

**SECTION 26 11 16
SECONDARY UNIT SUBSTATIONS**

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, connection, and testing of the secondary unit substations, referred to as substation(s) in this section.

1.2 RELATED WORK

- A. Section 03 30 00, CAST-IN-PLACE CONCRETE: Requirements for concrete equipment pads.
- B. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Requirement for seismic restraint for nonstructural components.
- C. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.
- D. Section 26 05 13, MEDIUM-VOLTAGE CABLES: Medium-voltage cables.
- E. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low-voltage conductors.
- F. 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.
- G. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits.
- H. Section 26 05 73, OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY: Short circuit and coordination study, and requirements for a coordinated electrical system.
- I. Section 26 23 00, LOW-VOLTAGE SWITCHGEAR: Switchgear for use in secondary unit substations.
- J. Section 26 24 13, DISTRIBUTION SWITCHBOARDS: Distribution switchboards for use in secondary unit substations.
- K. Section 26 25 11, BUSWAYS: Busways and fittings.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 FACTORY TESTS

- A. Substations shall be thoroughly tested at the factory to assure that there are no electrical or mechanical defects. Tests shall be conducted per UL and ANSI Standards. Factory tests shall be certified. The following tests shall be performed:

1. Medium-Voltage Section: Refer to Section 26 13 13, MEDIUM-VOLTAGE CIRCUIT BREAKER SWITCHGEAR.
1. Transformer Section:
 - a. Perform insulation-resistance tests winding-to-winding and each winding-to-ground.
 - b. Perform turns-ratio tests at all tap positions.
2. Low-Voltage Section: Refer to Section 26 23 00, LOW-VOLTAGE SWITCHGEAR.
- B. Furnish four (4) copies of certified manufacturer's factory test reports to the COR prior to shipment of the substations to ensure that the switchgear has been successfully tested as specified.
- C. The Government shall have an option to witness the factory tests. All expenses of the Government Representative's trips to witness the testing will be paid by the Government. Notify the COR not less than 30 days prior to making tests at the factory.//

1.5 SUBMITTALS

- A. Submit six copies of the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
 1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - b. Prior to fabrication of substations, submit the following data for approval:
 - 1) Complete electrical ratings, including primary and secondary voltage, decibel rating, temperature rise, nominal impedance, voltage regulation, and no load and full load losses.
 - 2) Nameplate data.
 - 3) Elementary and interconnection wiring diagrams.
 - 4) Technical data for each component.
 - 5) Dimensioned exterior views of the substations.
 - 6) Dimensioned section views of the substations.
 - 7) Floor plan of the substations.
 - 8) Foundation plan for the substations.
 - 9) Provisions and required locations for external conduit and wiring entrances.
 - 10) Approximate design weights.
 - c. Certification from the manufacturer that the substations have been seismically tested to International Building Code

requirements. Certification shall be based upon simulated seismic forces on a shake table or by analytical methods, but not by experience data or other methods.

2. Manuals:

- a. Submit, simultaneously with the shop drawings, complete maintenance and operating manuals, including technical data sheets, wiring diagrams, and information for ordering replacement parts.
 - 1) Include three-line diagrams showing device terminal numbers.
 - 2) Include schematic signal and control diagrams, with all terminals identified, matching terminal identification in the substation.
 - 3) Include information for testing, repair, troubleshooting, assembly, and disassembly.
- b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.

3. Test Reports:

- a. Submit certified factory design and production test reports for approval.
- b. Two weeks prior to the final inspection, submit certified field test reports.

4. Certifications: Two weeks prior to final inspection, submit the following:

- a. Certification by the manufacturer that substations conform to the requirements of the drawings and specifications.
- b. Certification by the Contractor that substations have been properly installed, adjusted, and tested.

1.6 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata), form a part of this specification to the extent referenced. Publications are referenced in the text by basic designation only.
- B. American Concrete Institute (ACI):
ACI 318-11.....Building Code Requirements for Structural Concrete.
- C. American Society for Testing and Materials (ASTM):

- D 117-10.....Standard Guide for Sampling, Test Methods, and
Specifications for Electrical Insulating Oils
of Petroleum Origin
- D 3487-09.....Standard Specification for Mineral Insulating
Oil Used in Electrical Apparatus.
- D. International Code Council (ICC):
 - IBC-12.....International Building Code
- E. Institute of Electrical and Electronic Engineers (IEEE):
 - C37.121-89American National Standard for Switchgear –
Unit Substations – Requirements
 - C57.12.00-00.....Standard General Requirements for Liquid-Filled
Distribution, Power, and Regulating
Transformers
 - C57.12.01-05.....Standard General Requirements for Dry-Type
Distribution and Power Transformers Including
Those with Solid-Cast and/or Resin Encapsulated
Windings
 - C62.11-05.....Metal Oxide Surge Arresters for AC Power
Circuits (> 1kV)
 - C62.41-91.....Surge Voltage in Low Voltage AC Power Circuits
- F. National Electrical Manufacturers Association (NEMA):
 - LA 1-09.....Surge Arresters
 - TP 1-02.....Guide for Determining Energy Efficiency for
Distribution Transformers
 - TR 1-00.....Transformers, Regulators, and Reactors
- G. National Fire Protection Association (NFPA):
 - 70-14.....National Electrical Code (NEC)

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Substations shall be in accordance with ANSI, ASTM, IEEE, NEC, UL, and as shown on the drawings.
- B. Substations shall be a unitized integral assemblies, complete, grounded, continuous-duty, metal-clad, dead-front, dead-rear, with liquid-filled transformer.
- C. Substations shall be designed, manufactured, and rated for indoor installation and service, with ventilation openings. External doors shall have provisions for padlocking.

- D. Substation ratings shall be not less than required by the NEC, and not less than shown on the drawings. Short circuit current ratings shall be not less than the available maximum short circuit currents as shown on the drawings.
- E. Substations shall conform to the arrangements and details shown on the drawings, and to the space designated for installation.
- F. Incorporate key-type mechanical interlock systems as required in as shown on the drawings.
- G. Substations shall be assembled and prewired by the manufacturer at the factory. Substations shall be sub-assembled and shipped in complete sections ready for connection at the site. Where practical, a substation shall be shipped as one unit.
- H. Substations shall be thoroughly cleaned, phosphate treated, and painted at the factory with light gray rust-inhibiting paint or baked enamel.

2.2 MEDIUM-VOLTAGE SECTION

- A. Provide medium voltage termination compartment with door Kirk Key (captive key) interlocked with primary breaker so that door cannot be opened unless breaker is locked out. Provide map directory on door to show location of breaker per NEC 450.14.

2.3 LIQUID-FILLED TRANSFORMERS

- A. Shall have the following features:
 - 1. Self-cooled by natural convection, with isolated windings.
 - 2. Auto-transformers will not be accepted.
 - 3. Ratings indicated are for continuous-duty without the use of cooling fans.
 - 4. Temperature rises shall not exceed the following NEMA Standard test values for the respective insulation systems: 65 degrees C (149 degrees F) by resistance and 80 degrees C (176 degrees F) hottest spot.
 - 5. Transformer insulating liquid shall be:
 - a. Less-flammable liquid: UL classified or FM approved less-flammable biodegradable liquid, having a fire point not less than 300 degrees C tested per ASTM D 92, and a dielectric strength not less than 33 kV tested per ASTM D 877.
 - 6. Nominal impedance shall not less than 4.5 percent.
 - 7. Sound levels shall conform to 3 dB below the NEMA standards.
 - 8. Primary and secondary windings:
 - a. Windings shall be copper.

- b. Primary windings shall be delta-connected.
 - c. Secondary windings shall be wye-connected except where otherwise shown on the drawings.
 - d. Leads shall be brought out through wet process, porcelain bushings, pressure-tight.
 - e. Secondary windings shall have neutral bushings for transformers with wye-connected secondary windings.
 - f. Terminals shall be the most suitable clamp or blade type as required for the circuit connections.
9. Provide four, 2-1/2 percent full capacity taps in the primary windings, with two taps above rated voltage and two taps below rated voltage.
10. Core and Coil Assemblies:
- a. Assemblies shall be rigidly braced to withstand the stresses caused by rough handling during shipment and the stresses caused by short circuit currents.
 - b. Cores shall be grain-oriented, non-aging, silicon steel.
 - c. Coils shall be continuous windings without splices except for taps.
 - d. Coil loss and core loss shall be optimized for efficient operation.
 - e. Primary, secondary, and tap connections shall be brazed or pressure type.
 - f. Coil windings shall have end fillers or tie downs.
11. Tanks, covers, and radiators shall be steel.
12. Features and accessories shall include the following:
- a. Tap changer.
 - b. Lifting, pulling, and jacking provisions.
 - c. Globe type valves for filtering and draining.
 - d. Grounding pad.
 - e. Dial-type liquid thermometer with a maximum reading pointer and an external reset.
 - f. Liquid level gauge.
 - g. Pressure relief device.
 - h. Diagrammatic nameplate, including date of manufacture.
 - i. Auxiliary cooling equipment and controls.
 - 1) Transformer shall have provisions for future addition of automatically controlled fans for forced-air cooling.

13. Transformer energy efficiency shall comply with DOE 2016 standards.

14. Factory Transformer secondary containment shall be factory form fitted to substation with 100 percent fluid containment without obstruction to work area. Provide removable gasketed front panels.

2.4 LOW VOLTAGE SECTION

A. Refer to Section 26 23 00, LOW-VOLTAGE SWITCHGEAR.

2.5 AUXILIARIES

- A. Install additional components as shown on the drawings or otherwise required for the substations.
- B. Provide liquid level gauges, pressure gauges, temperature monitoring and fluid containment leak alarms.
- C. Alarms to have remote contacts for remote connection to PMCS for high temperature and fluid leak.
- D. Provide temperature monitoring for remote connection to PMCS.

2.7 BATTERY SYSTEM

- A. Batteries for all primary and secondary breakers in transformer room:
 - 1. Provide high discharge rate type maintenance-free nickel-cadmium batteries. Battery voltage shall be 125 volts nominal. Calculate the battery capacity based on the lowest ambient temperature in the room where it is to be installed. Include a safety margin of 50 percent for reserve capacity.
 - a. Provide sufficient battery capacity to carry all continuous loads (lamps, relays, etc.) for 8 hours and then perform the greater of the following duties, with the charger de-energized.
 - 1) Trip all circuit breakers simultaneously or,
 - 2) Close the largest breaker in a line-up of four or less breakers, or close the two largest breakers simultaneously in a line-up of more than four breakers. Breaker closing current shall include both the spring release coil current and the starting current of the spring charging motor.
 - 2. Provide battery connector covers for protection against external short circuits.
 - 3. Provide corrosion-resistant steel battery racks.
 - 4. In seismic areas, batteries shall be secured to the battery rack to prevent overturning during a seismic event. Battery rack shall also be secured to the floor.
- B. Battery Charger:

1. Provide a charger of the full-wave rectifier type utilizing silicon controlled rectifiers as the power-control elements. Construction shall be modular with plug-in control units for easy replacement.
2. The charger shall maintain 1/2 of one percent voltage regulation from no load to full load for line voltage variation of 10 percent, and frequency variation of 3 Hz from 60 Hz.
3. The charger shall maintain a nominal float voltage of 1.4 vpc, and a nominal equalizing voltage of 1.5 vpc.
4. The charger shall be capable of continuous operation in an ambient temperature of 40 degrees C (104 degrees F) without derating. The charger shall be installed in a convection cooled NEMA Type 1 ventilated enclosure. The housing is to have a hinged front door with all equipment accessible from the front.
5. Provide both AC and DC transient protection. Charger shall be able to recharge a fully discharged battery without tripping AC protective devices. AC circuit breaker shall not trip under any DC load condition, including short circuit on output terminals.
6. The charger shall be capable of supplying the following demand simultaneously:
 - a. Recharging a fully discharged battery in 12 hours.
 - b. Supervisory panel and control panel.
 - c. Steady loads (indicating lamps, relays, etc.).
7. The charger shall have fused AC input and DC output protection.
8. The charger shall not discharge the batteries when AC power fails.
9. The charger shall have the following accessories:
 - a. On-off control switch with pilot light.
 - b. AC power failure alarm light.
 - c. High DC voltage alarm light.
 - d. Low DC voltage alarm light.
 - e. Ground detection switch and alarm light.
 - f. DC ammeter - 2 percent accuracy.
 - g. DC voltmeter - 2 percent accuracy: Float/equalize voltage marked in red on voltmeter.
 - h. Provisions for activation of remote annunciation of trouble for the above conditions.

2.8 NAMEPLATES AND MIMIC BUS

- A. Nameplates: For Normal Power system, provide laminated black phenolic resin with white core with 12 mm (1/2 inch) engraved lettered

nameplates to identify each circuit breaker and transformer. Nameplates shall indicate equipment served, spaces, or spares in accordance with one line diagram shown on drawings. Nameplates shall be mounted with plated screws on front of breakers or on equipment enclosure next to breakers. Mounting nameplates only with adhesive is not acceptable.

- B. Mimic Bus: Provide an approved mimic bus on front of each substation assembly. Color shall be black for the Normal Power system, either factory-painted plastic or metal strips. Plastic tape shall not be used. Use symbols similar to one line diagram shown on drawings. Plastic or metal strips shall be mounted with plated screws.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install substations in accordance with the NEC, as shown on the drawings, and as recommended by the manufacturer.
- B. Coordinate the components of the substations and their arrangements electrically and mechanically. Coordinate all circuit entrances into the substations, including methods of entrance and connections.
- C. Anchor substations with rustproof bolts, nuts, and washers not less than 13 mm (1/2 inch) diameter, in accordance with manufacturer's instructions, and as shown on the drawings.
- D. See specification section 13 05 51 Seismic Restraint Requirements for Non-Structural Components: substations shall be adequately anchored and braced to withstand the seismic forces at the location where installed.
- E. Interior Location. Mount substations on concrete slab. Unless otherwise indicated, the slab shall be at least 100 mm (4 inches) thick. The top of the concrete slab shall be approximately 100 mm (4 inches) above finished floor. Edges above floor shall have 15 mm (1/2 inch) chamfer. The slab shall be of adequate size to project at least 100 mm (8 inches) beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 75 mm (3 inches) above slab surface. Concrete work shall be as specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.
- F. Substation Grounding:

1. Provide bare copper cable not smaller than No. 4/0 AWG, interconnecting with the indicated grounding electrode system.

3.2 ACCEPTANCE CHECKS AND TESTS

A. Perform tests in accordance with the manufacturer's recommendations.

In addition, include the following:

1. Medium-Voltage Section Tests:

- a. Refer to Section 26 13 13, MEDIUM-VOLTAGE CIRCUIT BREAKER SWITCHGEAR.

2. Transformer Inspection and Tests:

- a. Compare equipment nameplate data with specifications and approved shop drawings.
- b. Inspect physical and mechanical condition. Check for damaged or cracked insulators and liquid leaks.
- d. Inspect all field-installed bolted electrical connections, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey after energization under load.
- e. Verify correct liquid level in transformer tank.
- f. Perform specific inspections and mechanical tests as recommended by manufacturer.
- g. Verify correct equipment grounding.
- h. Verify that the tap-changer is set at specified ratio.
- i. Verify proper secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.//

3. Low-Voltage Section Tests:

- a. Refer to Section 26 23 00, LOW VOLTAGE SWITCHGEAR.

3.3 FOLLOW-UP VERIFICATION

A. Upon completion of acceptance checks, settings, and tests, the Contractor shall demonstrate that the substations are in good operating condition and properly performing the intended function.

3.4 ONE LINE DIAGRAM AND SEQUENCE OF OPERATION

- A. At final inspection, an as-built one line diagram shall be laminated or mounted under acrylic glass, and installed in a frame mounted in the substation room or in the outdoor substation enclosure.
- B. Furnish a written sequence of operation for the substation and connected line side/load side electrical distribution equipment. The sequence of operation shall be laminated or mounted under acrylic

glass, and installed in a frame mounted in the substation room or in the outdoor substation enclosure.

- C. Deliver an additional four copies of the as-built one line diagram and sequence of operation to the COR.

3.6 INSTRUCTION

- A. Furnish the services of a factory-trained technician for one 4-hour training period for instructing personnel in the maintenance and operation of the substations, on the dates requested by the COR.

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