



Dry Substation - Vacuum Pressure Impregnated (VPI) Transformer

Specification Guide

1. Scope

- 1.1. The basis for this specification is MGM Transformers dry substation vacuum pressure impregnated (VPI) transformer design.

This specification together with the applicable Transformer Data Sheet (Annex A: Transformer Data Sheet) provides the technical requirements for the design, manufacture, and testing of secondary unit substation transformers. The service conditions shall be as specified in the "Usual Service Conditions" section of C57.12.01.

This specification covers only the general requirements of the transformer. The specific requirements will be given in detail on the attached Transformer Data Sheet.

2. Codes and Standards

- 2.1. The ventilated dry-type transformers and protection devices in this specification are designed and manufactured according to the latest revision of the following standards (unless otherwise noted).
- 2.1.1. IEEE C57.12.01, General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid Cast and / or Resin-Encapsulated Windings.
 - 2.1.2. ANSI C57.12.51, Requirements for Ventilated Dry-Type Power Transformers, 501KVA and Larger, Three-Phase with High-Voltage 601 to 34 500 Volts, Low Voltage 208Y/120 to 4160 Volts.
 - 2.1.3. ANSI C57.12.55, Dry-Type Transformers in Unit Installations, Including Unit Substations –Conformance Standard.
 - 2.1.4. ANSI/IEEE C57.98, Impulse Tests, Guide for Transformer (Appendix to ANSI/IEEE C57.12.90)
 - 2.1.5. ANSI/NFPA 70, National Electrical Code.
 - 2.1.6. ANSI C57.12.50, Requirements for Ventilated Dry-Type Distribution Transformers, 1-500 KVA, Single-Phase and 15-500, Three-Phase with High Voltage 601-34500, Low Voltage 120.
 - 2.1.7. IEEE C57.12.91, Test Code for Dry-Type Distribution and Power Transformers.
 - 2.1.8. IEEE C57.94, Recommended Practice for Installation, Application, Operation and Maintenance of Dry-Type General Purpose Distribution and Power Transformers
 - 2.1.9. IEEE C57.96, Guide for Loading Dry-Type Distribution and Power Transformers
 - 2.1.10. NEMA ST 20, Dry Type Transformers for General Applications, American Society of Testing and Materials (ASTM)

2.2. National Electrical Code (NEC)

It shall be the Seller's responsibility to be, or to become, knowledgeable of the requirements of these Codes and Standards. Any required changes or alterations to the equipment to meet the Codes and Standards requirements shall be at the expense of the Seller.

Equipment proposed by the Seller that cannot fully meet the requirements of this specification shall have all exceptions clearly stated in the proposal. No exception shall be allowed, unless approved by the Buyer in writing.

3. Quality Assurance

The manufacturer shall have a well-documented quality assurance program, which includes procedures for all activities in order entry, design, material procurement, manufacturing processes, testing, shipping and post shipment.

The manufacturer shall have specialized in the design, manufacture and assembly of dry-type distribution transformers for a minimum of {25} years.

The transformers shall be manufactured by a company which is certified to ISO, 9001:2000 for design and manufacture of Power, Distribution and Specialty Dry Type Transformers.

The test floor should have a documented calibration program. All equipment shall receive regular calibrations. Calibration standards shall be traceable to the National Bureau of Standards. Records of all equipment calibration shall be made available to the Buyer upon request.

Measured values of electric power, voltage, current, resistance, and temperatures are used in the calculations of reported data. To ensure sufficient accuracy in the measured and calculated data the test system accuracy requirements listed in ANSI C57.12.01 Table 3 shall be met as a minimum.

4. Transformer Technical Requirements

4.1. Description

The transformer shall be of dry type vacuum pressure impregnated construction, the preferred open-wound dry type technology, and shall be mounted in a suitably ventilated enclosure. Primary and secondary terminations shall be as indicated on the data sheet.

4.2. Core Characteristics

The transformer core shall be constructed of high-grade non-aging silicon steel laminations with high magnetic permeability and low hysteresis and eddy current losses. Magnetic flux densities are to be kept well below the saturation point. A mitered core joint shall be used to minimize losses, exciting currents and sound levels. The core laminations shall be clamped together with heavy steel members.

4.3. Temperature Rise

The average temperature rise of the transformer windings shall be rated at (80°C, 115°C, 150°C) and shall be built utilizing Class 220°C insulations, regardless of the temperature rise specified. The transformer shall not exceed the specified temperature rise when the unit is operated continuously at full nameplate rating. The transformer shall be capable of carrying 100% of the nameplate rating in a 40°C maximum, 30°C 24-hour period average ambient.

4.4. Coil Characteristics

The high voltage and low voltage windings shall be constructed using copper or aluminum conductors as indicated on the data sheet. The conductors shall be insulated with a 220°C insulation. Transformer windings, insulation class 1.2 kV (600v) and below, shall be wound using foil or sheet conductors, or wire conductors when applicable. A sheet or foil wound coil allows free current distribution within the axial width of the conductor/coil to essentially eliminate axial forces under short circuit.

Transformer windings, insulation class 2.5 kV (2400v) and above, shall be wound using wire conductors. The high voltage winding shall be wound over the low voltage winding with sufficient mechanical bracing to prevent movement during fault conditions and sufficient solid Class 220°C insulation to isolate the high voltage winding dielectric potential from the low voltage windings.

4.5. Taps

Transformer primary winding shall have adjustable taps as indicated on the data sheet. Tap connections shall be made by re-connectable links or jumper cables on the face of the primary winding and shall be located behind removable panels on the front of transformer enclosure. Taps shall be for de-energized operation only.

4.6. Vacuum Pressure Impregnation Process

The coils shall be dried at atmospheric pressure in an oven through which hot air is continuously circulated. The totally dried coils shall be vacuum pressure impregnated in polyester resin varnish. The VPI process shall apply a one (1) cycle polyester protective shield of varnish to the coils. The VPI process shall effectively impregnate the coil assemblies, thus resulting in a unit which is virtually impermeable to moisture, dust, dirt, salt air, and other industrial contaminants. The VPI processed coils shall be permanently assembled on the core and then dipped in polyester resin varnish. The varnish shall be cured on the core and coil assembly following an established temperature vs. time baking cycle in a hot air circulating oven.

4.7. Core and Coil Assembly

After installation of windings on core and stacking of the top yoke core steel, core and coil assembly is to be secured with a rigid frame. Primary and secondary coordination bus assemblies, as required for connection to associated switchgear are to be of welded or bolted construction.

4.8. Dielectric Threshold

The impulse rating of the transformer must equal or exceed the basic impulse level specified by ANSI for the applicable voltage class. The basic impulse level shall be inherent to the winding design and is to be obtained without the use of supplemental surge arrestors.

4.9. Vibration Isolation

The transformer shall have vibration isolation pads installed between core and coil assembly and enclosure base structures to prevent the transmission of structure borne vibration. The pads shall be neoprene-cork-neoprene sandwich type.

4.10. Enclosure

The enclosure shall be constructed of heavy gauge sheet steel and shall be finished in ANSI 61 paint color applied using either a powder coat or epoxy paint system. All ventilating openings shall be in accordance with NEMA and NEC standards for ventilated enclosures. The base of the enclosure shall be furnished with ground pads located on opposite diagonal corners. The base shall have jacking pads and shall be constructed of heavy steel members to permit skidding or rolling in any direction. The core shall be visibly grounded to the enclosure frame by means of a flexible grounding strap.

4.10.1. Optional – Transformer case anchoring provisions shall be certified to meet California Building Code (CBC) Zone 4 seismic requirements with seismic table validation.

4.10.2. Optional - Outdoor enclosures shall be constructed to provide NEMA 3R protection against rain, sleet and external ice construction.

4.11. Nameplate

Transformer shall be furnished with a non-corrosive diagrammatic nameplate per ANSI C57.12.01, permanently attached with non-corrosive hardware. The diagrammatic nameplate shall include the name of the manufacturer of the transformer as well as the location where the transformer was manufactured and tested.

4.12. Forced Air Cooling

Forced air cooling, when required, shall increase the continuous self-cooled rating of the transformer by 33 1/3% for units rated 3750 kVA and below and 25% for units 3751 kVA and larger. The FA rating increase shall be possible with forced cooling without exceeding the specified maximum temperature rise. The forced air cooling shall be regulated automatically by sensors placed in the low voltage winding's air ducts. Forced air cooling shall include: three phase electronic digital temperature monitor, fans, control wiring, control panel with test switch, indicating lights, alarm and alarm silencing switch.

4.13. Optional Overload Capabilities

When 80°C and 115°C winding temperature rise are specified, they can be designed with inherent overload capabilities. An 80°C rise unit would be capable of continuous operation at 33% above nameplate rating and a 115°C rise unit would be capable of continuous operation at 15% above nameplate rating. This overload capability would be achieved on the AA and FA rating and is accomplished by allowing the transformers' maximum rise to be 150°C. Customer specification must define the high-capacity overloads.

5. Test

Testing shall be accomplished using calibrated test equipment, which have recorded accuracy traceable to National Institute of Standards Technologies (NIST).

After completion, each transformer shall undergo the following routine production tests per ANSI C57.12.01 and ANSI C57.12.91:

- Megger
- Ratio
- Resistance
- Phase relation
- Load Loss, Impedance and Regulation
- No Load Loss and Excitation Current
- Applied Potential Test
- Induced Potential Test
- Partial Discharge Test
- Witness testing is also available and can be arranged to fit your schedule.
- A temperature rise test shall be performed on the first unit of each new design.
- A sound level test shall be performed on the first unit of each new design.

The temperature rise of the windings at rated KVA loading shall not exceed maximum rise specified during operation at 30° C average ambient, which does not exceed 40° C in a 24-hour period.

The sound level shall not exceed the maximum specified by ANSI C57.12.01 for applicable KVA size of dry-type transformer.

The core and coil design and construction techniques shall be verified by a full short circuit test on similar or larger units in accordance with applicable ANSI standards.

6. Accessories

Standard transformer accessories shall include:

- Diagrammatic instruction nameplate
- Provisions for lifting and jacking
- Removable case panel for access to HV taps
- Stainless steel ground pads
- Line voltage adjustment taps

7. Documentation

When requested, manufacturer shall provide copies of following documents to buyer for review:

- A certified test report containing minimum information per IEEE C57.12.91
- Installation, maintenance, and operating instructions
- Outline Drawing
- Connection Diagram
- Nameplate Drawings
- Spare parts list
- Applicable wiring diagrams

Annex A: Transformer Data Sheet
(Marked items are specific to this project.)

Customer Name: _____ Project/Quote Number: _____
Item No. _____

KVA Rating: ☐ 150 ☐ 225 ☐ 300 ☐ 500 ☐ 750 ☐ 1000 ☐ 1500 ☐ 2000
☐ 2500 ☐ 3000 ☐ 3750 ☐ 5000 ☐ 7500 ☐ 10000 ☐ OTHER (_____)

Winding conductor ☐ ALUMINUM ☐ COPPER

Frequency: ☐ 50 HZ ☐ 60 HZ

Impedance: ☐ 5.75% ☐ ±7.5% ☐ OTHER (_____)

Winding Temperature Rise: ☐ 150 C ☐ 115 C ☐ 80 C ☐ OTHER (_____)

Overload Capability: ☐ 33% (80°C RISE) ☐ 15% (115°C RISE)

Primary Voltage: (kV) ☐ 2.4 ☐ 4.16 ☐ 12.47 ☐ 13.2 ☐ 13.8 ☐ 24.9 ☐ 34.5
☐ OTHER (_____)

Primary Taps: ☐ Standard (2-2 ½) ☐ OTHER (_____)

Primary BIL*: (kV) ☐ Std. ☐ OTHER (_____) *see chart on next page

Primary Connection: ☐ Delta ☐ Wye

Primary Termination: ☐ Stub-up Bus ☐ Bus to End Close Coupled to Switchgear
☐ Bus to End w/ Air Terminal Chamber ☐ Bus to End w/ Transition Section

ANSI Segment: ☐ 1(front) ☐ 2(left) ☐ 3(rear) ☐ 4(right) *when facing front of xfrmr

Secondary Voltage: ☐ 208 ☐ 240 ☐ 480 ☐ 600 ☐ 2400 ☐ 4160 ☐ OTHER (_____)

Secondary BIL*: (kV) ☐ Std. ☐ OTHER (_____) *see chart on next page

Secondary Connection: ☐ Delta ☐ Wye

Secondary Termination: ☐ Stub-up Bus ☐ Bus to End Close Coupled to Switchgear
☐ Bus to End w/ Air Terminal Chamber ☐ Bus to End w/ Transition Section

ANSI Segment: ☐ 1(front) ☐ 2(left) ☐ 3(rear) ☐ 4(right) *when facing front of xfrmr

Application Location: ☐ Indoor NEMA 1 ☐ Outdoor NEMA 3R

Forced Air Rating: ☐ AA ☐ AA/FA ☐ AA/FFA ☐ OTHER (_____)

Sound Level: ☐ Standard ☐ 3dB below NEMA ☐ Other (_____)

Special Tests: ☐ Temperature ☐ Impulse ☐ Sound ☐ Partial Discharge ☐ Power Factor
☐ OTHER (_____)

Drawings: ☐ Record ☐ Approval

Elevation: ☐ Standard (3,300ft, 1,000m max) ☐ Other (_____)

Other Special Instructions:

[illegible]

Standard/Optional Basic Impulse Levels

Insulation Class	Standard BIL	Optional BIL
1.0	10	20 30
2.5	20	30 45
5.0	30	45 60
8.7	45	60 95
15.0	60	95 110
25.0	110	125 150
34.5	150	