

SECTION 26 22 00
LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, connection, and testing of low-voltage dry-type general-purpose 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 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Requirements for seismic restraint of nonstructural components.
- C. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.
- D. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low-voltage conductors.
- E. 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.
- F. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduit.

1.3 QUALITY ASSURANCE

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

1.4 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. Include electrical ratings, dimensions, mounting details, materials, required clearances, terminations, weight, temperature rise, wiring and connection diagrams, plan, front, side, and rear elevations, accessories, and device nameplate data.
 2. Manuals:

- a. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals including technical data sheets and wiring diagrams.
 - 1) Schematic signal and control diagrams, with all terminals identified, matching terminal identification in the transformers.
 - 2) Include information for testing, repair, troubleshooting, assembly, disassembly, and factory recommended/required periodic maintenance procedures and frequency.
- 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. Certifications: Two weeks prior to final inspection, submit the following.
 - 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, adjusted, and tested.

1.5 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. International Code Council (ICC):
IBC-15.....International Building Code
- C. National Fire Protection Association (NFPA):
70-14.....National Electrical Code (NEC)
- D. National Electrical Manufacturers Association (NEMA):
TR 1-13.....Transformers, Step Voltage Regulators and
Reactors
ST 20-14.....Dry Type Transformers for General Applications
- E. Underwriters Laboratories, Inc. (UL):
UL 506-08.....Standard for Specialty Transformers
UL 1561-11.....Dry-Type General Purpose and Power Transformers
- F. United States Department of Energy

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

PART 2 - PRODUCTS

2.1 TRANSFORMERS

- A. Unless otherwise specified, transformers shall be in accordance with NEMA, NEC, UL and as shown on the drawings.
- B. Transformers shall have the following features:
 - 1. Self-cooled by natural convection, isolating windings, indoor dry-type. Autotransformers will not be accepted, except as specifically allowed for buck-boost applications.
 - 2. Rating and winding connections shall be as shown on the drawings.
 - 3. Ratings shown on the drawings are for continuous duty without the use of cooling fans.
 - 4. Copper windings.
 - 5. Insulation systems:
 - a. Transformers 30 kVA and larger: UL rated 220 °C (428 °F) system with an average maximum rise by resistance of 150 °C (302 °F) in a maximum ambient of 40 °C (104 °F).
 - b. Transformers below 30 kVA: Same as for 30 kVA and larger or UL rated 185 °C (365 °F) system with an average maximum rise by resistance of 115 °C (239 °F) in a maximum ambient of 40 °C (104 °F).
 - 6. Core and coil assemblies:
 - a. Rigidly braced to withstand the stresses caused by short-circuit currents and rough handling during shipment.
 - b. Cores shall be grain-oriented, non-aging, and silicon steel.
 - c. Coils shall be continuous windings without splices except for taps.
 - d. Coil loss and core loss shall be minimized for efficient operation.
 - e. Primary and secondary tap connections shall be brazed or pressure type.
 - f. Coil windings shall have end filters or tie-downs for maximum strength.
 - 7. Average audible sound levels shall comply with NEMA.

8. If not shown on drawings, nominal impedance shall be as permitted by NEMA.
9. Single phase transformers rated 15 kVA through 25 kVA shall have two 5% full capacity taps below normal rated primary voltage. All transformers rated 30 kVA and larger shall have two 2.5% full capacity taps above, and four 2.5% full capacity taps below normal rated primary voltage.
10. Core assemblies shall be grounded to their enclosures with adequate flexible ground straps.
11. Enclosures:
 - a. Comprised of not less than code gauge steel.
 - b. Outdoor enclosures shall be NEMA 3R.
 - c. Temperature rise at hottest spot shall conform to NEMA Standards and shall not bake and peel off the enclosure paint after the transformer has been placed in service.
 - d. Ventilation openings shall prevent accidental access to live components.
 - e. The enclosure at the factory shall be thoroughly cleaned and painted with manufacturer's prime coat and standard finish.
12. Standard NEMA features and accessories, including ground pad, lifting provisions, and nameplate with the wiring diagram and sound level indicated.
13. Dimensions and configurations shall conform to the spaces designated for their installations.
14. Transformers shall meet the energy conservation standards for transformers per the United States Department of Energy's 10 CFR Part 431.

2.2 NONLINEAR TRANSFORMERS - NOT USED

2.3 ENERGY SAVING HARMONIC CANCELLATION TRANSFORMERS - NOT USED

2.4 BUCK-BOOST TRANSFORMERS - NOT USED

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation of transformers shall be in accordance with the NEC, as recommended by the equipment manufacturer and as shown on the drawings.

- B. Anchor transformers with rustproof bolts, nuts, and washers, in accordance with manufacturer's instructions, and as shown on drawings.
- C. Install transformers with manufacturer's recommended clearance from wall and adjacent equipment for air circulation. Minimum clearance shall be 150 mm (6 inches).
- D. Install transformers on vibration pads designed to suppress transformer noise and vibrations.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform 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.
- c. Inspect all field-installed bolted electrical connections, using the calibrated torque-wrench method to verify tightness of accessible bolted electrical connections.
- d. Perform specific inspections and mechanical tests as recommended by manufacturer.
- e. Verify correct equipment grounding.
- f. Verify proper secondary phase-to-phase and phase-to-neutral voltage after energization and prior to connection to loads.

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.

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

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 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground currents.
- F. Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION: Manholes, pull-boxes, and ducts for underground raceway systems.
- G. 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. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 FACTORY TESTS

- A. 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:
1. Perform insulation-resistance tests, winding-to-winding and each winding-to-ground.
 2. Perform turns-ratio tests at all tap positions.

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B. Factory test shall comply with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, factory test.

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. 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.

2. Manuals:

- a. At closeout, submit companion 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.
 - 4) Include information for testing, repair, troubleshooting, assembly, disassembly, and recommended maintenance intervals.
 - 5) 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.

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- 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 National Standards Institute (ANSI):
- C37.47-11.....High Voltage Distribution Class Fuses Current-Limiting Type Fuses and Fuse Disconnecting Switches
- C. American Society for Testing and Materials (ASTM):
- D3487-09.....Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus
- D. Institute of Electrical and Electronic Engineers (IEEE):
- 48-09.....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
- 386-06.....Separable Insulated Connector Systems for Power Distribution Systems Above 600 V
- 592-07.....Exposed Semiconducting Shields on High-Voltage Cable Joints and Separable Connectors
- C2-12.....National Electrical Safety Code
- C57.12.00-10.....Liquid-Immersed Distribution, Power and Regulating Transformers
- C57.12.10-10.....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

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C57.12.29-14.....Pad-Mounted Equipment - Enclosure Integrity for
Coastal Environments

C57.12.34-09.....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

C57.12.90-10.....Test Code for Liquid-Immersed Distribution,
Power, and Regulating Transformers

C62.11-12.....Metal-Oxide Surge Arresters for AC Power
Circuits

E. International Code Council (ICC):

IBC-15.....International Building Code

F. National Electrical Manufacturers Association (NEMA):

TR 1-13.....Transformers, Regulators, and Reactors

G. National Fire Protection Association (NFPA):

70-14.....National Electrical Code (NEC)

H. Underwriters Laboratories Inc. (UL):

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

I. United States Department of Energy (DOE):

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

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Transformers shall be in accordance with ANSI, ASTM, IEEE, NEMA, 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,

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

2.3 BIL RATING

- A. 15 kV class equipment shall have a minimum 95 kV BIL rating.

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2.4 TRANSFORMER FUSE ASSEMBLY - NOT USED

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.
- B. Surge Arresters: Distribution class, one for each primary phase, complying with IEEE C62.11, supported from tank wall.

2.6 MEDIUM-VOLTAGE SWITCH - NOT USED

2.7 MEDIUM-VOLTAGE TERMINATIONS

- 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

- A. The low-voltage leads shall be brought out of the tank by epoxy pressure tight bushings, and shall be standard arrangement.
- B. 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.

2.9 TRANSFORMERS

- 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.
- 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.

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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.

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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.

2.10 CABLE FAULT INDICATORS (LOOP SYSTEM ONLY): - NOT USED

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. 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.
- D. 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

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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 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.

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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 COR.

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