

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

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation and connection of padmounted transformers.
- B. Padmounted transformers shall be complete, outdoor type, continuous duty, integral assembly, grounded, tamper-resistant and weatherproof with liquid-immersed transformers.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements that are common to more than one section of Division 26.
- B. Section 26 05 71, ELECTRICAL SYSTEM PROTECTIVE DEVICE STUDY: Short circuit and coordination study.
- C. Section 26 05 13, MEDIUM-VOLTAGE CABLES: High voltage cables.
- D. Section 26 24 16, PANELBOARDS: Low voltage panelboards.
- E. Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION: Manholes, handholes and duct lines for underground raceway systems.
- 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.

1.3 SUBMITTALS

- A. In accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, submit the following:
- B. Shop Drawings:
 - 1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
 - 2. Include electrical ratings, nameplate data, impedance, dimensions, weight, mounting details, decibel rating, termination information, temperature rise, no load and full load losses, regulation, overcurrent protection, connection diagrams, and accessories.
 - 3. Complete nameplate data including manufacturer's name and catalog number.
- C. Manuals:
 - 1. Submit simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals including technical data sheets, wiring diagrams, and information for ordering replacement parts.

- a. Identify terminals on wiring diagrams to facilitate installation, maintenance and operation.
 - b. Indicate, on wiring diagrams, the internal wiring for each item of equipment and interconnections between the items of equipment.
 - c. Approvals will be based on complete submissions of manuals together with shop drawings.
- 2. Two weeks prior to the final inspection, submit four copies of the final up-dated maintenance and operation manuals to the Resident Engineer.
 - a. Update the manual to include any information necessitated by shop drawing approval.
 - b. Show all terminal identification.
 - c. Include information for testing, repair, trouble shooting, assembly, disassembly, and recommended maintenance intervals.
 - d. Provide a replacement parts list with current prices. Include a list of recommended spare parts, tools, and instruments for testing and maintenance purposes.
 - e. Furnish manuals in loose-leaf binder or manufacturer's standard binder.
- D. Certifications:
 - 1. Two weeks prior to the final inspection, submit four copies of the following certifications to the Resident Engineer:
 - a. Certification by the manufacturer that the equipment conforms to the requirements of the drawings and specifications.
 - b. Certification by the contractor that the padmounted transformers have been properly installed, connected and tested.

1.4 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 Concrete Institute (ACI):
 - 318-02.....Building Code Requirements for Structural Concrete
- C. American National Standards Institute (ANSI):
 - C37.47-00.....High Voltage Current-Limiting Type Distribution Class Fuses and Fuse Disconnecting Switches
 - C57.12.25-90.....Transformers-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
- C57.12.28-99.....Pad-Mounted Equipment Enclosure Integrity
- C57.12.29-99.....Switchgear and Transformers - Pad-Mounted
Equipment - Enclosure Integrity for Coastal
Environments
- D. American Society for Testing and Materials (ASTM):
- D3487-00.....Standard Specification for Mineral Insulating
Oil Used in Electrical Apparatus
- E. Institute of Electrical and Electronic Engineers (IEEE):
- 48-03.....Standard Test Procedures and Requirements for
Alternating Current Cable Terminations 2.5kV
Through 765kV
- 386-01.....Standard for Separable Insulated Connector
Systems for Power Distribution Systems Above
600V (ANSI/IEEE)
- 592-96.....Standard for Exposed Semiconducting Shields on
High Voltage Cable Joints and Separable
Insulated Connectors
- F. National Electrical Manufacturers Association (NEMA):
- C57.12.26-93.....Pad-Mounted, Compartmental-Type, Self-Cooled,
Three-Phase Distribution Transformers for Use
with Separable Insulated High-Voltage
Connectors, High-Voltage, 34500 Grd Y/19920
Volts and Below; 2500 kVA and Smaller TR1-93
Transformers, Regulators, and Reactors.
- G. National Fire Protection Association (NFPA):
- 70-05.....National Electrical Code (NEC)
- H. Underwriters Laboratories Inc. (UL):
- 467-93.....UL Standard for Safety Grounding and Bonding
Equipment

PART 2 - PRODUCTS

2.1 EQUIPMENT, GENERAL

- A. Equipment shall be in accordance with ANSI, ASTM, IEEE, NEMA, NFPA, UL,
as shown on the drawings and as hereinafter specified.
- B. Ratings shall not be less than shown on the drawings.
- C. Provide units designed to withstand the mechanical stresses caused by
rough handling during shipment in addition to the electrical and
mechanical stresses that may occur during operation.

- D. Completely fabricate units at the factory so that only the external cable connections are required at the job 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. All surfaces of the unit 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. The high and low voltage compartments and the transformer compartment shall be fabricated by a single manufacturer. The compartments and the transformer tank shall be assembled as an integral unit by a single manufacturer. Enclosures shall be in accordance with ANSI C57.12.28.
2. The high and low voltage compartments shall be separated with a steel barrier.
3. The compartments shall be constructed of sheet steel (gage to meet ANSI requirements) with bracing, reinforcing gussets and jig-welding to assure rectangular rigidity.
4. Use cadmium or zinc plated bolts, nuts and washers.
5. Sufficient space shall be provided for equipment, cabling and terminations in the compartments.
6. Affix the transformer instruction nameplate permanently to the unit within the low voltage compartment. Voltage ratings, 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 provision for a single padlock to secure the compartment area. The high voltage compartment door shall be prevented mechanically from opening, unless the low voltage door is opened.
2. The secondary compartment door shall have a one-piece steel handle and incorporate three-point locking mechanisms to assure a secure and tight door closing. Provide each compartment door with open-position doorstops and tamperproof hinges. The hinge assembly shall be made of corrosion-resistant material welded in place.
3. Provide a 50mm (2-inch) size padlock for each assembly as approved by the Chief Engineer. Padlocks shall be keyed to the Engineer's established key set. Firmly attach the padlock to the door assembly.

2.3 BIL RATING

- A. 15 kV class equipment shall have a minimum 95 kV BIL rating, unless otherwise specified.

2.4 TRANSFORMER FUSE ASSEMBLY

- A. The transformer primary fuse assembly shall be load break combination fuse and dry-well fuse holder rated for system voltage, for 10 load makes and 10 load breaks with rated 200 amp load current at 75 percent power factor, 10,000 symmetrical amperes 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 ampere symmetrical interrupting, 15 kV class, non-expulsion, current-limiting primary distribution type, size 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 requiring transformer tank cover removal for replacement.

2.5 PRIMARY CONNECTIONS

- A. Transformer primary connections shall be 200A deadfront load break wells and inserts for cable sizes shown on the drawings.

2.6 HIGH-VOTAGE SWITCHING

- A. The transformer primary selector switch for loop feed or primary selective systems shall be oil-immersed, internal, gang-operated, load break interrupters. Rating shall be 200 amperes with close-in on fault duty of 5,000 amperes symmetrical at 15 kV. The switch or switches shall be hot stick operated, and have the following selections:

| Position | Source A | Source B | Transformer |
|------------------------|----------|----------|-------------|
| 1 | X | O | X |
| 2 | O | O | O |
| 3 | O | X | X |
| 4 | X | X | X |
| X denotes connected | | | |
| O denotes disconnected | | | |

For primary selective systems, the switch or switches shall be mechanically designed to prevent connection of source A and B together.

2.7 HIGH VOLTAGE PREFORMED TERMINATIONS

- A. Terminate the high voltage cables in the high voltage compartment with load break premolded rubber elbow connectors. Elbow connectors shall

have a minimum of 3mm (0.125 inch) semi-conductive shield material covering the housing. Each connector shall be tested - prior to shipment from the factory.

- B. Ground metallic cable shields with a device designed for the purpose. It shall consist of a solderless connector enclosed in watertight rubber housing covering the entire assembly. The grounding device and elbow connector are to be of the same manufacturer to insure electrical integrity of shielded parts.
- C. Premolded parts shall be suitable for submersible applications.
- D. Elbow connectors shall be rated as follows:
 - 1. Voltage: 14.4 kV phase-to-phase.
 - 2. BIL: 95 kV.
 - 3. AC withstands: 34 kV, 60 Hz for 1 minute.
 - 4. DC withstands: 65 kV (field test rating).
 - 5. Corona voltage: 11 kV minimum.
 - 6. Continuous current: 200 amperes RMS.
 - 7. Short time current: 10,000 amperes for 12 cycles.
 - 8. Fault closure: 10,000 amperes RMS symmetrical for 10 cycles (after 10 loadmake/loadbreak operations at 200 amperes and 14.4 kV contact voltage).
 - 9. Switching: 10 loadmake/loadbreak operations at 200 amperes, 70-80 percent power factor, and 14.4 kV maximum recovery voltage between contacts.
- E. Interchangeability: The separable connector system shall include the loadbreak elbow, the bushing insert, and bushing well. Separable connectors shall comply with the requirements of IEEE 386, and shall be interchangeable between suppliers. Loadbreak elbow and bushing insert shall be from the same manufacturer.
- F. Allow sufficient slack in high voltage cable, ground, and drain wires to permit elbow connectors to be moved to their respective parking stands.
- G. Provide insulated cable supports to relieve any strain imposed by cable weight or movement.
- H. Lightning arrestor protection shall consist of one set of load break metal oxide elbow arrestors suitable for overvoltage protection of underground distribution system equipment and cables. Arrestors shall be rated 6KV (5.10KV MCOV). Arrange as T-Op connectors or deadbreak junctions to facilitate the bonding connection of the lightning arrestor ground lead.

2.8 LOW VOLTAGE EQUIPMENT

- 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 per ANSI
- 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 neutral and ground pad.
- D. Mount the main breaker off of the transformer tank to allow sufficient ventilation and assure that the heat from the transformer tank will not be transmitted through conduction. Circuit breakers shall be of the ambient compensating type, and have interrupting ratings for the available fault current.

2.9 TRANSFORMERS

- A. Transformers shall be three-phase, liquid-immersed, isolated winding, and self cooled by natural convection.
- B. The kVA ratings shown on the drawings are for continuous duty without the use of cooling fans.
- C. Temperature rises shall not exceed the NEMA TR1 standards of 65 degrees C by resistance, and 80 degrees C hot spot at rated kVA.
- D. Transformer insulating dielectric cooling material shall be a listed less-flammable fluid meeting the requirements of National Electrical Code Section 450.23 and the requirements of the National Electrical Safety Code (IEEE C2-1997), Section 15. The fluid shall be non-toxic, non-bioaccumulating, and be readily and completely biodegradable per EPA OPPTS 835.3100. It shall be comprised of edible oils and food grade performance enhancing additives and compliant with the U.S. Department of Agriculture (USDA) BioPreferred program. It shall result in zero mortality when tested on trout fry per OECD 203. It shall not require oils derived from genetically altered seeds. It shall be FM Approved and UL Classified. The fluid shall have a minimum open cup flash point of 300°C and a fire point of 340°C.
- E. Transformer impedance shall be not less than 4.5 percent for sizes 150 kVA and larger or as shown on the drawings.
- F. Sound levels shall conform to NEMA TR1 standards.
- G. 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.
- H. Primary windings shall have four 2-1/2 percent full capacity voltage taps; two taps above and two taps below rated voltage.
- I. Core and Coil Assemblies:
 1. Cores shall be grain-oriented, non-aging, and 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.
 4. Coil and core losses shall be optimum for the most efficient operation.
 5. Primary, secondary and tap connections shall be brazed or pressure type.
 6. Provide end fillers or tie downs for coil windings.
- J. The transformer tank, cover, and radiator gage thickness shall not be less than that outlined in ANSI.
- K. 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 gage and filling plug.
 - f. A grounding pad in the high and low voltage compartments.
 - g. A diagrammatic nameplate and operating instructions enclosed by a transparent cover located in the low voltage compartment.
 - 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.
- L. Liquid filled transformers shall meet the minimum energy efficiency values per NEMA TP1:

| KVA | (%) |
|-------|------|
| 75 | 98.1 |
| 112.5 | 98.3 |
| 150 | 99.0 |
| 225 | 99.0 |
| 300 | 99.0 |
| 500 | 99.1 |
| 750 | 99.2 |
| 1000 | 99.2 |
| 1500 | 99.3 |
| 2000 | 99.4 |
| 2500 | 99.4 |

2.10 CABLE FAULT INDICATORS

- A. Provide single-phase cable fault indicating equipment at locations indicated on the drawings. Provide holes for mounting fault indicator targets on the equipment cabinets for outside viewing without opening the cabinet.
 1. The sensor assembly shall have a split-core for easy installation over the cables. Provide a clamp to secure the two coil halves around the cable.
 - a. The core shall be laminated, grain-oriented silicon steel. The coil shall be encapsulated.
 2. Select the coil to pick up at the current setting shown on the drawings.
 - a. The coil setting shall be accurate to within 10 percent of pickup.
 - 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 its normal condition, ready to operate.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install transformers as shown on the drawings, in accordance with the NEC and as recommended by the equipment manufacturer.
- B. Foundation:
 1. Provide foundation of reinforced concrete, Type C, 21mPa (3000 psi minimum, 28 day compressive strength), and comply with the ACI 318.

2. Locate the top of foundation pads 150mm (6-inches) above the adjacent finished grade, unless otherwise shown on the drawings. Refer to drawings for size, location, and structural steel reinforcing required.
3. Grade the adjacent terrain so that surface water will flow away from the foundation.
4. Anchor the transformers with cadmium or zinc plated bolts, nuts and washers. Bolts shall not be less than 12mm (1/2-inch) diameter.

C. Grounding:

1. Ground each padmounted transformer in accordance with the requirements of the NEC. Install 19mm (3/4-inch) diameter by 3m (10 feet) long copper-clad ground rods, driven 3m (10 feet) below grade to maintain a maximum resistance of five ohms to ground. Thermitite weld the cable to the ground rods.
2. Connect the ground rod to the ground pads in the high and low voltage compartments, and to the secondary (and primary) neutral with not less than a 2/0 AWG bare copper conductor.
3. Refer to the section of the specifications describing GROUNDING for testing.
4. Independently connect cable shield grounding devices ground wires to ground with sufficient slack to permit elbow connector operation. Connect elbow connectors with a No. 14 AWG bare copper drain wire from its grounding eye to the related cable shield grounding device ground wire. Do not connect drain wires in any manner that will permit circulating currents, or cable fault currents, to pass through them.

3.2 SPARE PARTS

A. Deliver the following spare parts for the project to the Resident Engineer two weeks prior to final inspection:

1. Six stand-off insulators.
2. Six insulated protective caps.
3. One spare set of high voltage fuses for each size fuse used in the project.

3.3 INSTRUCTIONS

1. The contractor shall instruct VA maintenance personnel, for not less than one (1) 2-hour period, on the maintenance and operation of the equipment on the date requested by the Resident Engineer.

- - - E N D - - -