

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

SPEC WRITER NOTE:

Delete between //----// if not applicable to project. This spec is applicable for transformers 2500 kVA and less, on 5 kV and 15 kV primary systems, with source not over 8.3 kV phase to ground. Any system higher than 15kV and 35kV or less is only allowed with VA approval.

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

- A. This section specifies the furnishing, installation, connection, and testing of the pad-mounted, liquid-filled, medium-voltage transformers, indicated as transformers in this section.

**1.2 RELATED WORK**

- //A. Section 03 30 00, CAST-IN-PLACE CONCRETE: Requirements for concrete equipment pads.//
- B. Section 09 06 00, SCHEDULE FOR FINISHES: Finishes for electrical equipment.
- //C. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Requirements for seismic restraint of non-structural components.//
- 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 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground currents.
- G. Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION: Manholes, pull-boxes, and ducts for underground raceway systems.
- H. Section 26 05 73, OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY: Short circuit and coordination study, and requirements for a coordinated electrical system.

**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. Transformers shall be thoroughly tested at the factory to ensure that there are no electrical or mechanical defects. Tests shall be conducted as per IEEE Standards. Factory tests shall be certified. The following tests shall be performed:
  - a. Perform insulation-resistance tests, winding-to-winding and each winding-to-ground.
  - b. Perform turns-ratio tests at all tap positions.

#### 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. Include electrical ratings, nameplate data, impedance, outline drawing with dimensions and front, top, and side views, weight, mounting details, decibel rating, termination information, temperature rise, no-load and full-load losses, regulation, overcurrent protection, connection diagrams, and accessories.
  - c. Complete nameplate data, including manufacturer's name and catalog number.

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. Coordinate with the structural engineer.

//d. Certification from the manufacturer that representative transformers 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. When submitting the shop drawings, submit companion copies of complete maintenance and operating manuals, including technical

data sheets, wiring diagrams, and information for ordering replacement parts.

- 1) Identify terminals on wiring diagrams to facilitate installation, maintenance, and operation.
  - 2) Indicate on wiring diagrams the internal wiring for each piece of equipment and interconnections between the pieces of equipment.
  - 3) Approvals will be based on complete submissions of manuals, together with shop drawings.
- 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.
- 1) Update the manual to include any information necessitated by shop drawing approval.
  - 2) Show all terminal identification.
  - 3) Include information for testing, repair, troubleshooting, assembly, disassembly, and recommended maintenance intervals.
  - 4) Provide a replacement parts list with current prices. Include a list of recommended spare parts, tools, and instruments for testing and maintenance purposes.

B. Certifications:

- 1. Two weeks prior to the final inspection, submit the following certifications.
  - a. Certification by the manufacturer that the transformers conform to the requirements of the drawings and specifications.
  - b. Certification by the Contractor that the transformers have been properly installed, connected, 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 designation only.

B. American Society for Testing and Materials (ASTM):  
D3487-16.....Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus

C. Institute of Electrical and Electronic Engineers (IEEE):  
48-20.....Test Procedures and Requirements for Alternating-Current Cable Terminations Used on

- Shielded Cables Having Laminated Insulation  
Rated 2.5kV Through 765kV or Extruded  
Insulation Rated 2.5kV Through 500kV
- 386-16.....Separable Insulated Connector Systems for Power  
Distribution Systems Above 600 V
- 592-18.....Insulation Shields on Medium-Voltage (15 kV -  
35 kV) Cable Joints and Separable Connectors
- C2-17.....National Electrical Safety Code
- C37.42-16.....Specifications for High-Voltage (>1000 V) Fuses  
and Accessories
- C57.12.00-21.....Liquid-Immersed Distribution, Power and  
Regulating Transformers
- C57.12.10-17.....Liquid-Immersed Power Transformers
- C57.12.25-90.....Pad-Mounted, Compartmental-Type, Self-Cooled,  
Single-Phase Distribution-Transformers with  
Separable Insulated High Voltage Connectors;  
High Voltage, 34500 Grd Y/19920 Volts and  
Below; Low-Voltage 240/120 Volts; 167 kVA and  
Smaller Requirements
- C57.12.28-14.....Pad-Mounted Equipment - Enclosure Integrity
- C57.12.29-14.....Pad-Mounted Equipment - Enclosure Integrity for  
Coastal Environments
- C57.12.34-15.....Pad-Mounted, Compartmental-Type, Self-Cooled,  
Three-Phase Distribution Transformers, 5 MVA  
and Smaller; High Voltage, 34.5 kV Nominal  
System Voltage and Below; Low Voltage, 15kV  
Nominal System Voltage and Below
- C57.12.90-21.....Test Code for Liquid-Immersed Distribution,  
Power, and Regulating Transformers
- C62.11-20.....Metal-Oxide Surge Arresters for AC Power  
Circuits
- D. International Code Council (ICC):  
IBC-21.....International Building Code
- E. National Electrical Manufacturers Association (NEMA):  
TR 1-13(R2019).....Transformers, Regulators, and Reactors
- F. National Fire Protection Association (NFPA):  
70-23.....National Electrical Code (NEC)
- G. Underwriters Laboratories Inc. (UL):

467-13.....Grounding and Bonding Equipment

H. United States Department of Energy (DOE):

10 CFR Part 431.....Energy Efficiency Program for Certain  
Commercial and Industrial Equipment

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

**PART 2 - PRODUCTS**

**2.1 GENERAL REQUIREMENTS**

- A. Transformers shall be in accordance with ASTM, IEEE, NFPA, UL, as shown on the drawings, and as specified herein. Each transformer shall be assembled as an integral unit by a single manufacturer.
- B. Transformers shall be complete, outdoor type, continuous duty, integral assembly, grounded, tamper-resistant, and with liquid-immersed windings.
- C. Ratings shall not be less than shown on the drawings.
- D. Completely fabricate transformers at the factory so that only the external cable connections are required at the project site.
- E. Thoroughly clean, phosphatize, and finish all the metal surfaces at the factory with a rust-resistant primer and dark green enamel finish coat, except where a different color is specified in Section 09 06 00, SCHEDULE FOR FINISHES. All surfaces of the transformer that will be in contact with the concrete pad shall be treated with corrosion-resistant compounds and epoxy resin or a rubberized sealing compound.

**2.2 COMPARTMENTS**

- A. Construction:
  - 1. Enclosures shall be weatherproof and in accordance with //IEEE C57.12.28// //IEEE C57.12.29 when installed in coastal environments//.
  - 2. The medium- and low-voltage compartments shall be separated with a steel barrier that extends the full height and depth of the compartments.
  - 3. The compartments shall be constructed of sheet steel (gauge to meet ANSI requirements) with bracing and with reinforcing gussets using jig welds to assure rectangular rigidity.
  - 4. All bolts, nuts, and washers shall be //zinc-plated//cadmium-plated// steel.

5. Sufficient space shall be provided for equipment, cabling, and terminations within the compartments.
6. Affix transformer nameplate permanently within the low-voltage compartment. Voltage and kVA rating, connection configuration, impedance, date of manufacture, and serial number shall be shown on the nameplate.

B. Doors:

1. Provide a separate door for each compartment with provisions for a single padlock to secure all doors. Provide each compartment door with open-position doorstops and corrosion-resistant tamperproof hinges welded in place. The medium-voltage compartment door shall be mechanically prevented from opening unless the low-voltage compartment door is open.
2. The secondary compartment door shall have a one-piece steel handle and incorporate three-point locking mechanisms.

SPEC WRITER NOTE: Include the following paragraph for projects containing five or more transformers. Delete if not applicable.

//3. Provide a 50 mm (2 inches) size padlock for each assembly, as approved by the //Resident Engineer// //COR//. Padlocks shall be keyed to the //Resident Engineer's// //COR's// established key set. Firmly attach the padlock to the door assembly by a chain.//

### 2.3 BIL RATING

SPEC WRITER NOTE: Edit the paragraphs below to conform to project requirements.

//A. 5 kV class equipment shall have a minimum 60 kV BIL rating.//  
 //B. 15 kV class equipment shall have a minimum 95 kV BIL rating.//  
 //C. 25 kV class equipment shall have a minimum 125 kV BIL rating.//  
 //D. 35 kV class equipment shall have a minimum 150 kV BIL rating.//

SPEC WRITER NOTE: The A/E shall determine the proper fuse assembly based on project requirements, transformer kVA and primary voltage ratings, existing facility equipment, and availability of new equipment.

### 2.4 TRANSFORMER FUSE ASSEMBLY

//A. The primary fuse assembly shall be a combination of externally replaceable Bay-O-Net liquid-immersed fuses in series with liquid-immersed current-limiting fuses.//

- //B. The primary fuse assembly shall be load-break combination fuse and dry-well fuse holder rated for system voltage, rated for 10 load makes and 10 load breaks, with rated 200 amp load current at 75% power factor, 10,000 symmetrical A close-in on fault duty, and 95 kV BIL. The entire fuse assembly shall be removable through the use of hot stick.
1. The fuses shall be concealed, hot stick removable, 50,000 A symmetrical interrupting, non-expulsion, current-limiting primary distribution type, of the size and voltage class as shown on the drawings. The fuses shall operate within the fuse holder as a unit disconnecting means. Fuses shall be in accordance with ANSI C37.47.
  2. Transformers shall not have internal "weak link" fuses that require transformer tank cover removal for replacement.
  3. For units above 500 kVA using fusing above the 50 A 15 kV and 100 A 5 kV application, a clip-mounted arrangement of the current limiting fuses (i.e., live-front configuration) is required.//

SPEC WRITER NOTE: Select the appropriate paragraph below.

## 2.5 PRIMARY CONNECTIONS

- //A. Primary connections shall be live-front bushings with NEMA spades or eyebolt terminals suitable for cable sizes shown on the drawings.//
- //A. Primary connections shall be //200 A dead-front loadbreak// //600 A deadbreak// wells and inserts for cable sizes shown on the drawings.//
- //B. Surge Arresters: Distribution class, one for each primary phase, complying with IEEE C62.11, supported from tank wall.//

SPEC WRITER NOTE: Select the appropriate paragraph below, for the type of switch (radial feed, or loop-feed T-blade or V-blade switch) and show on the drawings. For renovation projects, switch type shall match existing transformers.

## 2.6 MEDIUM-VOLTAGE SWITCH

- A. The transformer primary disconnect switch shall be an oil-immersed, internal, gang-operated, load-interrupter type, rated at ampacity and system voltage as shown on the drawings, with a minimum momentary withstand rating of not less than the calculated available fault current shown on the drawings.
- //B. For radial feeds, switch shall be a two-position, on-off, manual switch located in the medium-voltage compartment and hot-stick-operated.//

//B. For loop feeds, switch shall be a four-position, T-blade manual switch located in the medium-voltage compartment and hot-stick-operated.//

//B. For loop feeds, switch shall be a four-position, V-blade manual switch located in the medium-voltage compartment and hot-stick-operated.//

SPEC WRITER NOTE: Select the appropriate paragraph below.

## 2.7 MEDIUM-VOLTAGE TERMINATIONS

//A. Terminate the medium-voltage cables in the primary compartment with 200 A loadbreak premolded rubber elbow connectors, suitable for submersible applications. Elbow connectors shall have a semi-conductive shield material covering the housing. The separable connector system shall include the loadbreak elbow, the bushing insert, and the bushing well. Separable connectors shall comply with the requirements of IEEE 386, and shall be interchangeable between suppliers. Allow sufficient slack in medium-voltage cable, ground, and drain wires to permit elbow connectors to be moved to their respective parking stands.//

//A. Terminate the medium-voltage cables in the primary compartment with 600 A deadbreak premolded rubber elbow connectors, suitable for submersible applications. Elbow connectors shall have a semi-conductive shield material covering the housing. The separable connector system shall include the loadbreak elbow, the bushing insert, and the bushing well. Separable connectors shall comply with the requirements of IEEE 386, and shall be interchangeable between suppliers. Allow sufficient slack in medium-voltage cable, ground, and drain wires to permit elbow connectors to be moved to their respective parking stands.//

//A. Terminate the medium-voltage cables in the primary compartment with live-front connections with externally clamped porcelain bushings and cable connectors suitable for terminating medium-voltage cable.//

B. Ground metallic cable shield with a cable shield grounding adapter, consisting of a solderless connector enclosed in watertight rubber housing covering the entire assembly, bleeder wire, and ground braid.

## 2.8 LOW-VOLTAGE EQUIPMENT

SPEC WRITER NOTE: If secondary main molded case circuit breaker is provided, show trip and interrupting current ratings on the drawings.

A. Mount the //transformer secondary main molded case circuit breaker, //low-voltage bushings, and hot stick in the low-voltage compartment.

- B. The low-voltage leads shall be brought out of the tank by epoxy pressure tight bushings, and shall be standard arrangement.
- C. Tin-plate the low-voltage neutral terminal and isolate from the transformer tank. Provide a removable ground strap sized in accordance with the NEC and connect between the secondary neutral and ground pad.
- //D. Mount the main breaker off of the transformer tank to allow sufficient ventilation and ensure that the heat from the transformer tank will not be transmitted through conduction. Circuit breakers shall be of the ambient compensating-type, with interrupting ratings for the available fault current.//

## 2.9 TRANSFORMERS

SPEC WRITER NOTE: Edit the following paragraph to conform to project requirements.

- A. Transformer ratings shall be as shown on drawings. kVA ratings shown on the drawings are for continuous duty without the use of cooling fans.
- B. Temperature rises shall not exceed the NEMA TR 1 of 65° C (149° F) by resistance.

SPEC WRITER NOTE: Select the appropriate insulating liquid below.

- //C. Transformer insulating material shall be mineral oil in accordance with ASTM D 3487.//
- //C. Transformer insulating material shall be less flammable, edible-seed-oil based, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300° C (600° F) when tested according to ASTM D 92. Liquid shall be biodegradable and nontoxic.//
- //C. Transformer insulating material shall be less flammable, dielectric, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300° C (600° F) when tested according to ASTM D 92. Liquid shall be biodegradable and nontoxic.//
- //C. Transformer insulating material shall be less flammable, silicone-based dielectric, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300° C (600° F) when tested according to ASTM D 92. Liquid shall have low toxicity and be nonhazardous.//
- D. Transformer impedance shall be not less than 4-1/2% for sizes 150 kVA and larger. Impedance shall be as shown on the drawings.
- E. Sound levels shall conform to NEMA TR 1 standards.
- F. Primary and Secondary Windings for Three-Phase Transformers:

1. Primary windings shall be delta-connected.
  2. Secondary windings shall be wye-connected, except where otherwise indicated on the drawings. Provide isolated neutral bushings for secondary wye-connected transformers.
  3. Secondary leads shall be brought out through pressure-tight epoxy bushings.
- G. Primary windings shall have four 2-1/2% full-capacity voltage taps; two taps above and two taps below rated voltage.
- H. Core and Coil Assemblies:
1. Cores shall be grain-oriented, non-aging, silicon steel to minimize losses.
  2. Core and coil assemblies shall be rigidly braced to withstand the stresses caused by rough handling during shipment, and stresses caused by any possible short-circuit currents.
  3. Coils shall be continuous-winding type without splices except for taps. Material shall be copper.
  4. Coil and core losses shall be optimum for efficient operation.
  5. Primary, secondary, and tap connections shall be brazed or pressure type.
  6. Provide end fillers or tie-downs for coil windings.
- I. The transformer tank, cover, and radiator gauge thickness shall not be less than that required by ANSI.
- J. Accessories:
1. Provide standard NEMA features, accessories, and the following:
    - a. No-load tap changer. Provide warning sign.
    - b. Lifting, pulling, and jacking facilities.
    - c. Globe-type valve for oil filtering and draining, including sampling device.
    - d. Pressure relief valve.
    - e. Liquid level gauge and filling plug.
    - f. A grounding pad in the medium- and low-voltage compartments.
    - g. A diagrammatic nameplate.
    - h. Dial-type liquid thermometer with a maximum reading pointer and an external reset.
    - i. Hot stick. Securely fasten hot stick within low-voltage compartment.
  2. The accessories shall be made accessible within the compartments without disassembling trims and covers.

- K. Transformers shall meet the energy conservation standards for transformers per the United States Department of Energy 10 CFR Part 431.

SPEC WRITER NOTE: Include the following paragraph for loop systems only.

**//2.10 CABLE FAULT INDICATORS (LOOP SYSTEM ONLY):**

- A. Provide each incoming and outgoing cable within the medium-voltage compartment with a single-phase cable fault indicator with in-rush restraint. Mount the indicator on the cable support member.
1. The sensor assembly shall have a split-core for easy installation over the incoming and outgoing cable. The core shall be laminated, grain-oriented silicon steel, and encapsulated. Provide a clamp to secure the two coil halves around the cable.
  2. Select the coil to the pick-up at the current setting shown on the drawings.
    - a. The coil setting shall be accurate to within 10% of the pick-up.
    - b. The coil current-time curve shall coordinate with the primary current-limiting fuse.
- B. Upon restoration of the system to normal operating conditions, the cable fault indicator shall automatically reset to normal and be ready to operate.//

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

**PART 3 - EXECUTION**

**3.1 INSTALLATION**

- A. Install transformers outdoors, as shown on the drawings, in accordance with the NEC, and as recommended by the manufacturer.
- B. Anchor transformers with rustproof bolts, nuts, and washers not less than 12 mm (1/2 inch) diameter, in accordance with manufacturer's instructions, and as shown on drawings.
- //C. In seismic areas, transformers 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.

D. Mount transformers 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 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 12-1/2 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.

E. Grounding:

1. Ground each transformer in accordance with the requirements of the NEC. Install ground rods per the requirements of Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS, to maintain a maximum resistance of 5 ohms to ground.
2. Connect the ground rod to the ground pads in the medium- and low-voltage compartments.
3. Install and connect the cable shield grounding adapter per the manufacturer's instructions. Connect the bleeder wire of the cable shield grounding adapter to the loadbreak or deadbreak elbow grounding point with minimum No. 14 AWG wire, and connect the ground braid to the grounding system with minimum No. 6 AWG bare copper wire. Use soldered or mechanical grounding connectors listed for this purpose.

### **3.2 ACCEPTANCE CHECKS AND TESTS**

A. Perform manufacturer's required field tests in accordance with the manufacturer's recommendations. In addition, include the following:

1. Visual 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 bushings and liquid leaks.

- c. Verify that control and alarm settings on temperature indicators are as specified.
- d. Inspect all field-installed bolted electrical connections, using the calibrated torque-wrench method to verify tightness of accessible bolted electrical connections, and perform thermographic survey after energization under load.
- e. Vacuum-clean transformer interior. Clean transformer enclosure exterior.
- f. Verify correct liquid level in transformer tank.
- g. Verify correct equipment grounding per the requirements of Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.
- h. Verify the presence and connection of transformer surge arresters, if provided.
- i. Verify that the tap-changer is set at rated system voltage.

**3.3 FOLLOW-UP VERIFICATION**

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

**3.4 SPARE PARTS**

- A. Deliver the following spare parts for the project to the //Resident Engineer// //COR// two weeks prior to final inspection:
  - 1. Six insulated protective caps.
  - 2. One spare set of medium-voltage fuses for each size and type of fuse used in the project.

SPEC WRITER NOTE: Include the following paragraph as required to conform to project requirements.

//3. One spare set of three cable fault indicators.//

**3.5 INSTRUCTION**

- A. The Contractor shall instruct maintenance personnel, for not less than one 2-hour period, on the maintenance and operation of the equipment on the date requested by the //Resident Engineer// //COR//.

---END---