

**SECTION 26 11 16  
SECONDARY UNIT SUBSTATIONS**

SPEC WRITER NOTE: Delete between //----//  
if not applicable to project. Also,  
delete any other item or paragraph not  
applicable to the section and re-number  
the paragraphs.

**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 25 10 10, ADVANCED UTILITY METERING: Electric meters installed in substations.
- D. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.
- E. Section 26 05 13, MEDIUM-VOLTAGE CABLES: Medium-voltage cables.
- F. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low-voltage conductors.
- G. 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.
- H. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits.
- I. Section 26 05 73, OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY: Short circuit, coordination and arc-flash study, and requirements for a coordinated electrical system.
- J. Section 26 13 13, MEDIUM-VOLTAGE CIRCUIT BREAKER SWITCHGEAR: Medium-voltage circuit breaker switchgear for use in secondary unit substations.
- K. Section 26 13 16, MEDIUM-VOLTAGE FUSIBLE INTERRUPTER SWITCHES: Medium-voltage fusible interrupter switches for use in secondary unit substations.

- L. Section 26 23 00, LOW-VOLTAGE SWITCHGEAR: Switchgear for use in secondary unit substations.
- M. Section 26 24 13, DISTRIBUTION SWITCHBOARDS: Distribution switchboards for use in secondary unit substations.
- N. Section 26 25 11, BUSWAYS: Busways and fittings.

### 1.3 QUALITY ASSURANCE

- A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

### 1.4 FACTORY TESTS

- A. Factory Tests shall be required.
- B. Factory Tests shall be in accordance with Paragraph, MANUFACTURED PRODUCTS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirement:
  1. 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:
    - a. Medium-Voltage Section: Refer to //Section 26 13 16, MEDIUM-VOLTAGE FUSIBLE INTERRUPTER SWITCHES// //Section 26 13 13, MEDIUM-VOLTAGE CIRCUIT BREAKER SWITCHGEAR//.
    - b. Transformer Section:
      - 1) Perform insulation-resistance tests winding-to-winding and each winding-to-ground.
      - 2) Perform turns-ratio tests at all tap positions.
    - c. Low-Voltage Section: Refer to //Section 26 23 00, LOW-VOLTAGE SWITCHGEAR// //Section 26 24 13, DISTRIBUTION SWITCHBOARDS//.

### 1.5 SUBMITTALS

- A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:
  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.

SPEC WRITER NOTE: Include the following paragraph for projects in seismic areas of moderate-high, high and very high seismicities as listed in Table 4 of VA Handbook H-18-8, Seismic Design Requirements.

//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 318-14.....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 3487-16.....Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus.
- D. International Code Council (ICC):
  - IBC-15.....International Building Code
- E. Institute of Electrical and Electronic Engineers (IEEE):
  - C37.121-12 .....Guide for Switchgear - Unit Substations - Requirements
  - C57.12.00-15.....General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
  - C57.12.01-15.....General Requirements for Dry-Type Distribution and Power Transformers
  - C62.11-12.....Metal Oxide Surge Arresters for AC Power Circuits (> 1kV)
  - C62.41-91.....Recommended Practice on Surge Voltage in Low Voltage AC Power Circuits

F. National Electrical Manufacturers Association (NEMA):  
TR 1-13.....Transformers, Step Voltage Regulators and  
Reactors

G. National Fire Protection Association (NFPA):  
70-17.....National Electrical Code (NEC)

H. United States Department of Energy  
10 CFR Part 431.....Energy Efficiency Program for Certain  
Commercial and Industrial Equipment

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not applicable to the section and re-  
number the paragraphs.

**PART 2 - PRODUCTS**

**2.1 GENERAL REQUIREMENTS**

A. Unless otherwise specified, substations shall be in accordance with  
ANSI, ASTM, IEEE, NFPA, UL, 10 CFR Part 431, and as shown on the  
drawings.

SPEC WRITER NOTE: Designer shall choose  
liquid-filled or dry-type transformers to  
meet project requirements.

B. Substations shall be a unitized integral assemblies, complete,  
grounded, continuous-duty, metal-clad, dead-front, dead-rear, with  
//liquid-filled// //dry-type// transformer.

C. Substations shall be designed, manufactured, and rated for //outdoor//  
//indoor// installation and service, with ventilation openings //and  
gasketing provided to ensure a weatherproof assembly under rain, snow,  
sleet, and hurricane conditions//. 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  
//Section 26 13 13, MEDIUM-VOLTAGE CIRCUIT BREAKER SWITCHGEAR//,  
//Section 26 13 16, MEDIUM-VOLTAGE FUSIBLE INTERRUPTER SWITCHES//, and

//Section 26 23 00, LOW-VOLTAGE SWITCHGEAR// //Section 26 24 13, DISTRIBUTION SWITCHBOARDS//, 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. Medium-Voltage Fused Switch(es): Refer to Section 26 13 16, MEDIUM VOLTAGE FUSIBLE INTERRUPTER SWITCHES.//
- //B. Medium-Voltage Circuit Breaker(s): Refer to Section 26 13 13, MEDIUM-VOLTAGE CIRCUIT BREAKER SWITCHGEAR.//
- C. Interrupting ratings shall be not less than the maximum short circuit current available, as shown on the drawings.

Spec Writer Note: Select transformer type according to project requirements, with Government approval. In lieu of mineral oil, consider the use of biodegradable less-flammable liquids. If the load is anticipated to increase in the future, specify provisions for forced air cooling. Delete the paragraphs on liquid-filled transformers when dry-type transformers are specified

## **//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. Mineral oil: ASTM D 3487, Type II, tested in accordance with ASTM D 117.//
    - //b. 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.//
- //c. Silicone: UL classified or FM approved less-flammable, silicone-based 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 be as shown on the drawings, but not less than //4-1/2// // // 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.//
    - //2) Transformer shall be forced-air cooled. Forced-air cooling fans shall have cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm silencing relay.////
13. Transformer energy efficiency shall comply with the United States Department of Energy's 10 CFR Part 431.//

SPEC WRITER NOTE: Delete the paragraphs on dry-type transformers when liquid-filled transformers are specified.

**//2.4 DRY-TYPE TRANSFORMERS**

- A. Shall comply with IEEE C57.12.01, and IEEE C57.12.50 for dry-type transformers rated up to 500 kVA, and IEEE C57.12.51 for dry-type transformers rated 501 kVA and larger.

SPEC WRITER NOTE: Select either cast coil or vacuum pressure impregnated transformer.

- //B. Provide a cast coil type transformer with primary and secondary windings individually cast in epoxy. Transformer shall have an insulation system rated 185 degrees C, with an 80 degree C average winding temperature rise above a 40 degrees C maximum ambient.//
- //C. Provide a vacuum pressure impregnated (VPI) type transformer with an insulation system rated 220 degrees C, and with an 80 degree C average winding temperature rise above a 40 degrees C maximum ambient.//
- D. Transformer shall be rated // kVA// //kVA rating as shown on the drawings//, //60// //95// // // kV BIL primary and 10 kV BIL secondary.
- E. Primary and secondary windings:



1. Windings shall be copper.
  2. Primary windings shall be delta-connected.
  3. Secondary windings shall be wye-connected except where otherwise shown on the drawings.
  4. Secondary windings shall have neutral bushings for transformers with wye-connected secondary windings.
  5. Terminals shall be the most suitable clamp or blade type as required for the circuit connections.
- F. Provide four 2-1/2 percent full capacity taps, two above and two below rated primary voltage. Locate tap adjustments on the face of the medium voltage coil. Adjustments shall be accessible by removing the front panel and shall be made when the transformer is de-energized.
- G. Features and accessories shall include the following:
1. Winding temperature indicator.
  - //2. Auxiliary cooling equipment and controls.
    - //a. Transformer shall have provisions for future addition of automatically controlled fans for forced-air-cooling.//
    - //b. Transformer shall be forced-air-cooled. Forced-air-cooling fans shall have automatic temperature control relay and winding temperature indicator with sequence contacts.//
- H. Transformer energy efficiency shall comply with the United States Department of Energy's 10 CFR Part 431.//

## 2.5 LOW VOLTAGE SECTION

- //A. Refer to Section 26 23 00, LOW-VOLTAGE SWITCHGEAR.//
- //B. Refer to Section 26 24 13, DISTRIBUTION SWITCHBOARDS.//

## 2.6 AUXILIARIES

- A. Install additional components as shown on the drawings or otherwise required for the substations.

Spec Writer Note: Specify heaters when environmental conditions may exceed those required by the manufacturer.

- //B. Provide 120-volt heaters in// incoming section, // //dry-type transformer section, // //and// //outgoing section//. Heaters shall be of sufficient capacity to control moisture condensation in the compartments, shall be 250 watts minimum, and shall be controlled by a thermostat and humidistat located in each section. Thermostat shall be industrial type, high limit, to maintain compartments within the range of 15.5 to 32.2 degrees C (60 to 90 degrees F). Humidistat shall have

a range of 30 to 60 percent relative humidity. If heater voltage is different than substation secondary voltage, provide transformer rated to carry 125 percent of heater full load rating. Transformer shall have 220 degrees C insulation system with a temperature rise not exceeding 115 degrees C and shall conform to NEMA ST 20. Energize electric heaters while the substation is in storage or in place prior to being placed in service. Provide method for easy connection of heater to external power source.//

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// ---- // if not applicable to project.  
Also delete any other item or paragraph  
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number the paragraphs.

### **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. In seismic areas, substations shall be adequately anchored and braced per details on structural contract drawings to withstand the seismic forces at the location where installed.//

SPEC WRITER NOTE: Mounting slab connections may have to be given in detail depending on the requirements for the seismic zone in which the equipment is located. Include construction requirements for concrete slab only if slab is not detailed in drawings.

- E. Exterior Location. Mount substations on concrete slab. Unless otherwise indicated, the slab shall be at least 200 mm (8 inches) thick, reinforced with a 150 by 150 mm (6 inches by 6 inches) No. 6 mesh placed uniformly 100 mm (4 inches) from the top of the slab. Slab shall be placed on a 150 mm (6 inches) thick, well-compacted gravel base. The top of the concrete slab shall be approximately 100 mm (4 inches) above the finished grade. Edges above grade shall have 15 mm (1/2 inch) chamfer. The slab shall be of adequate size to project at

least 200 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. 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.

G. Substation Grounding:

1. Provide bare copper cable not smaller than No. 4/0 AWG, and not less than 610 mm (24 inches) below grade, interconnecting with the ground rods.
2. Surge arresters (if applicable) and neutral shall be bonded directly to the transformer enclosure, and then to the grounding electrode system with bare copper conductors, sized as shown on the drawings. Lead lengths shall be kept as short as practical with no kinks or sharp bends.

//3. Bonding connections to metallic fences shall not be smaller than No. 4 AWG. Ground fence at each gate post and cornerpost, and at intervals not exceeding 3 M (10 feet). Bond each gate section to the fence post through a 3 mm by 25 mm (1/8 inch by 1 inch) flexible braided copper strap and clamps.//

### **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 16, MEDIUM-VOLTAGE FUSIBLE INTERRUPTER SWITCHES// //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//.
- //c. Verify that cooling fans operate correctly and that fan motors have correct overcurrent protection.//
- 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.

SPEC WRITER NOTE: Remove paragraph below when dry-type transformers are specified.

- //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// //Section 26 24 13, DISTRIBUTION SWITCHBOARDS//.

### 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 TEMPORARY HEATING

- A. Apply temporary heat to substations, according to manufacturer's written instructions, throughout periods when the environment is not controlled for temperature and humidity within manufacturer's stipulated service conditions.

### 3.5 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 //Resident Engineer// //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 //Resident Engineer// //COR//.

---END---