE/UNITS
LDI 1	Low lube oil pressure prealarm	
LDI 2	Low water temperature	
LDI 3	High engine temperature prealarm	
LDI 4	Battery charger AC failure	
LDI 5	Spare	
LDI 6	Control switch not in automatic position	
LDI 7	High battery voltage	
LDI 8	Low coolant level	
LDI 9	Low cranking voltage	
LDI 10	Low voltage in battery	
LDI 11	EPS supplying loads	
LDI 12	Generator circuit breaker ground fault	
LDI 13	Low lube oil pressure	
LDI 14	High engine temperature	
LDI 15	Overcrank	
LDI 16	Overspeed	
LDI 17	Remote emergency manual stop switch	
LDI 18	Overcurrent (circuit breaker trip and lockout)	
LDI 19	Reverse power relay trip	
LDI 21	Engine running	
LDI 22	Generator running	
LDI 23	Generator circuit breaker open	
LDI 24	Generator circuit breaker closed	
LDI 25	Generator circuit breaker failed to close	
LDI 26	Spare	
LDI 27	Control voltage failure	
LDI 28	Auto start	
LDI 29	Battery charger failure	
LDI 30	Spare	
LDI 31	Spare	
LDI 32	Spare	

TYP E	CONDITION/DESCRIPTION	RANGE/UNITS
LDI 33	Sub-base fuel storage leak	
LDI 34	Spare	
LDI 35	Spare	
LDI 36	Spare	
LDI 37	Spare	
LDI 38	Spare	
LDI 39	Spare	
LDI 40	Spare	
LDI 41	Spare	
LDI 42	Load shed activated Priority #2	
LDI 43	Load shed activated Priority #3	
LDI 44	Load shed activated Priority #4	
LDI 45	Load shed activated Priority #5	
LDI 46	Load shed activated Priority #6 (spare)	
LDI 47	Load shed activated Priority #7 (spare)	
LDI 48	Load shed activated Priority #8 (spare)	
LDI 49	Load demand activated Priority #2	
LDI 50	Load demand activated Priority #3	
LDI 51	Load demand activated Priority #4	
LDI 52	Load demand activated Priority #5	
LDI 53	Load demand activated Priority #6 (spare)	
LDI 54	Load demand activated Priority #7 (spare)	
LDI 55	Load demand activated Priority #8 (spare)	
LDI 56	Air damper closed	
LDI 57	System test mode (lamp test)	
LDI 58	Spare	
LDI 59	Spare	
LDI 60	Spare	
LDI 61	Spare	
LAI 1	Generator phase A-B voltage	Volts
LAI 2	Generator phase B-C voltage	Volts
LAI 3	Generator phase C-A voltage	Volts
LAI 4	Generator phase A current	Amperes
LAI 5	Generator phase B current	Amperes
LAI 6	Generator phase C current	Amperes
LAI 7	Total real power	KW
LAI 8	Total apparent power	KVA
LAI 9	Total reactive power	KVAR
LAI 10	Generator power factor	
LAI 11	Generator phase A frequency	Hertz
LAI 12	Generator phase B frequency	Hertz
LAI 13	Generator phase C frequency	Hertz

LAI 14	Battery voltage	Volts
LAI 15	Engine oil pressure	KPA
LAI 16	Engine speed	RPM
LAI 17	Engine water temperature	Degrees Centigrade
LAI 18	Engine running time	Hours
LAI 19	Spare	
LAI 20	Spare	
LAI 21	Spare	
LDO 1	Remote fault reset	
LDO 2	Remote start initiative	

TYP E	CONDITION/DESCRIPTION	RANGE/UNITS
LDO 3	Cool down override control	
LDO 4	Phase select	
LDO 5	Load adding and load shedding	

Notes:

LAN – Local Area Network

3. Provide all additional information as required for a complete and operable system.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

- A. Install engine-generator set and associated equipment as indicated. Coordinate final location of equipment with General Contractor. Final location of equipment to be reviewed with Owner’s Representative prior to installation.
- B. Install equipment in accordance with manufacturer's recommendations. Provide equipment protection during and subsequent to installation.

### **3.2 ACCEPTANCE TESTS**

- A. Testing by Testing Agency
- B. Perform Acceptance Testing in accordance with Section 26 0812 - Power Distribution Acceptance Tests and Section 26 0813 – Power Distribution Acceptance Test Tables.

### **3.3 LOAD TEST**

- A. Conduct load testing of engine-generator set, under direct supervision of factory-authorized representatives of manufacturers of engine-generator set and auto-transfer switch.
- B. Tests to include minimum of 10 starts of engine-generator set, minimum of 10 operations of auto- transfer switch, 8 h maintained operation under conditions of randomly applied loads at 10 to 100% of rated capacity.
  1. Loading shall be by use of load banks.
- C. Provide certified results of testing, including frequency and voltage regulation at 25, 50,

75, and 100% of rated load, fuel consumption and exhaust emissions at the above load ratings, actual measured values for pickup and drop out relays for ATS, measured values for time delay relays.

- D. Engine-generator set test results are to be certified to comply with specification parameters or necessary corrective actions implemented and tests repeated until compliance is certified.
- E. At conclusion of testing, service engine-generator set including replacing air, oil and fuel filters, changing lubrication oil, checking and refilling batteries, adjusting fan belts for proper tightness, and refilling of cooling system as required.
- F. Provide fuel for load testing of engine-generator set.

**END OF SECTION 26 32 13**



## **SECTION 26 33 53 - STATIC UNINTERRUPTIBLE POWER SUPPLY WITH BATTERY ENERGY**

### **STORAGE PART 1 – GENERAL**

#### **1.1 RELATED WORK**

- A. Section 26 00 00 - General Electrical Requirements
- B. Section 26 05 48 - Vibration and Seismic Controls for Electrical Systems

#### **1.2 REFERENCE**

- A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

#### **1.3 DESCRIPTION OF SYSTEM**

- A. Provide an on-line, double conversion, solid-state uninterruptible power system (UPS) to furnish continuous, regulated alternating current (AC) power with battery backup. The UPS shall consist of a rectifier, charger, batteries, inverter, static bypass transfer switch, synchronizing equipment, maintenance bypass switch protective devices, and accessories. Refer to the one-line diagram for specific configuration of devices.

#### **1.4 REFERENCE STANDARDS**

- A. ANSI C62.41 – IEEE Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits
- B. NEMA PE 1 - Uninterruptible Power System Specification and Performance Verification.
- C. NECA 411 – Standard for Installing and Maintaining Uninterruptible Power Supplies.
- D. UL 1778 - Uninterruptible Power Supply Equipment.

#### **1.5 SUBMITTALS**

- A. Provide cover letter with compliance table listing each specification section and indicating compliance "C", deviation for alternate "D", or exception with explanation "E". Any deviation or exception shall be accompanied with detailed explanation of how design intent is being upheld.
- B. For each UPS being furnished, submit the following information:
  - 1. Product Data:
    - a. Manufacturer's technical datasheet(s) indicating system performance characteristics, including guaranteed efficiency at 25%, 50%, 75%, and 100% load.
  - 2. Shop Drawings:
    - a. General Arrangement:
      - 1) Front, plan, and side views; access requirements (front, side, rear);

- overall dimensions and components list; shipping splits and weights.
- a. ring Diagrams:
  - 1) Showing input, output, and bypass power flow within the UPS.
  - 2) Identifying terminal numbers / labels for all external connections.
- b. Data:
  - 1) power requirements
  - 2) heat dissipation
- 3. Closeout Submittals:
  - a. Operations and Maintenance (O&M) Manual:
    - 1) Installation instructions
    - 2) Operating instructions
    - 3) Maintenance instructions including recommended maintenance intervals
  - b. As-built shop drawings

## 1.6 QUALITY ASSURANCE

- A. Regulatory Requirements:
  - 1. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.
- B. Certifications:
  - 1. Furnish Engineer with Manufacturer Seismic Qualification Certification: Submit certification that switchgear, accessories, and components will remain intact to withstand seismic forces defined in Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems. Include the following:
    - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - 2. Furnish Engineer with Installation Seismic Qualification Certification: Submit certification that switchgear, accessories, and components will remain in place without separation of any parts when subjected to the seismic forces defined in Section 26 0548 – Vibration and Seismic Controls for Electrical Systems. Include the following:
    - a. Detailed description of equipment supports and seismic restraints on which the certification is based and their installation requirements.
    - b. Certification shall bear the seal and signature of an Engineer registered and licensed in the State of California.

## 1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect units from dirt, fumes, water, corrosive substances, construction debris, and traffic. Provide temporary heaters as required to prevent condensation.

## 1.8 WARRANTY

- A. Refer to Division 01 and Section 26 00 00 – General Electrical Requirements for general warranty requirements.

- B. Manufacturer shall provide standard 1-year warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.
- C. Extended factory warranty shall include replacement coverage for UPS parts for a period of 12 months from Owner system acceptance after commissioning.
- D. Service protection package shall include on-site repair/replacement labor for UPS parts and batteries and technical support coverage. Standard response time shall be 4 hours from receipt of call.

## **PART 2 - PRODUCTS**

### **2.1 ACCEPTABLE MANUFACTURERS**

- A. UPS
  - 1. System:
    - ABB
  - 2. Eaton
  - 3. General
  - 4. Electric Liebert
  - 5. Mitsubishi
  - 6. Schneider/APC
  - 7. Toshiba
  - 8. Or equal
- B. VRLA Batteries:
  - 1. C&D
  - 2. EnerSys
  - 3. Exide
  - 4. As recommended by UPS system vendor

### **2.2 SYSTEM OPERATION**

- A. Normal Mode:
  - 1. UPS shall supply continuous power to load via double-conversion process.  
Rectifier/charger shall convert input AC to DC. Inverter output shall convert DC to AC.
  - 2. Inverter output shall be synchronized with AC power source provided that AC power source is within specified frequency range.
  - 3. Rectifier/charger shall convert AC input power to DC power for continuous float charging the battery.
- B. Loss of Normal AC Input Power:
  - 1. Battery plant, via DC-DC converter, shall supply DC power to inverter (without any switching) so that there is no interruption of AC power to critical load whenever AC input power source of UPS module deviates from specified tolerances or fails completely.
  - 2. Battery shall continue to supply power to inverter for specified protection time.

- C. Return of AC Power Source:
  - 1. Rectifier/charger shall assume DC load from battery when AC power source returns.
  - 2. Rectifier/charger shall supply inverter with DC power and recharge battery.
- D. Internal Static Bypass Mode:
  - 1. If UPS is taken out of service for maintenance or repair, or should inverter capacity be exceeded, static bypass transfer switch shall perform transfer of load from inverter to AC power source via internal bypass pathway.
  - 2. Transfer back to Normal Mode shall be accomplished with no interruption in power to critical loads.
- E. Retransfer to Inverter:
  - 1. Static transfer switch shall automatically retransfer load back to inverter after inverter has returned to normal voltage and synchronizes with alternate bypass source.
- F. Energy Saving Mode:
  - 1. When manually selected at UPS control panel, UPS will enter energy saving mode, which provides full load efficiency of greater than 98% with rapid transfer to battery backup. In this mode, UPS operates on internal static bypass pathway. Rectifier and inverter shall remain on and idling.
- G. Recharge Mode:
  - 1. Upon restoration of utility AC source, rectifier shall derive power from utility AC source and supply DC power to inverter and DC-DC converter, which simultaneously float charges battery. This shall be an automatic function and shall cause no interruption to critical AC load.
- H. Battery Unavailable Mode:
  - 1. If battery is unavailable, UPS shall continue to function and meet specified steady-state performance criteria for power outage backup time capability.

### **2.3 EQUIPMENT AND RATINGS**

- A. Design, manufacture, and test UPS in accordance with applicable portions of the following standards:
  - 1. UL 1778 - Uninterruptible Power Supply Equipment
  - 2. NEMA PE 1 - Uninterruptible Power System Specification and Performance Verification
- B. Electrical Input (Normal):
  - 1. Nominal Voltage: As indicated on the Drawings
  - 2. Voltage Range: +10%, -15% of Nominal
  - 3. Frequency Range: +60 Hz,  $\pm 5$  Hz
  - 4. Input Power Factor: Minimum 0.99 lagging at full load
  - 5. Current Limit: 170% of nominal input full load current if load is connected to UPS module, or to bypass line by static transfer switch, or if load is disconnected. If load is connected to maintenance bypass line, input current limit to UPS module is to automatically reduce to 25% of normal full load input current.
  - 6. Current Distortion: Maximum 5% reflected input total current harmonic distortion at nominal input voltage and 100% load.

7. Input Surge Withstand Rating: Complying with ANSI C62.41, Category A and B.
- C. Electrical Input (Bypass):
  1. Nominal Voltage: As indicated on the Drawings
  2. Sync Voltage Range: +10%, -10% of Nominal
  3. Voltage Range: +15%, -20% of Nominal
  4. Sync Frequency Range: +60 Hz,  $\pm 5$  Hz
  5. Frequency Range: +20%, -20% of Nominal
- D. Electrical Output
  1. Nominal Voltage: As indicated on the Drawings
  2. Voltage Regulation:  $\pm 1\%$  for balanced load  
 $\pm 2\%$  for unbalanced load
  3. Sync Voltage Regulation:  $\pm 10\%$  of nominal
  4. Frequency Regulation: 60 Hz  $\pm 0.25\%$
  5. Voltage Transient Response: 100% Load Step:  
 $\pm 2\%$   
10-100% or 100-10% Load Step:  $\pm 5\%$   
Loss or return of AC input power:  $\pm 1\%$   
Retransfer from bypass to inverter:  $\pm 3\%$
  6. Overload Capability: 150% for 1 minute  
125% for 10 minutes  
110% for 60 minutes
  7. Voltage Transient Recovery To within 1% of output voltage rating  
within 20 milliseconds.
  8. Distortion: 5% THDv maximum at 100% non-linear load  
Maximum 2% THDv for linear load  
Maximum 5% THDv for 100% non-linear load
- E. Environmental Conditions:
  1. Operating ambient temperature:
    - a. UPS Module 32° to 104°F
    - b. Battery 77°  $\pm 9$ °F
  2. Non-operating and storage ambient temperature -4° to 158°F.
  3. Relative humidity 0% to 95% for temperatures in operating range without condensation.
- F. Audible Noise:
  1. Noise generated by UPS under any condition of normal operation shall not exceed 69 dB measured at 5 ft from nearest surface of cabinet.
- G. Efficiency:
  1. Efficiency measured under following conditions:
    - a. Battery fully charged and floating on system
    - b. Input voltage within specified range.
    - c. In fully-online double-conversion mode, minimum efficiency shall meet requirements in the table below:

<b>UPS RATING G (KVA)</b>	<b>25% LOAD</b>	<b>50% LOAD</b>	<b>75% LOAD</b>	<b>100% LOAD</b>
<b>10</b>	<b>86.5</b>	<b>91.7</b>	<b>93.0</b>	<b>93.9</b>
<b>20</b>	<b>92.9</b>	<b>94.5</b>	<b>94.6</b>	<b>94.3</b>
<b>30</b>	<b>91.0</b>	<b>92.6</b>	<b>92.8</b>	<b>92.3</b>
<b>40</b>	<b>93.5</b>	<b>95.4</b>	<b>95.2</b>	<b>94.5</b>
<b>50</b>	<b>93.1</b>	<b>95.3</b>	<b>95.6</b>	<b>95.6</b>

<b>UPS RATING G (KVA)</b>	<b>25% LOAD</b>	<b>50% LOAD</b>	<b>75% LOAD</b>	<b>100% LOAD</b>
<b>80</b>	<b>93.9</b>	<b>95.1</b>	<b>95.0</b>	<b>94.7</b>
<b>100</b>	<b>95.2</b>	<b>96.3</b>	<b>96.3</b>	<b>96.1</b>
<b>150</b>	<b>96.4</b>	<b>96.9</b>	<b>96.8</b>	<b>96.6</b>
<b>225</b>	<b>95.6</b>	<b>96.3</b>	<b>96.3</b>	<b>96.2</b>
<b>250</b>	<b>95.9</b>	<b>96.6</b>	<b>96.4</b>	<b>96.1</b>
<b>500</b>	<b>93.5</b>	<b>95.0</b>	<b>95.3</b>	<b>95.2</b>
<b>750</b>	<b>95.5</b>	<b>96.5</b>	<b>96.8</b>	<b>96.6</b>
<b>1000</b>	<b>95.5</b>	<b>96.5</b>	<b>96.8</b>	<b>96.5</b>
<b>1200</b>	<b>95.5</b>	<b>96.5</b>	<b>96.8</b>	<b>96.5</b>

## **2.4 COMPONENTS**

### **A. UPS Module**

#### **1. Rectifier/Charger:**

er:

#### **a. Rectifier/charger shall include:**

- 1) Circuit to limit AC input current to an adjustable level from 100% of nominal up to rated maximum input current rating.
- 2) Circuit to limit battery charging current to an adjustable level of 2% to 25% of maximum battery discharge current.
  - a) A second circuit shall provide greater limiting when signaled by an external contact (i.e., operation of generator).
  - b) Battery charge current limit to be factory set at 10% for normal

- operation and 2% for generator operation.
- 3) Input circuit breaker or fused input contactor
- 4) Output filter minimize ripple current to battery. Ripple current to battery shall not exceed 2% RMS. Filter shall insure that DC output of rectifier/charger will meet input requirements of inverter.
- 2. Inverter:
  - a. Solid-state, capable of accepting rectifier/charger or battery output and providing rated output power.
  - b. Insulated gate bipolar transistor (IGBT) phase-controlled, pulse width modulated (PWM) design.
  - c. Able to sustain an overload of up to 150% with + 2% output voltage regulation.
  - d. Capable of 300% current for short circuit conditions. If short circuit is sustained, inverter shall transfer load to bypass.
  - e. With input current walk-in feature to gradually transfer load from battery to AC input source upon restoration of AC input power, over a minimum period of 5 seconds.
- 3. DC-DC Converter:
  - a. Includes controls to regulate output of rectifier to levels appropriate for charging battery and to boost battery voltage to level required to operate inverter.
- 4. Momentary Overloads:
  - a. In event of load current inrush or branch load circuit fault, static transfer switch to pulse on for at least 40 milliseconds allowing up to 1000% load current to flow from bypass line to clear overload.
- 5. Automatic Closing:
  - a. When load is transferred to bypass line by static transfer switch, bypass switch to automatically close removing static transfer switch from power flow.
- 6. Manual Transfers:
  - a. Manual load transfer between UPS system and bypass line can be initiated from control panel.
- B. Static Bypass Section
  - 1. System bypass section:
    - a. Shall contain devices to electromechanically transfer load from the UPS system to bypass source and vice versa.
    - b. Devices shall provide isolation of UPS system from critical load when utilizing bypass as source
    - c. Shall provide system overload protection for UPS
  - 2. system. Input contactor
  - 3. Static transfer switch:
    - a. Solid-state device that automatically transfers load to bypass without interruption if UPS cannot supply continuous power.
  - 4. Bypass switch:
    - a. Motor operated circuit breaker that connects load to bypass.

- b. Automatic load transfers to be initiated when a sustained system overload occurs or when an essential (non-redundant) UPS module is taken off line.
  5. System bypass shall be an in-phase non-interruptive bypass.
  6. Operation of bypass switch shall cause transfer of load to AC input power without deviation of output bus beyond acceptable limits. Simultaneously, bypass switch shall isolate load bus from UPS output bus.
  7. System bypass shall have appropriate phase, voltage and frequency monitors to prevent synchronous transfer or transfer to bypass source with unacceptable voltage, frequency or phase rotation.
- C. Controls
  1. Monitoring functions to be displayed in numbers and words on digital display. Operator controls and monitors to be located on front of UPS module cabinet.
    - a. Controls:
      - 1) UPS On
      - 2) Bypass On
      - 3) Energy-Saving Mode On
      - 4) Emergency Power Off
      - 5) Alarm Silence
    - b. Meters:
      - 1) AC Input Voltage, 3 phase, L-L, and L-N for each phase
      - 2) Bypass Input Voltage, 3 phase, L-L and L-N for each phase
      - 3) AC Input Current, each phase
      - 4) AC Output Voltage, 3 phase, L-L and L-N for each phase
      - 5) AC Output Current, each phase
      - 6) AC Output Frequency
      - 7) Battery Voltage
      - 8) Battery Charge/Discharge Current
      - 9) Percent of Rated Load Being Supplied by UPS
      - 10) Battery Time Left During Battery Operation
    - c. Alarms to be displayed:
      - 1) UPS on-line
      - 2) Input power failed
      - 3) Alternate source power failed
      - 4) Battery discharging
      - 5) Low battery
      - 6) Overload
      - 7) Overload shutdown
      - 8) Load on bypass
      - 9) Equipment over temperature
      - 10) Over temperature shutdown
      - 11) Fan failure
      - 12) DC overvoltage
      - 13) Control power failed
      - 14) Output overvoltage
      - 15) Output undervoltage



- 16) Fuse open
  - 17) Rectifier/charger failure
  - 18) Static transfer switch failure
  - 19) Emergency power off
  - 20) On maintenance bypass
  - 21) On static bypass line
  - 22) Sync with line
  - 23) Not sync with line
  - 24) Out of frequency range
  - 25) Rectifier/charger in current limit
  - 26) Battery circuit breaker open
- d. Pushbuttons to test and reset visual and audio
3. alarms. Remote Monitoring Capabilities:
    - a. Network Communications Port: Modbus RTU Serial, Modbus TCP, & SNMP v3

## 2.5 BATTERY SYSTEM

- A. Battery System:
    1. Battery Units:
      - a. Type: Valve-regulated lead acid (VRLA)
      - b. Design Life: 10 years, as guaranteed by the battery manufacturer
      - c. Quantity:
        - 1) As required to deliver voltage specified for UPS system.
        - 2) Strings: Dual strings in separate enclosures, allowing one string to be isolated for maintenance while the other remains in operation.
      - d. Capacity Rating:
        - 1) As required to deliver runtime specified for UPS system, 15min at full load at end of expected battery life.
      - e. Insulation:
        - 1) Insulated to withstand  $\pm 1000$  V DC high potential test applied to either positive or negative terminals, while connected to UPS system in operable condition with DC disconnect open.
      - f. Self-sealing flame-arresting caps
      - g. Interconnecting Components:
        - 1) Provided with intercell and inter-tier connectors.
      - h. At end of discharge, cell voltage shall not be less than 1.67 EVPC and 1.250 specific gravity.
    2. Battery Enclosures/Racks:
      - a. Type: Vented NEMA Type
- 1 Enclosure Overcurrent Protection:
- a. Circuit breaker between each battery string and UPS.
    - 1) Located in battery enclosure
    - 2) With (2) Form C auxiliary contacts indicating breaker position.
    - 3) Shunt trip to disconnect battery from UPS module when battery reaches minimum discharge voltage level or when signaled by other control functions.

4. Thermal runaway protection:
  - a. Provide International Fire Code compliant thermal runaway protection to trip battery breaker when thermal runaway condition is detected.

### **PART 3 - EXECUTION**

#### **3.1 INSTALLATION**

- A. Install UPS in accordance with NECA 411 – Standard for Installing and Maintaining Uninterruptible Power Supplies.
- B. Perform manufacturer’s recommended start-up procedure using the services of a factory- trained representative of UPS manufacturer.

#### **3.2 OWNER TRAINING**

- A. Provide training in start-up, operation, and maintenance of equipment supplied using the services of a factory-certified representative of UPS manufacturer. Provide 2 training session(s) of 1 hour minimum on separate days.
- B. Submit training plan for Owner's approval. Training plan to include duration of training sessions, suggested class size/attendees, locations, lesson objectives, and outline of training topics.

#### **3.3 TESTING REQUIREMENTS**

- A. Factory Testing:
  1. UPS system shall be tested during manufacturing process to assure that equipment is fully functioning and its performance meets specifications. Upon request, manufacturer shall describe testing program and supply sample test procedures and test data sheets to document testing program.
- B. Site Testing:
  1. Provide acceptance testing and thermographic scanning with load banks per Section
  2. 26 08 12. UPS equipment shall be fully tested after installation. Testing shall be part of start-up service provided by manufacturer. Site testing shall include complete inspection of installation to assure it was performed in accordance with manufacturer's recommendations.
  3. Provide all additional testing per CxA functional testing scripts.

### **END OF SECTION 26 33 53**

## **SECTION 26 36 23 - AUTOMATIC TRANSFER**

### **SWITCHES PART 1 - GENERAL**

#### **1.1 RELATED WORK**

- A. Section 26 00 00 – General Electrical Requirements
- B. Section 26 05 29 – Hangers and Supports for Electrical Systems
- C. Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems
- D. Section 26 32 13 – Engine Generators

#### **1.2 REFERENCE**

- A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

#### **1.3 DESCRIPTION OF SYSTEM**

- A. Provide automatic transfer switch, 3 phase, 60 Hz, 4 pole, with solid-neutral for voltage and current as indicated on drawings.

#### **1.4 REFERENCE STANDARDS**

- A. ICS 10 Industrial Control and Systems Part 1: Electromechanical AC Transfer Switch Equipment
- B. UL1008 Automatic Transfer Switches

#### **1.5 SUBMITTALS**

- A. Submit shop Drawings for equipment provided under this Section.

#### **1.6 QUALITY ASSURANCE**

- A. Obtain automatic transfer switches from one source and by single manufacturer.
- B. Regulatory Requirements:
  - 1. Comply with NFPA 70 for components and installation.
  - 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.
- C. Certifications:
  - 1. Furnish Owner's Representative with Manufacturer Seismic Qualification Certification: Submit certification that switchgear, accessories, and components will remain internally intact to withstand seismic forces defined in Section 26 0548 – Vibration and Seismic Controls for Electrical Systems. Include the following:
    - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Furnish Owner's Representative with Installation Seismic Qualification Certification: Submit certification that switchgear(s), accessories, and components will remain in place without separation of any parts when subjected to the seismic forces defined in Section 26 0548 – Vibration and Seismic Controls for Electrical Systems and will be fully operational after the seismic event. Include the following:
  - a. Detailed description of equipment supports and seismic restraints on which the certification is based and their installation requirements.
  - b. Certification shall bear the seal and signature of an Engineer registered and licensed in the State of California.
- D. Factory Test
  1. Test system in accordance at the factory in accordance with Section 26 08 12 - Power Distribution Acceptance Tests and Demonstration of Transfer Functions.
  2. Provide factory test report.

### **1.7 DELIVERY, STORAGE, AND HANDLING**

- A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect units from dirt, fumes, water, corrosive substances, construction debris, and traffic. Provide temporary heaters in switchgear as required to prevent condensation.
- B. Deliver in (48") maximum width shipping splits, individually wrapped for protection, and mounted on shipping skids. Mark crates, boxes, and cartons clearly to identify equipment. Show crate, box, or carton identification number on shipping invoices.
- C. Use factory-installed lifting provisions. Handle carefully to avoid damage to internal components, enclosure, and finish.

### **1.8 WARRANTY**

- A. Refer to Division 01 and Section 26 00 00 – General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1-year warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

## **PART 2 - PRODUCTS**

### **2.1 MATERIALS**

- A. Acceptable Manufacturers: Asco, Cummins, Russelectric, Zenith or equal

### **2.2 AUTO-TRANSFER SWITCH**

- A. Auto-transfer switch:
  - 1. Mechanically held, electrically operated type.
  - 2. Interlocked to ensure only 2 possible positions, normal and emergency.
  - 3. Rated for continuous duty in unventilated sheet metal enclosure.
  - 4. Suitable for all classes of loads at maximum rated voltages.
  - 5. Withstand rating that meets or exceeds withstand rating of transfer switch feeder breakers.
  - 6. Shall be open transition type.
- B. Provide main contacts with silver alloy wiping action type protected by arcing contacts.
- C. Provide switch components accessible from front of enclosure.
- D. Provide 3 cycle short circuit rating to guarantee contact opening and no damage when transfer switch is served by molded case circuit breakers.
- E. Provide 10 cycle short circuit rating to guarantee contact opening and no damage when transfer switch is served by power circuit breakers.
- F. Provide switch with the following items:
  - 1. Adjustable 1 to 3 second time delay to override momentary voltage dips and outages.
  - 2. Time delay on transfer to emergency. Adjustable from 1 to 300 seconds (factory set at 3 seconds).
  - 3. Time delay on retransfer to normal. Adjustable from 2 seconds to 30 minutes.
  - 4. Full phase protection consisting of 2 phase relays and one close differential relay. Phase relays shall be set to 70% drop out, 90% pick up, and differential relays set for 92 to 95% pick-up and 83 to 85% drop-out.
  - 5. Pushbutton reset to normal.
  - 6. Pushbutton to bypass time delay on retransfer to normal.
  - 7. Pilot light to indicate normal position.
  - 8. Pilot light to indicate emergency position.
  - 9. Auxiliary contact to close when normal power fails.
  - 10. Auxiliary contact to open when normal power fails.
  - 11. Auxiliary contact on same shaft as main contacts (closed on normal).
  - 12. Auxiliary contact on same shaft as main contacts (closed on emergency).
  - 13. Four position selector switch to provide "Test," "Auto," "OFF", and "Engine Start."
  - 14. Contacts to start engine-generator when normal power fails.
  - 15. Time delay engine start, adjustable from 0 to 5 seconds.
  - 16. Adjustable time delay on retransfer to normal source with 5 minute unloaded running time of standby plant:
    - a. Minimum delay 2 minutes
    - b. Maximum delay 25 minutes
    - c. Built in circuitry to nullify time delay if emergency source fails and power is available at normal source.
  - 17. Relay to prevent transfer to emergency until voltage and frequency of generating plant have reached 90% of rated value.
  - 18. Provide bi-direction in-phase monitor or dual motor operator with programmed neutral to allow voltage decay in motor and transformer circuits.
- G. Bypass/isolation switch:
  - 1. Dual-source enclosed.
  - 2. Isolate transfer switch and de-energize for maintenance, testing or repair.
  - 3. Dual-source operation - bypass either to normal or emergency source directly

- to load at discretion of operator.
- 4. Break-before-make operation of contacts.
- 5. Operation - fully mechanical, designed to provide quick-make-quick-break of contacts and only allow switch to be fully closed or fully open with no mid position possible.
- 6. Operation - possible regardless of the position or condition of the automatic transfer switch.

### **2.3 ELEVATOR CONTROL INTERFACE**

- A. Provide auxiliary contacts to provide emergency system status to elevator controller.
- B. Contacts required are:
  - 1. Emergency power signal
  - 2. Pre-transfer warning signal
- C. Pre-transfer warning signal relay to change state prior to operation of transfer switch in either direction.
- D. These contacts are in addition to other required contacts.

### **2.4 ATS REMOTE CONTROL PANEL**

- A. Provide remote annunciator and control panel to indicate each switch position.
- B. Panel shall allow switch position to be changed remotely from panel location.
- C. Panel shall be located on drawings.
- D. Provide sign indicating "ATS [INSERT ATS NAME] SERVES ELEVATORS."

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

- A. Install equipment in accordance with manufacturer's recommendations.
- B. Provide equipment protection during and subsequent to installation.
- C. Provide wiring between transfer switch and elevator controller. Final connections at elevator controller by Elevator Contractor.
- D. Connect transfer switches that are part of fire pump controllers.

### **3.2 OPERATION**

- A. Parallel "start engine-generator" contacts of automatic transfer switches, such that failure of normal source at any switch shall start engine.
- B. Transfer of one switch from normal to emergency shall not preclude any other switch from transferring.
- C. Engine generator cool down cycle shall not start until all transfer switches have timed out back to normal source.

**3.3 ACCEPTANCE TESTING**

- A. Testing by Testing Agency
- B. Perform acceptance testing in accordance with Section 26 08 12 – Power Distribution Acceptance Tests.
- C. Adjust or replace equipment as needed to comply with manufacturer's specifications and resubmit corrected test reports.

**END OF SECTION 26 36 23**

## **SECTION 26 41 13 - LIGHTNING PROTECTION FOR STRUCTURES**

### **PART 1 – GENERAL**

#### **1.1 RELATED WORK**

- A. Section 26 05 26 – Grounding and Bonding for Electrical Systems
- B. Section 26 05 33 – Raceway and Boxes for Electrical Systems

#### **1.2 REFERENCE**

- A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

#### **1.3 DESCRIPTION**

- A. Section includes lightning protection systems consisting of air terminals, roof conductors, bonding conductors, down conductors, fastener connections, and grounding.

#### **1.4 REFERENCE STANDARDS**

- A. ANSI/NEMA GR1 - Grounding Rod Electrodes and Ground Rod Electrode Couplings
- B. NFPA 70 - National Electrical Code
- C. NFPA 780 - Standard for the Installation of Lightning Protection Systems
- D. UL 467 – Grounding and Bonding Equipment
- E. UL 96 - Lightning Protection Components
- F. UL 96A - Installation Requirements for Lightning Protection Systems

#### **1.5 SUBMITTALS**

- A. Product Data:
  - 1. Submit manufacturer’s descriptive and technical literature and catalog cuts.
- B. Shop Drawings:
  - 1. Submit installation shop drawings for the overall lightning protection system. Include physical layout of the equipment, mounting details, and relationship to other parts of the work.
  - 2. Submit detail drawings for each major component.
  - 3. Submit location, size, and material of grounding electrodes, and connection type.
  - 4. Submit roof adhesive data for air terminals mounted on single-ply roofing.
- C. Certification, signed by Contractor, that roof adhesive for air terminals is approved by manufacturers of both the terminal assembly and the single-ply roofing material.
- D. Copy of Owner’s UL Master Label Certificate.
- E. Manufacturer’s Installation Instructions:
  - 1. Indicate application conditions and limitations of use stipulated by product



testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation.

- F. Closeout Submittals:
  - 1. Project record documents:
    - a. Record active location of lightning protection system components.
  - 2. Operation and maintenance data:
    - a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventative maintenance instructions.

## **1.6 QUALITY ASSURANCE**

- A. Qualifications:
  - 1. Lightning protection system materials:
    - a. Consists of standard products by a manufacturer regularly engaged in production of lightning protection systems.
    - b. UL Listed
  - 2. Lightning protection system installer: UL Listed.
- B. Regulatory Requirements:
  - 1. Lightning protection system: Comply with NFPA 780, UL 96, and UL 96A.
- C. Certifications:
  - 1. Furnish Owner's Representative with UL Master Label Certificate upon completion of installation providing proof that the lightning protection system is in compliance with UL 96 and UL 96A standards.

## **1.7 SEQUENCING**

- A. Coordinate installation of lightning protection with installation of other building systems and components, including supporting structures and building materials, metal bodies requiring bonding to lightning protection components, exterior and interior building finishes, and building roofing.

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS**

- A. Thompson Lightning Protection Company
- B. Harger Lightning Protection, Inc.
- C. Heary Brothers Lightning Protection Company, Inc.
- D. National Lightning Protection Corporation
- E. Erico International Corporation
- F. Or Equal

### **2.2 LIGHTNING PROTECTION SYSTEM COMPONENTS**

- A. NFPA 780, UL 96.

- B. Materials: Air terminals, main and cross-run roof conductors, bonding and down conductors, conductor fasteners, air terminal supports, chimney bands, clips, and connections: Class I:
  - 1. Air terminals: Solid-type with a safety tip, 10" in height minimum, above the object to be protected when spaced at intervals not exceeding 20 ft, with mounting base.
- C. ANSI/NEMA GR1 Grounding Electrodes: 3/4" x 10 ft long copper-clad steel ground rod.
- D. Concrete-Encased Electrodes: As shown on drawings.
- E. Solid Copper Ground Plate (if called for on drawings): Where shallow or rocky top soil conditions preclude the use of driven ground rods. This ground plate is 18" x 18" x 20 gauge thick (0.032" minimum) and comes complete with two premium die cast bolt pressure type cable connections for cables through #3/0.
- F. Ground Ring Electrode: As shown on drawings.
- G. Ground Connectors: Conform to UL 96
  - 1. Bronze of the clamp type and bronze clamp accessories.
  - 2. Provide in accordance with the requirements in Section 26 05 26 – Grounding and Bonding for Electrical Systems.
- H. Galvanic Compatibility of Materials:
  - 1. Air terminals, conductors, fasteners, and connectors shall be galvanically compatible with surfaces they are mounted to.
  - 2. Copper materials in all locations except where the use of aluminum materials is necessary for galvanic compatibility.
  - 3. Aluminum materials on copper roofs are not acceptable.
  - 4. Aluminum materials where mounted on aluminum roofing, siding, or other aluminum surfaces.
- I. Bimetallic fittings when joining metals that are not galvanically compatible.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

- A. Install lightning protection to comply with UL 96A, NFPA 70, and NFPA 780. Conform to the most stringent requirement in NFPA 780.
- B. Bond exterior metals including flashing, roof drains, vent stacks, fans, water pipes, metal raceways, enclosures, frames, and other non-current carrying metal parts of electrical and mechanical equipment on roof to lightning protection system.
- C. Bond lower end of exhaust ducts, vent stacks, etc., passing through roof.
- D. Run bonding jumpers continuously horizontally or down from point of bond to point of connection to main conductor.
- E. Make down conductors electrically continuous, with direct paths from air terminals to ground connections. Avoid sharp bends and narrow loops. Protect down conductors, where necessary, to prevent physical damage or displacement to the conductor. Use PVC Schedule 40 conduits. Provide conduits in accordance with requirements in Section

26 0533 – Raceway and Boxes for Electrical Systems.

1. Provide down conductors for every 100 feet of building perimeter.
  2. For structural steel construction, utilize steel columns (bond top and bottom) in lieu of down lead conductors – every other column and not to exceed an average of 60 foot spacing.
- F. Conceal system conductors and interior conductors.
- G. Conceal conductors from normal view from exterior locations at grade within 200 ft of building.
- H. Notify Owner’s Representative at least 48 H before concealing lightning protection system components.
- I. Below-grade or concealed cable connections: Use approved exothermic-welded connections for all conductor splices and connections between conductors and other components.
- J. Exposed cable connections: Use approved mechanical connections.
- K. Air terminals mounted on single-ply roofing: Use adhesive recommended by manufacturer of air terminals and approved by manufacturer of roofing material. Comply with adhesive manufacturer’s installation instructions. For roofing work, refer to Division 07 - Thermal and Moisture Protection.
- L. Attach each down conductor to the grounding electrode by exothermic welding.
- M. Provide grounding electrodes with top 2 ft below finished grade.
- N. Ramps and covered passageways shall be protected by the lightning protection system.
- O. For construction utilizing post tensioning systems to secure precast concrete sections, do not use the post tension rods as down conductors. Bond tension rods to the lightning protection and grounding system – follow recommendations of the post tension rod manufacturer.

**3.2 CORROSION PROTECTION**

- A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the present of moisture, unless moisture is permanently excluded from the junction of such materials.
- B. Use conductors with suitable protective coatings where conditions would cause deterioration or corrosion of conductors.

**3.3 FIELD QUALITY CONTROL**

- A. Apply for inspection by Underwriters Laboratories, Inc. (UL) to obtain UL Master Label Certificate.
- B. Verify that lightning protection surge arrestor devices are installed on all incoming power and communications lines, in order to obtain UL Master label Certificate.
- C. Test grounding system to ensure continuity prior to backfilling and paving: Check that resistance to earth does not exceed 25 ohms, measured by “Fall-of-Potential” method.
- D. Make resistance measurements in dry weather not earlier than 48 H after rainfall.

- E. Make visual inspection to verify that there are no loose connections that may result in high resistance joints, and conductors and system components are securely fastened to their mounting surfaces and are protected against accidental mechanical displacement.
- F. Photograph all concealed components of the system such as grounding electrode connections, down conductors and connections to reinforcing steel. Identify locations where each photograph was taken.

**END OF SECTION 26 41 13**

## **SECTION 26 43 00 - SURGE PROTECTIVE DEVICES**

### **(SPD) PART 1 - GENERAL**

#### **1.1 RELATED WORK**

- A. Section 26 00 00 - General Electrical Requirements
- B. Section 26 05 26 - Grounding and Bonding for Electrical Systems
- C. Section 26 23 00 - Low-Voltage Switchgear
- D. Section 26 24 13 - Switchboards
- E. Section 26 24 16.13 - Lighting and Appliance Panelboards
- F. Section 26 24 16.16 - Distribution Panelboards
- G. Section 26 27 26 - Wiring Devices

#### **1.2 REFERENCE**

- A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

#### **1.3 DESCRIPTION**

- A. Provide Type 1 Surge Protective Devices (SPD) for the protection of AC electrical circuits formerly known as Transient Voltage Surge Suppression (TVSS) System. Provide high energy surge current diversion and be suitable for application in Type 1 environments.
- B. Modes of Protection:
  - 1. Line to Ground, Line to Neutral and Neutral to Ground for services with a neutral.
  - 2. For Services without a neutral, Line to Line and Line to Ground.
- C. Provide common and normal modes of protection.

#### **1.4 REFERENCE STANDARDS**

- A. ANSI/UL 1449 Surge Protective Devices Third Edition or Newer
- B. IEEE 587
- C. FIPS PUB 94
- D. IEEE C62.11 – Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (> 1 kV)
- E. IEEE C62.41.1 Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
- F. IEEE C62.41.2 Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits
- G. IEEE C62.45 IEEE Recommended Practice on Surge Testing for Equipment Connected to Low- Voltage (1000 V and less) AC Power Circuits

- H. IEEE C62.62 IEEE Standard Test Specifications for Surge Protective Devices (SPDs) for Use on the Load Side of the Service Equipment in Low Voltage (1000V and less) AC Power Circuits
- I. National Electrical Code – Article 285
- J. NEMA LA 1 – Surge Arresters
- K. National Fire Protection Association – NFPA 20, 70, 75, and 780
- L. UL 96A Installation Requirements for Lightning Protection Systems

### **1.5 SUBMITTALS**

- A. Submit Shop Drawings for equipment provided under this Section.
- B. Submit shop drawings and product information for approval and final documentation in quantities listed according to Conditions of the Contract. Identify customer name, customer location, and customer order number.
- C. Submit ANSI/UL 1449 Listing documentation to indicate the following:
  - 1. Short Circuit Current Rating (SCCR)
  - 2. Voltage Protection Ratings (VPRs) for all modes
  - 3. Maximum Continuous Operating Voltage rating (MCOV)
  - 4. Nominal Discharge Current rating (I-n)
  - 5. Type 1 device
  - 6. VPR, MCOV, I-n, and Type 1 information is posted at [www.UL.com](http://www.UL.com) under Certifications; search using UL Category Code: VZCA. SCCR's are posted in manufacturer's published documentation.
  - 7. UL data and visual inspection takes precedence over manufacturer's published documentation.
- D. Provide shop drawings including manufacturer installation instruction manual and line drawings detailing dimensions and weight of enclosure, internal wiring diagram illustrating all modes of protection in each type of SPD required, wiring diagram showing field connections, and manufacturer's recommended wire and breaker sizes (if required).
- E. Upon request, modules using encapsulation shall be presented without encapsulation for visual inspection, proprietary technology included. MOV type and quantity shall reflect kA ratings on cutsheets, verification of diagnostic monitoring, thermal and overcurrent protection, etc.

## **PART 2 - PRODUCTS**

### **2.1 MATERIAL**

- A. Acceptable manufacturers:
  - 1. Advanced Protection Technologies, Inc. (APT)
  - 2. Thomas & Betts; Current Technology
  - 3. LEA International
  - 4. Emerson; Liebert Corporation
  - 5. Mersen
  - 6. Erico

7. Or equal

## 2.2 PERFORMANCE CHARACTERISTICS

- A. SPD shall bear the UL Mark and shall be Listed to Third Edition of ANSI/UL 1449. "Manufactured in accordance with" is not equivalent to UL Listing and does not meet intent of specification.
- B. Post SPD and performance parameters at [www.UL.com](http://www.UL.com) under Category Code: VZCA. Products or parameter without posting at UL.com are not approved.
- C. Minimum surge current capacity for Service Entrance units based on 8 x 20 microsecond current waveform:
  1. 200,000 A between each phase for line-to-line mode
  2. 200,000 A each phase for line-to-ground mode
  3. 200,000 A each phase for line-to-neutral mode
  4. 200,000 A for neutral-to-ground mode
- D. Minimum surge current capacity for panelboard units based on 8 x 20 microsecond current waveform:
  1. 80,000 A between each phase for line-to-line mode
  2. 80,000 A each phase for line-to-ground mode
  3. 80,000 A each phase for line-to-neutral mode
  4. 80,000 A for neutral-to-ground mode
- E. Sequential Surge Current Survivability:
  1. 1,000 sequential category surges without failure.
- F. Current Rating:
  1. Rated for continuous current and AIC rating of equipment protected.
  2. Mark SPD Short-Circuit Current Rating on the SPD label.

## 2.3 OPERATING CONDITIONS

- A. Temperature range: -40°F to 122°F
- B. Relative humidity range: 0 to 95%, non-condensing
- C. Audible noise level: > 40 dBA at 5 ft
- D. SPD Surface Temperature: less than 131°F

## 2.4 FABRICATION

- A. SPD Modules:
  1. UL Labeled as Type 1 (verifiable at [www.UL.com](http://www.UL.com)), intended for use without need for external or supplemental overcurrent controls. Protect suppression component of every mode, including N-G, by internal overcurrent and thermal overtemperature controls. SPDs relying on external or supplementary installed safety disconnects do not meet intent of specification.
  2. UL Labeled with 20kA I-nominal (I-n) (verifiable at UL.com) for compliance to UL 96A Lightning Protection Mater label and NFPA 780.
  3. Suppression components: Heavy-duty MOVs, selenium cells, or combination of both.
  4. Provide surge current diversion paths for all modes of protection: L-N, L-G, N-G

in WYE systems, and L-L, L-G in DELTA systems.

5. Provide service entrance SPD audible diagnostic monitoring by way of audible alarm.
6. Provide service entrance SPD with 1 set of NO/NC dry contacts for alarm conditions.
7. Provide visual LED diagnostics including a minimum of 1 green LED indicator per phase, and 1 red service LED. Include an audible alarm with on/off silence function and diagnostic test function (excluding branch).
8. If a dedicated breaker for the SPD is not provided in the switchgear, switchboard, or panelboard include an integral UL Recognized disconnect switch. Dedicated breaker to serve as a means of disconnect for distribution SPDs.
9. Meet or exceed the following criteria:
  - a. ANSI/UL 1449 Listed Voltage Protection Ratings (VPRs) for 6kV 3000A testing as follows:

<b>VOLTAGE</b>	<b>L-N L-G N-G</b>	<b>L-L</b>
208Y/120 V	≤800V	≤1200 V
480Y/277 V	≤1200 V	≤2000 V

10. ANSI/UL 1449 Listed Maximum Continuous Operating Voltage (MCOV) (verifiable at UL.com):

<b>System Voltage</b>	<b>Allowable System Voltage Fluctuation (%)</b>	<b>MCO V</b>
208Y/120	15%	150V
480Y/277	15%	350V

11. Provide serviceable, replaceable modules (excluding Branch).
  12. Provide warranty for a period of 10 years, incorporating unlimited replacements of suppressor parts if they are destroyed by transients during the warranty period.
  13. Provide SPD with digital surge event counter with capacitor backup.
- B. Service Entrance:
1. Install 1 primary suppressor external to the service entrance in accordance with manufacturer instructions.
  2. Install SPD on line or load side.
  3. Bond SPD ground to service entrance ground.
- C. Distribution Panelboards:
1. Install 1 suppressor external to each designated distribution panelboard.
  2. Install surge suppression device in accordance with manufacturer instructions.
- D. SPD Low-Impedance Interconnect Cable:
1. Provide low-impedance cable specifically listed for SPD installations.
  2. Low impedance approximately 25% of conventional pipe and wire for improved



clamping voltage.

### **PART 3 - EXECUTION**

#### **3.1 APPLICATION OF SPD**

- A. Provide UL approved disconnect switch at Service Entrance or Transfer Switch as a means of service disconnect if a breaker sized per manufacturer's recommendations is not available.
- B. Provide independent means of servicing disconnect at Distribution, MCC, and Branch such that the protected panel remains energized. A 30A breaker (or larger based on manufacturer's recommendations) may serve this function.
- C. Provide SPD for each panel, distribution panel associated with the Emergency branch of power.

#### **3.2 INSTALLATION**

- A. Install per manufacturer's recommended practices.
- B. Provide short and straight conductors not exceeding 3 ft in length. Manufacturer-approved cables may be used that allow conductor length to extend beyond 3 ft in length without affecting capability of unit.
- C. Input conductors twisted together to reduce inductance.
- D. Avoid 90-degree bends in cable.

#### **3.3 QUALITY ASSURANCE**

- A. Factory test system before shipment. Include quality control check, "Hi-Pot" tests at 2 times rated voltage plus 1,000 V, ground leakage tests, and calibration.
- B. Manufacturer Qualifications: Engage a firm with at least 5 yrs experience in manufacturing surge protective devices.
- C. Manufacturer of equipment shall have produced similar electrical equipment for a minimum period of 5 yrs. When requested by Owner's Representative, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with requirement.
- D. Provide SPD compliant with the Restriction of Hazardous Substances (RoHS) Directive 2002/95/EC.

#### **3.4 FIELD QUALITY CONTROL**

- A. Inspections before SPD startup:
  - 1. Visual Inspection:
    - a. Verify installation per drawings.
    - b. Verify phase, neutral, and ground conductors are properly sized and configured.
  - 2. Mechanical Inspection:
    - a. Check connections for tightness.
    - b. Check terminal screws, nuts and/or connectors for tightness.
  - 3. Electrical Inspection:

- a. Confirm input voltage.
- b. Confirm phase, neutral and ground connections are proper.

**3.5 WARRANTY**

- A. Provide 10-year manufacturer warranty.

**END OF SECTION 26 43 00**

## **SECTION 26 50 00 - LIGHTING**

### **PART 1 - GENERAL**

#### **1.1 RELATED WORK**

- A. Section 26 00 00 - General Electrical Requirements
- B. Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables
- C. Section 26 05 19.16 - Manufactured Wiring Systems
- D. Section 26 05 26 - Grounding and Bonding for Electrical Systems
- E. Section 26 05 33 - Raceway and Boxes for Electrical Systems
- F. Section 26 09 23 - Lighting Control Devices

#### **1.2 REFERENCE**

- A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

#### **1.3 DESCRIPTION OF WORK**

- A. Provide complete and fully operational lighting system per Contract Drawings and Specifications.
- B. Luminaires shall be provided complete with necessary accessories for proper installation.
- C. Catalog numbers shown in luminaire schedule are basic luminaire types. Additional features, accessories and options specified, scheduled or necessary for proper installation shall be included.
- D. Provide lamps for luminaires as recommended by luminaire manufacturer, unless noted otherwise.
- E. Specifications and drawings convey the features and functions of luminaires only and do not show every item or detail necessary for the work.
- F. Work includes final aiming and focusing of luminaires under direction of the Owner's Representative.
- G. All lighting is to use LED sources. The use of incandescent, HID, Florescent, etc is generally not permitted but will be evaluated on a case by case basis. Contact University representatives for approval of any deviation from use of LED.

#### **1.4 REFERENCE STANDARDS**

- A. NECA/IESNA 500 - Standard for Installing Indoor Commercial Lighting Systems (ANSI)
- B. NECA/IESNA 501 - Standard for Installing Exterior Lighting Systems (ANSI)
- C. NECA/IESNA 502 - Standard for Installing Industrial Lighting Systems (ANSI)
- D. NECA 503 – Standard for Installing Fiber Optic Lighting Systems
- E. NEMA LE 4 - Recessed Luminaires, Ceiling Compatibility

- F. UL 496 – Lampholders
- G. UL 773 - Plug-in Photocontrols for use with area lighting
- H. UL 924 - Emergency Lighting and Power Equipment
- I. UL 1574 – Track Lighting
- J. UL 1598 – Luminaires
- K. UL 1838 – Low Voltage Landscape Lighting Systems
- L. UL 2108 – Low Voltage Lighting Systems
- M. UL 2388 – Flexible Lighting Products
- N. UL 2562 – Pendant Cable
- O. UL 8750 – LED Light Sources for use in Lighting Products
- P. ANSI C78.377 – Chromaticity
- Q. IESNA LM-79 – Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products
- R. IESNA LM-80 - Approved Method: Testing Lumen Maintenance of LED Light Sources
- S. IESNA TM21-11 - Projecting Long Term Lumen Maintenance of LED Light Sources including Addendum A

#### **1.5 QUALITY ASSURANCE**

- A. Luminaire and accessory components shall be constructed of materials appropriate for their use.
- B. Luminaires, ballasts, drivers, lamps and other components shall meet the requirements of all applicable State and Municipal codes and energy codes.
- C. Provide luminaires listed and labeled by UL or other testing lab acceptable to local jurisdiction for their indicated use and installation conditions.
- D. Contractor shall coordinate installation of lighting systems with all trades.
  - 1. Manufacturers listed in the luminaire schedule shall be assumed capable of supplying listed luminaires. Any such exceptions shall immediately be brought to the attention of Owner's Representative.
  - 2. Multiple Name Specification:
    - a. When multiple manufacturers are listed, Electrical Contractor shall choose which of the listed products are to be provided.
    - b. Products of the same type shall be of same manufacturer.
  - 3. Single Name Specification:
    - a. When only one product is suitable for the application and/or no other known acceptable products exist, only one manufacturer/product is listed in the Luminaire Schedule. For such instances, Electrical Contractor shall provide the listed product with no exceptions.
    - b. Specifier has secured accurate pricing for all single name products prior to bidding and has shared this information with Architect/Owner's Representative. Contractor shall supply contractor net unit pricing for all single name products specified. Unit price shall be for equipment only and

not include installation or miscellaneous electrical costs.

4. Contractor shall coordinate and verify compatibility of luminaires with lighting control system.
  - a. Control protocol indicated for luminaires matches protocol of lighting control system specified. Contractor shall coordinate and verify compatibility of all dimming luminaires with control system to ensure that dimming is flicker free, continuous dimming through the dimming range noted on the luminaire schedule.
- E. Substitution requests:
  1. Will be evaluated prior to Bid.
  2. Shall follow procedures set forth in this Section under paragraph 1.7 and in Section 01 2500 - Substitution Procedures.
  3. Shall be made not less than 10 days prior to bid date.
  4. Shall include the following information indicating that the proposed substitution is of similar construction quality and assembly, lumen output and distribution, color temperature, color consistency, and controllability:
    - a. Specified and proposed manufacturer's product data sheet, noting options and features.
    - b. Provide dimensioned drawing of luminaire.
    - c. Provide photometric data in form of an electronic IES file on CD, USB or via email for use in a recognized computer lighting program.
  5. Provide table-top working samples and/or mockup of specified luminaire and proposed alternate.
  6. Samples shall:
    - a. Be fully operable, complete with specified lamp(s) and with functioning cord and plug ready for installation.
    - b. Remain available during construction.
    - c. Meet the requirements outlined in Section 1.8.
  7. Electrical Contractor shall be responsible for all costs incurred by substitution request sample and/or mockup production and review.
  8. Equipment delivery lead time shall not be held as a valid reason for requesting luminaire substitution unless luminaire lead time from specified manufacturer is in excess of 14 weeks. It shall be sole responsibility of Electrical Contractor to determine necessary equipment lead times, deliver submittals for review in a timely fashion, and place orders accordingly to ensure timely delivery.
  9. When requesting a substitution, Electrical Contractor shall provide unit and extended pricing for specified luminaire, unit and extended pricing for proposed alternate, and unit and extended delta savings to Owner's Representative to be realized by accepting proposed alternate. If requested, provide unit pricing for each luminaire type specified to provide a baseline comparison for substitution request.
  10. Electrical Contractor shall guarantee pricing on all luminaire types for which a substitution request has been granted. This price guarantee shall be per unit and shall be maintained through the end of construction, regardless of quantity

purchased.

11. For all luminaire types using an LED light source, provide independently tested, IESNA LM- 79 compliant photometry testing data and IESNA LM-80 Lumen Maintenance data.

## 1.6 Warranty

- A. Ballasts: Provide manufacturer's warranty for a period of not less than five years from the date of substantial completion. Warranty shall include parts and labor to replace defective ballasts.
- B. Exit Signs Utilizing LED lamp Technology: Provide manufacturer's warranty for a period of not less than five years from the date of substantial completion including parts and labor for full replacement of defective product.
- C. LED Luminaires: Provide Manufacturer's warranty for a period of not less than five years from the date of substantial completion or the specified warranty period greater than five years for repair or replacement of defective electrical parts, including light source and driver.

## 1.7 SUBMITTALS

- A. After award of Contract, submit complete list of lighting products to be furnished, with manufacturer and catalog designations, including currently quoted lead times for product delivery. Should Electrical Contractor anticipate delivery schedule of any specified product may adversely impact construction schedule, they shall bring it to the attention of Owner's Representative at this time.
- B. In addition to complying with requirements of Section 26 00 00 - General Electrical Requirements, submittals shall include the following:
  1. Manufacturer's product data
  2. Installation instructions
  3. Maintenance data
  4. Parts list for each luminaire accessory
  5. Photometric Data: photometric data for luminaire, including optical performance as follows:
    - a. Coefficients of utilization
    - b. Luminance table
    - c. Candela distribution data
    - d. Zonal lumens
    - e. Area and roadway luminaires shall include Isocandela Charts, IES Roadway Distribution Classification and IES BUG (Backlight – Uplight – Glare) ratings.
  6. Driver schedule indicating manufacturer, type, and catalog number for each luminaire
  7. Driver cut sheet for each driver used, referencing luminaire type(s)
  8. Lamp schedule indicating manufacturer, type, and catalog number for each luminaire
  9. Lamp cut sheet for each lamp used, referencing luminaire type(s)
  10. Documentation of lamp and ballast or LED and driver compatibility
  11. Product color/finish
    - a. Where specific finish or color is not specified and options exist, submit color or finish samples to Owner's Representative for selection.

- C. Shop Drawings for equipment provided under this Section shall include the following:
1. Overall submittal drawings indicating luminaire size, mounting (including ceiling type), light source, shielding, and voltage attributes, as well as manufacturer's product data, installation instructions, maintenance data, and parts list for each luminaire.
  2. Catalog cutsheets lacking sufficient detail will not be accepted.
  3. Detailed drawings of linear pendant mounted and suspended luminaires including dimensions, support spacing, suspension type, power feed type and locations, lamp combinations, ballast/driver locations, wiring and controls configuration, luminaire joint locations and end plates. Provide canopy details that indicate coordination with the ceiling system provided.
  4. Detailed drawings for each cove and linear wall system configuration including dimensions, power feed locations, driver locations, luminaire joint locations, extension plates for end and corner sections and end plates.
    - a. For LED strip luminaires mounted in architectural coves, provide dimensioned drawings and sections and include accessory cut sheets as specified. Within coves, all luminaires are to be mounted end to end with no more than 12" unlit split evenly between ends.
  5. Detailed drawings for LED systems including LED color, color consistency, rated life, warranty, and scale plans with luminaire layout, number, type and location for drivers, and a complete bill of materials.
  6. Detailed drawings for continuous recessed or continuous surface mounted LED luminaires including dimensions, power feed locations, ballast or driver locations/quantity, luminaire joint locations, extension plates for end and corner sections and end plates as applicable.
  7. Detailed drawings for custom LED handrail systems including dimensions, power feed locations, ballast or driver locations/quantity, luminaire joint locations as applicable.
  8. For LED luminaires, submit documentation that indicates specified products have been tested, or will be tested, for compatibility with the lighting controls being procured and will perform as specified. Control devices or system shall be able to control luminaires with flicker free, continuous dimming, in range specified. Electrical Contractor, luminaire manufacturer and lighting control manufacturer shall be financially responsible for any incompatibilities.
  9. Detailed drawings for nonstandard/custom luminaires indicating dimensions, weights, method of field assembly, components, features, and accessories. Details shall be scaled to a legible size.
  10. Detailed drawings for fiber optic systems including scaled plans with cable layout number and type of fiber bundles, illuminator quantity and location, and a complete bill of materials.
  11. Drawings for site lighting shall include pole data with wind loading, complete dimensions and finish, pertinent physical characteristics and accessories including mounting details, ballast/driver type and location and any specified control options.

12. Photometric Data: Where indicated on luminaire schedule and Contract Drawings, supply complete photometric data for luminaire, including optical performance rendered by independent testing laboratory developed according to methods of the Illuminating Engineering Society of North America as follows:
  - a. Coefficients of utilization
  - b. Luminance table with data presented numerically, showing maximum luminaire luminance at shielding angles. Readings should be taken both crosswise and lengthwise in case of fluorescent luminaire or luminaire with an asymmetric distribution.
  - c. Candela distribution data, presented graphically and numerically, in 5-degree increments (5-degrees, 10-degrees, 15-degrees, etc.). Data developed for up and down quadrants normal, parallel, and at 11-1/2-degrees, 45-degrees, 67-1/2-degrees to lamps if light output is asymmetric.
  - d. Zonal lumens stated numerically in 10-degree increments (5-degrees, 15-degrees, etc.) as above.
13. No variation from the general arrangement and details indicated on drawings shall be made on shop drawings unless required by actual conditions. All variations shall be marked on drawings submitted for approval.

- D. Provide luminaires with factory or field finish as directed by Owner's Representative. Verify final finish requirements before releasing luminaires for fabrication.
- E. Where specific finish or color is not specified and options exist, submit color or finish samples to Owner's Representative for selection. Luminaires not having color or finish acceptable to Owner's Representative shall be replaced at no additional cost.

### **1.8 SAMPLES**

- A. Upon return of submittals, and prior to release for manufacturing, Contractor shall furnish one working sample of each luminaire for which sample requirement is noted in Luminaire Schedule.
  1. All requested samples shall be furnished as specified on luminaire schedule including but not limited to: light output, correlated color temperature, distribution, lens type and finish.
- B. Shipping: Samples shall be complete with specified lamp(s) or LED module(s), cord and plug, ready for hanging, energizing, and examining, and shall be shipped, prepaid by Contractor, to Owner's Representative or as otherwise advised.
- C. Samples will not be returned, nor included in quantities listed for project.
- D. Sample must be actual working unit.
- E. All custom luminaires require a submission of material finish samples, component approval and a complete operating prototype luminaire. Prototype to be submitted prior to commencement of final luminaire fabrication and shall include specified lamps. Modifications may be required as a result of prototype review. These modifications and others that do not materially affect the cost of the luminaire shall be incorporated at no additional cost to Owner.



### **1.9 LUMINAIRE MOCK-UPS**

- A. Upon return of submittals, and prior to release for manufacturing, Contractor shall provide mock-up on site (or at another agreed upon location) in actual architectural conditions for review by Owner's Representative for each luminaire noted in Luminaire Schedule.
- B. Provide type and quantity of luminaires as requested by Owner's Representative.
- C. Mock-up shall include working luminaires and fastening devices.

## **PART 2 - PRODUCTS**

### **2.1 ACCEPTABLE MANUFACTURERS**

- A. Luminaires:
  - 1. As shown on Luminaire Schedule
- B. LED Drivers:
  - 1. Shall be manufacturer recommended compatible driver.
  - 2. All LED drivers shall be dimming type standard unless otherwise noted. Refer to construction documents for control per application.
  - 3. Manufacturers must be compatible with lighting control system(s) provided and control luminaires from 100% to 1% light output or 100% to 10% light output per Luminaire Schedule and controls intent documents.
- C. Low Voltage Transformers:
  - 1. Q-Tran or as specified in the Luminaire Schedule
- D. LED Modules:
  - 1. Philips Lumileds, Xicato, Cree, GE, Nichia, Osram Sylvania, Bridgelux, Citizen or as specified in the Luminaire Schedule

### **2.2 FABRICATION AND MANUFACTURER**

- A. Luminaires:
  - 1. Construction
    - a. Luminaires shall bear label indicating circuit voltage. Labels shall not be visible from normal viewing angles.
    - b. Luminaires shall be constructed with joints made by means of welded, brazed, screwed, or bolted construction methods.
    - c. Housings shall be so constructed that all electrical components are accessible and replaceable without removing luminaires from their mountings.
    - d. Surface temperatures of luminaires with ballasts or integral drivers shall not exceed 90°C in 30°C ambient.
    - e. Luminaires recessed in ceilings utilized as air handling plenums shall be certified as suitable for the purpose and conform to NEC Article 300.
    - f. Miter cuts shall be accurate, joints shall be flush and without burrs.
    - g. LED troffers with doors shall have spring-loaded door cam latches.
    - h. Luminaires shall be free of light leaks and designed to provide sufficient

- ventilation of lamps to provide the photometric performance documented. Ballasts, low voltage transformers and drivers shall be vented per manufacturer's specifications.
- i. Provide inscription for exit and stairway signs to conform to applicable codes.
  - j. Verify types of ceiling construction with General Contractor prior to releasing luminaires for fabrication and delivery and provide luminaires adapted to ceiling construction used.
  - k. Coordinate recessed luminaire mounting appurtenances, flanges and trims with construction of ceiling in which luminaire is to be recessed. Provide correct luminaire mounting assembly.
  - l. Luminaire frames shall be manufactured of non-ferrous metal or be suitably rust proofed after fabrication.
  - m. Recessed high intensity discharge luminaires with integral ballasts, installed indoors, shall have UL listed thermal protection integral with ballast. Exceptions are luminaires installed in suspended lay-in, grid type ceilings and which comply with UL suspended ceiling luminaire listing.
2. LED Luminaires are considered a lighting system with dependent components that must be evaluated as a complete system. Each LED luminaire includes a light emitting source, provisions for heat transfer, electrical control, optical control, mechanical support and protection, as well as aesthetic design elements. All LED luminaires shall:
- a. Be UL listed or equivalent. Where remote drivers are specified, all drivers shall also have UL listing or equivalent and comply with code requirements.
  - b. Be tested to IESNA LM-79-08 testing using absolute photometry criteria.
  - c. Be rated at > or = to 70% lumen maintenance at 50,000 hours of operation.
  - d. Be rapid cycle stress tested.
  - e. Have integral lamp modules with a minimum operating temperature of -20°C.
  - f. Have lamp modules that are capable of being easily replaced upon failure with a manufacturer provided replacement module without voiding the UL listing of the luminaire.
  - g. Have driver housings easily accessible for ease of maintenance.
  - h. Have a maximum operating temperature at LED junction to not exceed 90°C over the expected operating range of the luminaire.
  - i. Be RoHS compliant, lead and mercury free.
  - j. Have an LED operating frequency of + or - 120 Hz.
  - k. Must meet the appropriate Federal Communications Commission (FCC) requirements for FCC 47 CFR 15 (consumer use) and/or FCC 47 CFR Part 18 (industrial use).
  - l. Be Class A Sound rated.
  - m. Be supplied with power supply that complies with IEEE C. 62.41-1991.
  - n. Operate at 120 or 277 volts, ±10%.
  - o. Have reverse polarity protected at all hardwired connections and have high voltage protection in the event connections are reversed or shorted during the installation process.
3. Lenses, Reflectors and Diffusers

- a. All lenses or louvers shall be removable but held so that normal motion will not cause them to drop out.
- b. All glass used in incandescent or LED luminaires shall be made from thermal shock resistant borosilicate glass.
- c. Optical lenses shall be free from spherical and chromatic aberrations.
- d. Acrylic lenses shall be 100% virgin acrylic material.
- e. Diffuser materials shall be UV stabilized in applications exposed to sunlight.
- f. LED troffer lenses shall be 0.125" thick, unless otherwise noted.
- g. Alzak reflectors and louvers shall be low iridescent equivalent to Coil Anodizers. All Alzak parabolic cones shall be guaranteed against discoloration for a minimum of ten years.
- h. Reflector cones shall not have visible lamp flashing in the cone.
4. Optics and Adjustments
  - a. Lamp holders shall be suitable for the indicated lamps and shall be set such that lamps are positioned in optically correct relation to all luminaire components.
  - b. Adjustable Angle Luminaire: Luminaires with adjustment beam angle shall contain reliable angle locking devices.
5. Finishes
  - a. Provide luminaires with finish as shown in the luminaire schedule. Verify final finish requirements before releasing luminaires for fabrication.
  - b. Painted luminaires shall be painted after fabrication or "post painted."
  - c. Ferrous parts and supports shall be rust proofed after fabrication.
  - d. For weatherproof or vaportight installations, painted finishes of luminaires and accessories shall be weather resistant using proper primers or galvanized and bonderized epoxy, so that entire assembly is completely corrosion resistant for service intended and rated for an outdoor life expectancy of not less than 20 years.
6. Wiring
  - a. Luminaires shall be completely wired at the factory and as required by code.
  - b. Internal wiring shall contain no splices.
  - c. Connections shall be made with insulated "wire nut" type mechanical connectors except that ballast and driver connections shall comply with NEC Article 410.
  - d. Wire for connections to lamp sockets and lamp auxiliaries shall be minimum #16 AWG luminaire wire.
  - e. Luminaires shall be provided with flexible conduit, pigtails, and equipment for external connections.
  - f. Recessed incandescent luminaires shall incorporate integral thermal protection.
  - g. Incandescent luminaires shall be wired with heat resistant wire.
  - h. Recessed luminaires installed in inaccessible ceilings shall be UL listed for through wiring with the junction box accessible from the luminaire opening.
  - i. Provide dual-level switching for luminaires as indicated on luminaire schedule and/or where shown on Contract Drawings. Typically, first switch designation controls outboard lamps, and second switch designation controls inboard

- lamp(s), unless noted otherwise.
- j. Provide wiring for master/ satellite luminaire configuration as indicated on luminaire schedule and/or where shown on Contract Drawings. For single lamp luminaires, provide a two-lamp ballast for two adjacent luminaires. For three-lamp luminaires, provide one two-lamp ballast for the outboard lamps in each luminaire and an additional two-lamp ballast for the center lamp in each of two adjacent luminaires.
- k. Provide wiring for tandem wired luminaires as indicated on luminaire schedule and/or where shown on Contract Drawings. Supply ballasts and wiring to control all top or inboard lamps together and control all bottom or outboard lamps together.
- l. Cords shall be fitted with proper strain reliefs and watertight entries where required by application.
- m. Provide lamps for all luminaires.
- 7. Ceiling Coordination
  - a. Verify type of ceiling construction prior to releasing luminaires for fabrication and delivery.
  - b. Provide mounting appurtenance, flanges, sloped ceiling adaptors where required.
  - c. Provide mounting assembly, clips or other mechanical mounting lugs as required for support of luminaires.
- 8. Track-Lighting Systems:
  - a. A lighting track system is defined as a manufactured assembly designed to support and energize luminaires that are capable of being readily repositioned on the track. Its length may be altered by addition or subtraction of sections of track. Lighting track may be either flexible or rigid depending on the specific application.
  - b. Provide lighting track types as specified in Luminaire Schedule, in lengths as indicated on lighting plans.
  - c. All line voltage track lighting systems shall be provided with integral current limiters or be fed from supplementary overcurrent protection panels to limit power consumed by track.
  - d. Lighting track system includes current carrying conductors which may convey either line voltages (120V or 277V) or low voltages (12V or 24V). Characteristics of lighting track that conveys line voltages are different than a lighting track system that conveys low voltages and as such are governed by different requirements. Therefore, they are considered individually in these Specifications.
    - 1) Line voltage (120V or 277V) Lighting Track systems:
      - a) Provide components, including track, fittings, and luminaires from the same manufacturer as recommended by manufacturer for the intended use. All components shall be UL Listed and comply with the National Electric Code Standards for Lighting Track.
      - b) Maintain continuity of conductors through feeds, splice fittings and boxes. Relative positions of live and neutral conductors must always be maintained along continuous run so that track fittings

- connect into the track in a consistent manner.
  - c) Support lighting track at intervals recommended by the track manufacturer.
  - d) One or two circuit Lighting Track shall be supplied with separate neutral busbars and have the ability to have each circuit separately dimmed as required when using standard voltage and low voltage luminaires with either magnetic or electronic transformers.
  - e) Lighting Track shall have the ability to be dimmed or switched in selected sections in addition to dimming or switching an entire track configuration or track run.
  - f) One and two circuit 120 volt Lighting Track shall be rated at 120/250 volt, 60 Hz, 2,400 watts maximum each circuit. Neutral busbar(s) shall be oversized and comparable to #10 AWG 30 amp wire to reduce the possibility of overheating due to non-linear loads and harmonics.
  - g) One and two circuit 277 volt Lighting Track shall be rated at 277 volt, 50/60 Hz, 5,540 watts maximum each circuit. Neutral busbar(s) shall be oversized and comparable to #10 AWG 30 amp wire to reduce the possibility of overheating due to non-linear loads and harmonics.
  - h) A separate grounding busbar shall be integral in all track lengths.
  - i) 277 volt Track fittings shall be identified by a red rotor and a 277 volt label.
- 2) Low voltage (12V or 24V) Lighting Track systems:
- a) Provide components, including track conductors, remote mounted transformers, fittings, and luminaires from the same manufacturer as recommended by the manufacturer for the intended use. Components shall be UL Listed as applicable for low voltage use.
  - b) Maintain continuity of conductors through feeds, splice fittings and boxes. Relative positions of conductors must always be maintained along continuous run so that track fittings connect into track in a consistent manner.
  - c) Support lighting track at intervals recommended by track manufacturer.
  - d) One and two circuit low voltage Lighting Track shall be supplied with three conductors and have the ability to have each circuit separately switched with either magnetic or electronic transformers provided by the track manufacturer. Two circuit low voltage Lighting Track can only be dimmed if both circuits are fed from the same transformer and as a result, separate circuit dimming shall not be attempted or permitted.
  - e) All transformers shall be supplied with both primary and secondary voltage over-current protection devices that shall remain readily accessible for maintenance and testing purposes.

- f) Lighting Track shall have the ability to be dimmed or switched in selected sections in addition to dimming or switching an entire track configuration or track run. Separate, single circuit transformers are required for each independently controlled circuit with the use of electrically isolated couplers.
  - g) Conductors used in low voltage Lighting Track shall be, at minimum, equivalent to #10 AWG 30 amp wire or heavier and be capable of carrying a 300 watt load (at 12 volts) up to 32 ft from transformer feed within range of luminaire voltage tolerance. At 24 volts, conductors shall be capable of supplying a 600 watt load up to 60 ft from transformer feed within range of luminaire voltage tolerance.
  - h) If taut strung cable conductors are used as low voltage Lighting Track system, they shall have a Kevlar core to prevent strain on outer current carrying conductors.
  - i) Only insulated type taut strung cable conductors shall be used in order to comply with local electrical codes governing installation.
9. Outdoor Lighting Systems:
- a. Provide luminaires, mounting arms, brackets, poles, hand-hole covers, base components, and all other accessories for a complete assembly. Manufacturers shall be responsible for proper fitting of elements and structural integrity of unit.
  - b. Provide poles as shown on luminaire schedule.
    - 1) Poles shall have hand-holes.
    - 2) Fusing for each luminaire head shall be located in hand-hole near base of pole.
    - 3) Pole base anchor bolts shall be galvanized.
  - c. Exterior Luminaires:
    - 1) Shall operate at a minimum ambient temperature of 0°F.
    - 2) Shall be fully gasketed, with UL wet location label.
    - 3) Shall have approved wire mesh screens for ventilation openings.
    - 4) Anodized aluminum reflectors shall have minimum of 0.00079" anodizing thickness.
  - d. Pole/Luminaire combination shall have EPA rating that will withstand site wind conditions.
  - e. All castings and extrusions shall be given minimum one coat of baked-on clear lacquer, unless painted finish is specified.
  - f. Aluminum surfaces shall receive a duronodic or polyester powder paint finish.
  - g. Cast-in Luminaire housings installed directly in concrete shall be fabricated of hot dip galvanized steel or cast aluminum or composite.
  - h. Where cast aluminum housings are used, give two coats of asphaltum paint prior to installation.
  - i. Provide 1/8" thick x 2" diameter solid neoprene grommets at each point light luminaire surfaces are mounted to concrete structure.

- A. LED Drivers and Power Supplies shall:
  - 1. Operate system LEDs within the current limit specification of the LED manufacturer.
  - 2. Be supplied with over-temperature protection circuitry.
  - 3. Be programmable where noted in the Luminaire Schedule to allow for LED replacement modules to be "tuned" to match the output of remaining adjacent modules in the event that some time has passed and there has been lumen depreciation.
  - 4. Be within a NEMA enclosure.
  - 5. Be equipped with knockouts to accommodate standard conduit sizes.
  - 6. Have a Power Factor to be = or > than 0.9
  - 7. Have a Lamp Current Crest Factor < 1.5
  - 8. Dimmable LED drivers must be compatible with dimming system(s) provided and control luminaires per luminaire schedule and controls documentation.
  - 9. ETL certified, CBM and UL Listed, high power factor, and meet or exceed NEMA and ANSI Standards.
  - 10. Class A sound rated
  - 11. Equipped with resetting thermal sensitive device.
  - 12. For operation at 60 Hz and voltage as scheduled.
  - 13. Meet or exceed all ANSI or NEMA standards.
  - 14. Capable of operating LEDs with less than 5% flicker.
  - 15. Be DMX compatible in Color changing LED luminaires.

#### **2.4 LOW VOLTAGE TRANSFORMERS**

- A. Transformers shall be:
  - 1. Sized to compensate for voltage drop over indicated distances.
  - 2. Locally fused.
- B. Transformers shall have line voltage switch within reach.
- C. Provide adequate ventilation to meet code and manufacturers requirements.

#### **2.5 TANDEM WIRED LUMINAIRE PAIRS**

- A. Luminaires may be tandem wired in a master/satellite configuration to minimize the use of single lamp ballasts or to minimize circuit connection points.
- B. Tandem wiring shall consist of UL Listed wiring system fabricated by luminaire manufacturer to interconnect ballast wiring from "master" luminaire to unballasted "slave" luminaire.
- C. Wiring shall be:
  - 1. #12 AWG minimum.
  - 2. Enclosed in 3/8" diameter flexible metallic conduit.
- D. Tandem wiring shall not be used for luminaires spaced greater than 10 ft apart (on center).
- E. Support conduit with nylon tie wraps or metal clips.

#### **2.6 LAMPS**

- A. Provide lamps as noted on Luminaire Schedule.
- B. Provide lamps of same type from same manufacturer.
- C. Where a specific lamp manufacturer has been indicated in the Luminaire Schedule,

lamps shall be supplied from named manufacturer only.

- D. White LED sources shall be:
  - 1. Minimum CRI of 85 unless noted otherwise on Luminaire Schedule.
  - 2. Less than 3% flicker.
  - 3. Within 0.004 on the CIE 1976 diagram for color spatial uniformity.
  - 4. Within 0.007 on the CIE 1976 diagram for color maintenance over the rated lifetime of the source.
  - 5. Binned within a 3-step MacAdam ellipse minimum, or as indicated in Luminaire Schedule.
  - 6. Color temperature as noted on Luminaire Schedule.
  - 7. Have a published life rating based on the point at which LED sources reach L70 lumen maintenance and tested in accordance with IES LM80-08 Approved Method: Testing Lumen Maintenance of LED light sources and IES TM-21-11: Projecting Long Term Lumen Maintenance of LED Light Sources.
  - 8. L70 rated life shall be a minimum of 50,000 hours.
  - 9. LED modules, unless noted otherwise, shall be provided by light fixtures manufacturer and integral to luminaire.
- E. , except quartz lamps and lamps which are dimmed shall be rated for 120 volt operation.
- F. Low voltage incandescent lamps, MR16 type, shall have a minimum of 10,000 hour rated life.
- G. Provide all other lamp types and special purpose lamps as noted on Luminaire Schedule.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

- A. Marking:
  - 1. Voltage identification: Luminaires designed for voltages other than 110-125 volt circuits shall be clearly marked with rated voltage.
  - 2. Lamp/ballast coordination: Luminaires equipped with ballast for operation of rapid start lamps shall be plainly marked "Use Rapid Start Lamps Only". Similarly, luminaires equipped with ballasts or other components requiring use of specific types of lamps shall be plainly marked.
  - 3. Markings must be clear and shall be located to be readily visible to service personnel but invisible from normal viewing angles when lamps are in place.
- B. Installation of Luminaires:
  - 1. Lamps, glassware, reflectors and refractors shall be clean and free of chips, cracks and scratches.
  - 2. Install decorative luminaires, reflector cones, baffles, aperture plates, lenses, trims, and decorative elements of recessed luminaires after completion of ceiling tile, plastering, painting, and general cleanup is completed. Where luminaire location or construction does not permit sequential installation, all reflectors, lenses, flanges and other visible surfaces shall be carefully protected.
  - 3. Light leaks between ceiling trim of recessed luminaires and ceiling are not allowed.
  - 4. Locations



- a. Install luminaires at locations and heights as indicated.
  - b. Do not scale electrical drawings for locations of luminaires.
  - c. Architectural reflected ceiling plans show locations of luminaires.
  - d. Where noted on the drawings, the exact location of luminaires shall be confirmed (in the field) with the Owner's Representative prior to installation.
  - e. Where luminaires are to be concealed, or surface mounted in highly visible public spaces, a small sampling of luminaires shall be installed, adjusted and aimed for Owner's Representative review approval, prior to installing remaining luminaire of same type.
  - f. Mount all luminaires so as to maintain full range of motion.
  - g. Install luminaires plumb, square, and level with ceilings and walls.
  - h. Coordinate stem, rod, chain, or aircraft cable hanger lengths with job conditions.
  - i. Industrial type luminaires in unfinished areas, which are near obstructions such as ducts and pipes, shall be:
    - 1) Suspended so that bottom of luminaire is no higher than bottom of obstruction.
    - 2) Located at height of lowest luminaire.
    - 3) Minimum height: 8'-0"
    - 4) Shall not be located until locations of obstructions are determined.
    - 5) Where a minimum height of 8'-0" is unachievable, wall mounted luminaires will be utilized.
5. Support
- a. Support surface mount luminaires from building structure.
  - b. Metal decking shall not be pierced for luminaire support.
  - c. Provide luminaires and/or luminaire outlet boxes with hangers to support luminaire weight.
  - d. LED troffers shall be held in place by support clips.
  - e. Provide plaster frames for recessed luminaires in plaster ceilings.
  - f. Rigid metallic pipe stems shall be utilized for the support of pendant mounted luminaires, unless otherwise noted.
  - g. Stem hangers shall be equipped with aligner box covers or canopies so that stems hang vertically, irrespective of the angle of the surface they are mounted from.
  - h. Wherever a luminaire or its hanger canopy is attached to a surface mounted outlet box, a finishing ring shall conceal the outlet box.
  - i. Yokes, brackets and supplementary supporting members needed to mount luminaires to suitable ceiling members shall be furnished and installed by Contractor. Verify mounting hardware required prior to installation.
  - j. Recessed luminaires shall be supported with 12 ga wire hangers, 2 per luminaire, at diagonally opposite corners.
  - k. LED troffers and luminaires over 55 lbs, such as 4' x 4' shall be supported with 12 ga wire hangers, 4 per luminaire, 2 at 45-degree diagonals, and two perpendicular to structure. Wire hangers and attachment to structure shall be capable of supporting 4 times luminaires weight.
  - l. In areas with seismic requirements, suspended or pendant mounted

luminaires shall be able to swing 45 degrees in any direction without hitting an obstruction. In the event hitting an obstruction is unavoidable, guy wires will be used to secure the luminaire in place.

- m. Surface luminaires installed in grid ceilings shall be supported by independent support clips and 12 ga wire.
  - n. Exit signs installed in grid ceilings shall be supported by electrical box hanger and additional 12 ga wire installed from box to structure.
  - o. Support surface mounted luminaires greater than 2 ft in length at a minimum of each additional 2 ft, or as recommended by manufacturer.
  - p. Brace suspended luminaires installed near ducts or other constructions with solid pendants or threaded rods.
  - q. Rigidly align continuous rows of luminaires.
  - r. Luminaire types with remote mounted ballast shall have:
    - 1) Proper support for ballast weight.
    - 2) Mounting distance from remote ballast to luminaire per manufacturer's recommendations.
6. Mounting and Enclosures
- a. Install flush mounted luminaires to eliminate light leakage.
  - b. For luminaires mounted adjacent to insulation, provide barrier to prevent insulation from coming in contact with luminaire, unless luminaire is approved for installation in contact with such insulation.
  - c. Provide approved fire rated enclosures around luminaires in fire rated ceilings.
7. Conduit and Wiring
- a. Wire for connections to lamp sockets and auxiliaries shall be suitable for temperature, current, and voltage conditions.
  - b. Recessed luminaires shall have final connections made with flexible metal conduit, not in excess of 72", with THHN conductors and green wire ground conductor.
  - c. Conduit shall be hidden from normal view in all possible cases. In public areas where surface mounted conduit must be used, contractor shall install conduit as unobtrusively as possible. Contractor shall obtain field approval by the Owner's Representative for all exposed conduit runs prior to rough in.
8. In-Grade Luminaires:
- a. Where installed in tree grates, furnish burial light lens and louver to tree grate manufacturer for coordination of opening.
  - b. Provide adequate drainage system per manufacturer's recommendations.
- C. Installation of Outdoor Pole Bases
- 1. Contractor shall provide bases for luminaires.
  - 2. Pole base details shall be provided by the project structural engineer.
  - 3. Provide handhole for electrical connection within 4'-0" of pole base.
  - 4. Contractor shall:
    - a. Rough-in conduits.
    - b. Coordinate spacing, base dimensions, heights, orientation of bases, etc. as necessary.
  - 5. Where square or rectangular poles or luminaire heads are used, Contractor

shall verify orientation with Owner's Representative.

- D. Pole Installation:
  - 1. Install luminaires, poles, hardware, etc., for complete system.
  - 2. Use web fabric slings (not chain or cable) to raise and set poles.
- E. Lamps:
  - 1. Provide new lamps delivered in original manufacturer's cartons.
  - 2. Fluorescent, LED and metal halide lamps shall be energized continuously for not less than 100 hours for proper seasoning.
- F. Grounding:
  - 1. Ground luminaires and metal poles according to Division 26 Section "Grounding and Bonding for Electrical Systems."
  - 2. Poles:
    - a. Install 10 ft driven ground rod at each pole.
  - 3. Non-metallic Poles:
    - a. Ground metallic components of lighting unit and foundations. Connect luminaires to grounding system with #10 AWG conductor.
- G. Spare Parts:
  - 1. Provide spare globes and guards, 1 for every 100 of each type and rating installed. Furnish at least one of each luminaire family.
  - 2. Provide spare louvers and reflector cones, 1 for every 100 of each luminaire family. Furnish at least one of each type.
  - 3. Provide spare plastic diffusers and lenses, 1 for every 100 of each luminaire family and rating installed. Furnish at least one of each type.
  - 4. Furnish one spare custom luminaire for each 10 supplied.
  - 5. Provide 1% spare replaceable LED lamp modules for each primary fixture series type in Luminaire Schedule. In all cases, provide a minimum of 1 unit.
    - a. Spare LED lamp modules shall be delivered to Owner's Representative in new condition and in original packaging.
    - b. Manufacturer and model number shall match those installed in the project's luminaires.
  - 6. Provide spare LED drivers, 1 for every 100 of each primary fixture series type and rating installed. Furnish at least one of each type.
    - a. Manufacturer and model number shall match those installed in the project's luminaires.
  - 7. Provide 1% spare LED luminaires with non-replaceable lamp modules consisting of entire LED luminaire assembly and driver(s).

### **3.2 SUBSTANTIAL COMPLETION**

- A. Quality Control:
  - 1. At Date of Substantial Completion, replace lamps/LED modules/LED luminaires which are not operating properly.
  - 2. Replace any lamps used as worklights during construction phase.
  - 3. Protection wrapping on lensed or louvered luminaires shall be removed before installation of furniture, but after finish work is complete.

4. Deliver spare equipment to Owner's representative.
- B. Tests:
1. Give advance notice of dates and times for field tests.
  2. Provide instruments to make and record test results.
  3. Verify normal operation of each luminaire after luminaires have been installed and circuits have been energized.
  4. Verify operation of luminaires with lighting control system and daylight harvesting systems. Any dimmed fixtures shall exhibit no signs of flickering.
  5. Replace or repair malfunctioning luminaires and components, then retest. Repeat procedure until all units operate properly.
  6. Report results of tests.
- C. Adjusting and Cleaning:
1. Clean luminaires of handling marks, dust and dirt.
  2. Cleaning and touch-up work shall be performed in accordance with luminaire manufacturer's recommendations.
  3. Damaged luminaires or components shall be replaced with new.
  4. Keep luminaires clean and protected for remainder of construction period.
  5. Verify orientation of directional luminaires prior to installation.
    - a. This includes wall washers, cove lighting, floodlights, exterior area lights and adjustable accent luminaires. Contractor shall provide electrician's services to aim, adjust, and focus luminaires, as required, at direction of Owner's Representative and shall be provided at no extra charge to Owner over base bid. Contractor shall provide equipment for luminaries' focus including ladders and mechanical lifting systems.
  6. Program preset dimming system lighting levels.
  7. Program ambient light sensors integral to luminaires for appropriate illumination levels as indicated in control narrative or in lighting control specifications.
  8. Program occupancy sensors integral luminaires for appropriate time delay as indicated in control narrative or in lighting control specifications.
  9. Exterior poles, bollards, bases and other exterior luminaires shall be painted to match factory color where finish has been damaged.
  10. No light leaks shall be permitted at ceiling line from any visible part or joint.
- D. Training
1. Contractor shall provide Owner's Representative with 3 complete copies of Operations and Maintenance manuals.
    - a. All "Approved as Noted" comments shall be corrected/picked-up in this record manual set.
    - b. Each manual shall contain specific information pertaining to the equipment installed. Each manual shall contain at a minimum:
      - 1) Detailed as built shop drawings for all lighting equipment installed.
      - 2) Manufacturer's product cut sheets for all equipment installed keyed by type as to  
as built drawings.
        - a) Luminaires

- b) Control gear/ballasts/drivers
    - c) Lamps
  - 3) Manufacturer's complete installation instructions for all equipment installed keyed by type to as built drawings.
    - a) Luminaires
    - b) Control gear/ballasts/drivers
    - c) Lamps
  - 4) Equipment maintenance requirements and schedules.
    - a) Luminaires
    - b) Control gear/ballasts/drivers
    - c) Lamps/LEDs
  - 5) Equipment manufacturer contacts.
    - a) Luminaires
    - b) Control gear/ballasts/drivers
    - c) Lamps/LED modules
  - 6) Equipment manufacturer warranties.
    - a) Luminaires
    - b) Control gear/ballasts/drivers
    - c) Lamps/LED modules
- 2. Contractor shall provide qualified personnel onsite to provide a minimum of three days of training to Owner's representatives.
- 3. This training shall cover:
  - a. Luminaire use and maintenance
  - b. Architectural lighting system use and maintenance
  - c. Group relamping cycles

**END OF SECTION 26 50 00**

## **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.
- B. American Society for Testing and Materials (ASTM).
- 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. Luminaires 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 luminaires 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.
- D. Spare parts: Provide 1% or minimum of 1 fixture head for each type of fixture installed.

#### **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**