**SECTION 26 12 13**

**MEDIUM-VOLTAGE TRANSFORMERS, LIQUID-FILLED, SUBSTATION STYLE (INDOOR)**

**BASED ON DFD MASTER ELECTRICAL SPEC DATED 03/01/23**

This section has been written to cover most (but not all) situations that you will encounter. Depending on the requirements of your specific project, you may have to add material, delete items, or modify what is currently written. The Division of Facilities Development expects changes and comments from you.

**PART 1 - GENERAL**

**SCOPE**

The work under this section includes indoor substation type, liquid-filled, medium voltage distribution transformers. Included are the following topics:

PART 1 - GENERAL

 Scope

 Related Work

 Reference Standards

 Submittals

 Operation and Maintenance Data

 Quality Assurance

PART 2 – PRODUCTS

 General Requirements

 Approvals

 Ratings

 Insulating Fluid

 Construction

 High Voltage Terminations

 Low Voltage Terminations

 Overcurrent Protection

 Over-voltage Protection

 Accessories

 Labeling

 Locks

PART 3 - EXECUTION

 Examination

 Field Assembly

 Installation

 Field Quality Control

 Adjusting

 Construction Verification Items

 Agency Training

RELATED WORK

Applicable provisions of Division 1 govern work under this Section.

Section 01 91 01 or 01 91 02 – Commissioning Process

**REFERENCE STANDARDS**

Transformers shall conform to the most recent edition of the following standards.

C57.12.00 - IEEE Standard for General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers

C57.12.10 - IEEE Standard Requirements for Liquid-Immersed Power Transformers

C57.12.36 - IEEE Standard Requirements for Liquid-Immersed Distribution Substation Transformers

C57.12.70 - IEEE Standard for Standard Terminal Markings and Connections for Distribution and Power Transformers

C57.12.80 - IEEE Standard Terminology for Power and Distribution Transformers

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

FM 3990 – Approval Standard for Less or Nonflammable Liquid-Insulated Transformers

U.S. Department of Energy (DOE) CFR Title 10, Chapter II, Subchapter D, Part 431, Subpart K - Distribution Transformers.

**SUBMITTALS**

Shop Drawings

Provide overall dimensions of transformer enclosure and air terminal cabinets showing front, side, and plan views, primary and secondary termination location, conduit entry location, and unit weight.

Electrical data shall include kVA, voltage, temperature rise, winding and tap configurations, impedance ratings and characteristics, loss data and efficiency at 25, 50, 75 and 100 percent rated load, nameplate data, and single-line and three-line diagrams.

Include manufacturer's installation instructions.

Factory Certified Tests

A certified test report shall be submitted for the transformer being supplied. The transformer serial number shall be noted in the report. The following factory certified tests shall be performed:

1. No-Load losses at rated voltage.
2. Total losses at rated current.
3. Percent Impedance at rated current.
4. Excitation Current (100 percent voltage) test.
5. Winding Resistance measurement tests for each winding at the rated voltage tap.
6. Ratio Tests using all tap settings.
7. Polarity and Phase relation tests.
8. Induced potential tests.
9. Full wave and Reduced wave impulse test.
10. Applied potential test shall be made on all high and low voltage windings to ground.

# OPERATION AND MAINTENANCE DATA

All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS and specification Section 01 91 01 or 01 91 02.

**QUALITY ASSURANCE**

Manufacturer: Company specializing in distribution transformers with minimum ten years of experience manufacturing liquid-filled transformers.

**PART 2 - PRODUCTS**

**GENERAL REQUIREMENTS**

Description: Three-phase, substation style, liquid-filled medium voltage distribution transformers suitable for locating in an indoor environment.

All transformers 2500 kVA and below shall meet the U.S. Department of Energy (DOE) minimum efficiency levels for distribution transformers as mandated in CFR Title 10, Chapter II, Subchapter D, Part 431, Subpart K - Distribution Transformers.

All characteristics, definitions, and terminology, except as specifically covered in this specification, shall be in accordance with the latest revision of ANSI, IEEE and NEMA standards.

The liquid-filled distribution transformer shall be rated and configured in accordance with the one-line diagram, and shall conform to the following specification.

***Specify the correct operating voltage for the site and delete the others.***

The transformer is intended for use on a three-phase, solidly grounded wye distribution system operating at [4160Y/2400] [12470Y/7200] [13800Y/7970] volts.

**APPROVALS**

The transformer shall be UL Listed and Factory Mutual (FM) Approved and shall conform to the requirements of NEC 450-23.

**RATINGS**

Capacity: [\_\_\_\_\_] kVA [size as shown on drawings]

Primary Voltage: [\_\_\_\_\_] kV [as shown on drawings]

Primary Winding Connection: Delta

Secondary Voltage: [480Y/277] [208Y/120] volts [as shown on drawings]

Secondary Winding Connection: Grounded Wye with the low voltage neutral brought out to a fully insulated X**o** bushing.

***Use 60 kV BIL for 5 kV class transformers and 95 kV for 15 kV class transformers. Coordinate with manufacturer and DFDM reviewer if these values cannot be met.***

Primary Voltage Basic Impulse Level (BIL): [ ] [60] [95] kV

Secondary Voltage Basic Impulse Level (BIL): 30 kV

Primary Winding Taps:

Each transformer shall be furnished with full capacity high-voltage taps. Each tap changer shall be clearly labeled to reflect that the transformer must be de-energized before operating the tap changer. The tap changer switch shall be an externally operated, snap-action switch with padlocking provisions. The unit shall have the following tap configuration:

Two 2-1/2 percent taps above and two 2-1/2 percent taps below rated voltage (split taps).

Temperature Rise:

***Specify one of the following two options based on loading duty.***

 [The transformer shall have a 65 oC average winding temperature rise rating. The average winding temperature rise shall not exceed 65 oC when loaded at the base kVA rating.]

[The transformer shall have a 55/65 oC average winding temperature rise rating. The average winding temperature rise shall not exceed 55 oC when loaded at the base kVA rating. The transformer shall provide an additional 12% capacity at the 65 oC rating.]

Cooling Class:

***Specify one of the following two options based on loading duty. The first option is preferred.***

[The transformer shall be cooled by the natural circulation of air over the tank surface and radiators with a cooling classification of KNAN.]

[The transformer shall be cooled by the natural circulation of air over the tank surface, with an additional 15% (750-2000 KVA) or 25% (2500 – 3500 KVA) rating obtained by forced air circulated over the radiator with a cooling classification of KNAN/KNAF. All cooling and control equipment shall be included with the transformer. The auxiliary power circuit for the cooling equipment shall be provided by the installing contractor.]

Impedance:

5.75% nominal with IEEE standard tolerance of +/- 7.5% of nominal

Frequency: 60 Hertz

**INSULATING FLUID**

The dielectric fluid shall be a listed less-flammable fluid meeting the requirements of NEC 450-23, including a minimum fire point of 300 degrees C. The fluid shall be biodegradable and non-toxic. The fluid shall be Factory Mutual Approved and UL Classified, Envirotemp FR3 fluid or equal.

**CONSTRUCTION**

The transformers shall be indoor substation type with sidewall mounted primary and secondary terminations located on opposite sides of the transformer.

The transformer windings shall be copper or aluminum.

The core and coil shall be vacuum processed to ensure maximum penetration of insulating fluid into the coil insulation system. While under vacuum, the windings will be energized to heat the coils and drive out moisture, and the transformer will be filled with preheated filtered degassed insulating fluid. The core shall be manufactured from burr-free, grain-oriented silicon steel and shall be precisely stacked to eliminate gaps in the corner joints.

The transformer shall be of sealed tank construction of sufficient strength to withstand a pressure of 7 psig without permanent distortion, and 15 psig without rupturing. The tank shall include a pressure relief valve with a flow at 15 psig of 35 SCFM minimum, or as required to meet the listing of the fluid.

The tank shall be welded using precision cut, cold-rolled steel and equipped with extra-heavy duty, welded-in-place lifting lugs and jacking pads. The tank base must be designed to allow skidding or rolling in any direction.

***Specify one of the following two options based on pathway space.***

[Panel type radiators shall be welded directly to the tank.]

[Panel type radiators shall be attached to the tank with bolted and gasketed flanges. The radiators shall be removable to aid in the installation and removal of the transformer. Provide shut-off valves ahead of the bolted connections.]

The exterior of the unit shall be painted ANSI #61 Light Gray in color.

**HIGH VOLTAGE TERMINATIONS**

The high voltage terminations shall be deadfront type and consist of three (3) sidewall mounted 15kV, 600A deadbreak one piece bushings arranged for radial feed configuration. The transformer shall be provided with three (3) 600A deadbreak connectors containing a 200A loadbreak tap and three (3) deadfront elbow surge arresters for installation on the connector tap.

***Specify one of the following two options based on desired primary cable entry point.***

[Provide a full height air terminal chamber (ATC) arranged for bottom entry cables with ample width for bending cables and ample depth to accommodate the elbow surge arresters mounted on the connector taps. Access shall be via a hinged door with provisions for a padlock.]

[Provide a full height air terminal chamber (ATC) arranged for top entry cables with ample width for bending cables and ample depth to accommodate the elbow surge arresters mounted on the connector taps. Access shall be via a hinged door with provisions for a padlock.]

**LOW VOLTAGE TERMINATIONS**

The low-voltage line and neutral bushings shall be sidewall-mounted with NEMA spade-type low voltage terminals.

The low voltage neutral shall be fully insulated with a removable ground strap.

The low voltage bushings shall be located on the opposite side of the transformer from the high-voltage terminals.

***Specify one of the following three options based on desired connection method to secondary switchboard.***

[Provide a transition flange for coupling to the secondary switchboard. Coordinate the termination and flange dimensions with the switchboard manufacturer.]

[Provide a partial height air terminal chamber arranged for bottom entry cables with ample room for bending cables.]

[Provide a partial height air terminal chamber arranged for top entry cables with ample room for bending cables.]

**OVERCURRENT PROTECTION**

***The Bay-O-Net type fusing is only available for transformers with a rated primary current of less than 125 amps. Therefore, Bay-O-Net fusing is only available for 4160V transformers rated 750 kVA and below, and 12.47 kV or 13.8 kV transformers rated 2500 kVA and below. Delete the following paragraph on Bay-O-Net fusing if the transformer size is larger than that indicated above.***

[The transformer primary shall include an externally removable loadbreak Bay-O-Net assembly with a flapper valve to minimize oil spillage. Overcurrent protection shall be provided by a two fuse-scheme utilizing a Bay-O-Net expulsion fuse in series with an under-oil current limiting backup fuse. The fusing scheme shall provide a full range of overcurrent protection.]

***Delete the following paragraph if Bay-O-Net fusing above is specified.***

[The transformer overcurrent protection will be provided by fuses in a separate upstream switchgear unit.]

**OVER-VOLTAGE PROTECTION**

Primary over-voltage protection shall be provided by externally mounted, deadfront elbow MOV surge arrestors mounted on the connector loadbreak tap. Elbow surge arresters shall be distribution class and meet the following ratings:

***Choose the applicable voltage rating and delete the others.***

[4160Y/2400 volt solidly grounded distribution system ratings: 3 kV duty rated, 2.55 kV MCOV, maximum discharge voltage at 10 kA (8 X 20 microsecond current wave) - 11.4 kV crest maximum.]

[12470Y/7200 volt solidly grounded distribution system ratings: 9 kV duty rated, 7.65 kV MCOV, maximum discharge voltage at 10 kA (8 X 20 microsecond current wave) - 32.8 kV crest maximum.]

[13800Y/7970 volt solidly grounded distribution system ratings: 10 kV duty rated, 8.40 kV MCOV, maximum discharge voltage at 10 kA (8 X 20 microsecond current wave) - 34.1 kV crest maximum.]

**ACCESSORIES**

The following accessories shall be provided:

* Full capacity containment pan to capture any insulating fluid that may escape from the transformer tank or radiators. The pan shall form-fit the transformer and provide 100% fluid containment. The pan shall be painted to match the transformer, contain a drain plug and a removable, gasketed front panel.
* Lifting lugs (4)
* 1-inch upper fill plug
* 1-inch drain valve with sampling device
* Automatic pressure relief device
* Liquid Level Gauge
* Dial Type Thermometer
* Pressure/Vacuum Gauge
* Stainless steel NEMA 2-hole ground pad in secondary compartment
* Pre-drilled copper ground busbar in primary compartment. Busbar shall be ¼” thick by 4” wide and sized to accommodate (4) one-hole compression connectors (0.28” diameter holes) and (4) two-hole compression connectors (0.44” diameter holes with 1.00” spacing).

**LABELING**

Hazard-Alerting Signs:

The transformer shall be provided with all required NEMA safety labels.

Nameplates, Ratings Labels, and Connection Diagrams:

The transformer shall be provided with an engraved nameplate indicating the manufacturer’s name, catalog and model number, serial number, manufacture date, and equipment ratings.

**LOCKS**

The installing contractor shall provide a padlock for the air terminal chamber door(s) and no-load tap changer handle. Padlock shall match user agency’s present padlocks and be keyed per user agency requirements. Coordinate and confirm padlock information with the facility maintenance personnel.

**PART 3 - EXECUTION**

**EXAMINATION**

Verify field measurements are as shown on Drawings.

Beginning of installation means installer accepts conditions.

**FIELD ASSEMBLY**

If the transformer is shipped or moved into place with the radiators detached, provide the services of a factory trained and certified technician to install the radiators and fill the unit with insulating fluid. Upon completion of the work, submit a field report and test log, signed by the factory certified technician.

**INSTALLATION**

Install in accordance with manufacturer's instructions.

Set transformer and containment pan on a 3-1/2” high (minimum) concrete pad. Coordinate the pad dimensions with the transformer manufacturer.

[Mount primary surge arresters on the high voltage termination connector taps.]

Install padlocks on the air terminal chamber door(s) and no-load tap changer.

**FIELD QUALITY CONTROL**

Prior to energizing the transformer, field testing will be performed by an independent testing consultant furnished by the DFD. The contractor shall coordinate the scheduling of the testing consultant with DFD.

Check for damage and torque connections to manufacturer recommendations prior to energizing transformer.

**ADJUSTING**

Measure the secondary voltage phase-to-phase and phase-to-ground after final energization and prior to loading.

Adjust primary taps so that secondary voltage is within 2 percent of rated voltage.

# CONSTRUCTION VERIFICATION ITEMS

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 01 91 01 or 01 91 02 in accordance with the procedures defined for construction verification checklists.

**AGENCY TRAINING**

All training provided for agency shall comply with the format, general content requirements and submission guidelines specified under Section 01 91 01 or 01 91 02.

END OF SECTION