Installation, Operation, and Maintenance Guide

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1. INTRODUCTION

This guide compiles recommendations for the installation, operation, and maintenance of low voltage dry-type transformers. These are general instructions and must be used in conjunction with applicable local codes. For unique conditions, please consult the manufacturer or an authorized representative directly.

These practices are intended for common applications and may be updated without prior notice. Any technical changes will be included in future editions; please ensure you are using the most current version.

Note that these recommendations do not replace local regulations or absolve responsibility for compliance. The goal is to offer a practical reference for the correct installation and safe maintenance of the equipment.

STANDARDS:

ANSI/IEEE C57.12.91: Standard Test Code for Liquid-Immersed and Dry-Type Transformers.

ANSI/IEEE C57.94: Recommended Practice for the Installation, Application, Operation, and Maintenance of Dry-Type Distribution Transformers.

ANSI/IEEE C57.96: Loading Guide for Dry-Type Transformers.

NEMA ST 20: Standards for Sound and Vibration Levels in Transformers.

NFPA 70 (NEC): National Electrical Code (specifically Articles 450 and 250).

NFPA 70E / CSA Z462: Electrical Safety Standards in the Workplace.

IBC (International Building Code): Seismic Anchorage Requirements (ICC-ES AC156).

Disclaimer:

The installation must be conducted exclusively by qualified electrical personnel. The manufacturer assumes no responsibility for damage resulting from negligent installation or unauthorized modifications to the equipment structure.

2. SAFETY WARNINGS

DANGER indicates an imminent hazardous situation which, if not avoided, will result in death or serious injury and/or substantial property damage.

WARNING indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury and/or substantial property damage.

CAUTION indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury and/or property damage.

To ensure a safe and efficient installation, all work related to dry-type transformers must comply with applicable codes, standards, and regulations. In addition, it is recommended to follow ANSI/IEEE C57.94, which establishes guidelines for the installation, application, operation, and maintenance of general-purpose dry-type transformers.

This document provides summarized guidelines that must be complemented with the corresponding local codes. The recommendations described herein are general; any specific requirement should be consulted directly with the manufacturer or its authorized representative.

Furthermore, all activities must be conducted in accordance with workplace electrical safety standards such as NFPA 70E and CSA Z462, always using appropriate personal protective equipment (PPE) to minimize risks.

Failure to follow these instructions may result in serious injury and even loss of life.

- Before energizing the equipment, verify that all covers, doors, and devices are correctly installed.
- Never attempt to modify the transformer; doing so voids the warranty and may create serious hazards.
- Do not make electrical connections without following the nameplate diagram and applicable codes.
- Avoid working inside the transformer without ensuring that all power is disconnected and the windings are properly grounded.
- Do not change taps or connections while the equipment is energized.
- Do not remove accessories or cover plates if the transformer is in operation.
- Do not tamper with alarms, control panels, internal interlocks, or circuits.
- Never allow cables to come into contact with the core, coils, or live parts; maintain the minimum clearances indicated during field tests.
- Do not unload the transformer without a full inspection; if damage is present, do not energize it and contact the manufacturer.
- Do not use terminals to support the weight of cables; use flexible connectors and additional support if necessary, ensuring adequate clearance.
- Do not lift or move the transformer without the proper equipment and qualified personnel; use only the manufacturer's lifting points. Rolling or sliding is acceptable only if the design allows it.
- Do not ignore NFPA 70E and CSA Z462 standards; always use the required personal protective equipment (PPE).
- Do not allow installation or maintenance to be performed by unqualified personnel.
- Prevent foreign objects from falling into the core or coils; if work is being performed nearby, cover the unit with protective fabric and remove it before energizing.
- Do not energize the transformer without verifying that all connections and grounds are complete and properly tightened.

3. RECEIVING, HANDLING, AND LOGISTICS

Incoming Inspection

Upon receiving the shipment, perform an immediate audit before signing the delivery receipt:

- Structural Integrity: Verify the verticality of the enclosure and check for any impacts that may have shifted the core-coil assembly.
- Impact Indicators: Inspect wooden supports (pallets). Fresh splinters or broken wood indicate drops or severe impacts.
- Core Displacement: Use a flashlight to inspect through the ventilation grilles. Confirm that the core-coil assembly has not shifted on the base insulators. Even minimal displacement can reduce critical dielectric clearances to ground.
- Specification Validation: Compare the nameplate against the project's single-line diagrams (kVA, impedance, vector diagram, taps).
- Accessory Verification: Confirm the presence of seismic mounting kits or weather shields if specified.
- Moisture Contamination: Look for water marks or early corrosion on metal parts.

Lifting and Handling Techniques

Given the high mass density and elevated center of gravity of ventilated transformers:

- Crane Use: Only use the lifting lugs provided on the upper structure. The use of spreader bars is recommended to prevent chains or slings from compressing and deforming the enclosure laterally.
- Forklift Use: Lift the unit only from the base (steel channels). If the unit is on a pallet, ensure the forks fully pass through the base. Remove the wooden pallet before final installation.
- Restrictions: Never lift the transformer by the coils, conductor bars, or internal supports.

Long-Term Storage

If installation is not immediate, moisture protection is the top priority.

- Environmental Control: Store indoors, in a clean and dry area. Ideal temperature range: –40°C to 60°C.
- Condensation Prevention: Sudden temperature changes can cause condensation on the core. Keep the protective plastic cover in place. If the environment is humid, install temporary internal heating (resistance heaters) to keep the core temperature at least a few degrees above ambient temperature.
- Pre-Drying: If moisture is suspected, do not energize the unit. Perform an insulation resistance test (Megger). If readings are low, apply circulating warm air until dielectric values are restored.

4. LOCATION AND VENTILATION

The system operates under natural air convection cooling principles (Class AA). The design relies on this effect to dissipate thermal losses; therefore, the ambient temperature must never exceed 40 °C (104 °F) at any time. Average winding temperature rises are classified as 80 °C, 115 °C, and 150 °C above ambient temperature. For the specific ratings of the equipment, refer to the transformer nameplate.

Space Requirements

- Distance to Walls: Maintain a clear perimeter of at least 15 to 20 cm (6–8 inches) around the unit to ensure proper airflow.
- Air Quality: Intake air must be free of corrosive vapors, metallic dust, or oil particles, which can accumulate inside the coil cooling ducts and reduce heat dissipation.
- Accessibility: According to the NEC, the equipment must remain accessible for inspection and maintenance. Do not obstruct the front with piping or structural elements.
- Obstructions: If bottom cable entry is allowed, conductors must not block more than 50% of the ventilation area between the bottom plate and the support legs.
- Restrictions: Do not install the unit in enclosed cabinets without external forced ventilation. Do not place objects on top of the transformer, as they will obstruct hot-air exhaust.

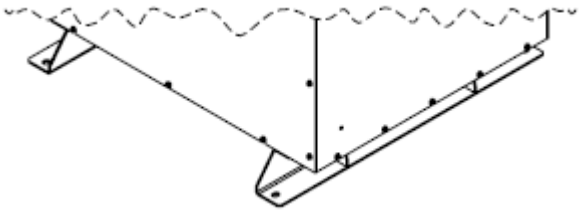
5. INSTALLATION AND ANCHORING

Floor Mounting

The surface must be level and capable of supporting the concentrated weight of the unit.

Seismic Anchoring: To comply with building codes in seismic zones (ICC-ES AC156 / 2015 IBC)

- Units < 300 kVA: Use Grade 5 steel bolts with lock washers.
- Units > 300 kVA: Use Grade 8 steel bolts.
- All base holes must be used to ensure proper stability.



Wall Mounting (Small/Medium Units Only)

If the unit is designed to be wall-mounted, use the manufacturer-approved support kits (brackets). Verify that the wall is structural (concrete or steel beams) and capable of supporting 4 times the weight of the unit for safety.

Acoustics and Vibrations

The phenomenon of magnetostriction in the core generates harmonic vibration (buzz). Transformers must comply with the applicable noise standards in NEMA ST 20 (IEEE C57.12.91 Section 13).

To reduce structural transmission of noise:

- Mechanical Decoupling: Use flexible conduit for the electrical connection.
- Base Isolation: It is recommended to install high-density neoprene/rubber pads between the transformer base and the concrete slab.
- Strategic Location: Avoid installing the unit in reverberant corners or narrow hallways that may act as resonance chambers.
- Do not rigidly anchor thin walls (such as drywalls) that could vibrate sympathetically.

The table below establishes the maximum average dB levels permitted by NEMA for these measurements.

KVA Rating	Maximum DB Ratings per NEMA
0-9	40
10-50	45
51-150	50
151-300	55
301-500	60
501-700	62
701-1000	64

Sound tests are performed at an average distance of 3.3 feet from the enclosure, in accordance with IEEE requirements, with no reflective surfaces allowed within 3.3 feet of the unit. Any reflective surfaces within this zone at the installation site can increase the measured sound level.

6. ELECTRICAL INSTALLATION

Cable Selection

All wiring used must comply with the NEC and applicable local electrical codes. During installation, verify that the connection conductors have a minimum insulation rating of 90 °C and that their ampacity is suitable for operation at 75 °C.

The gauge of the connection conductors must be determined based on the transformer's line current (primary and secondary). The final selection is made using the reference tables in this manual or those established by the applicable standards.

KVA	Single-Phase Transformer Current Table					
	120V	240V	480V	600V	2400V	4160 V
0.5	4.17	2.08	1.04	0.83		
0.75	6.25	3.13	1.56	1.25		
1	8.33	4.17	2.08	1.67		
1.5	12.5	6.25	3.13	2.5		
3	25	12.5	6.25	5	1.25	0.72
5	41.7	20.8	10.4	8.33	2.08	1.2
7.5	62.5	31.3	15.6	12.5	3.13	1.8
10	83.3	41.7	20.8	16.7	4.17	2.4
15	125	62.5	31.3	25	6.25	3.61
25	208	104	52.1	41.7	10.4	6.01
37.5	313	156	78.1	62.5	15.6	9.01
50	417	208	104	83.3	20.8	12
75	625	313	156	125	31.3	18
100	833	417	208	167	41.7	24
150	1250	625	313	250	62.5	36
167	1392	696	348	278	69.6	40.1
250	2083	1042	521	417	104	60.1
333	2775	1388	694	555	139	80

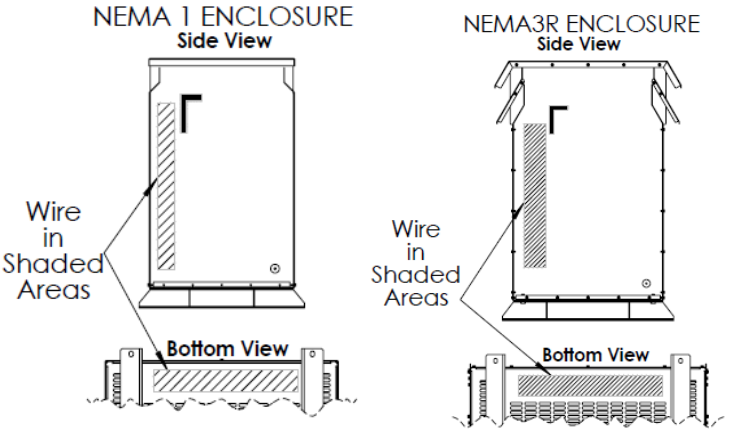
KVA	Three-Phase Transformer Current Table					
	208V	240V	480V	600V	2400V	4160V
3	8.33	7.22	3.61	2.89	0.72	0.42
6	16.7	14.4	7.22	5.77	1.44	0.83
9	25	21.7	10.8	8.66	2.17	1.25
15	41.6	36.1	18	14.4	3.61	2.08
30	83.3	72.2	36.1	28.9	7.22	4.16
45	125	108	54.1	43.3	10.8	6.25
75	208	180	90.2	72.2	18	10.4
100	278	241	120	96.2	24.1	13.9
112.5	312	271	135	108	27.1	15.6
150	416	361	180	144	36.1	20.8
225	625	541	271	217	54.1	31.2
300	833	722	361	289	72.2	41.6
450	1249	1082	541	433	108	62.4
500	1388	1203	601	481	120	69.4
505	1388	1203	601	481	120	69.4
600	1665	1443	722	577	144	83.3
750	2082	1804	902	722	180	104
1000	2776	2406	1203	962	241	139
1500	4164	3609	1804	1443	361	208
2000	5552	4811	2406	1925	481	278
2500	6940	6014	3007	2406	601	347
3000	8327	7217	3608	2887	722	416

Cable Entry

Location: It is recommended to route the cables through the lower front or lower frontside section of the enclosure. If the enclosure includes performed openings, they must be used. Otherwise, the responsibility for making the openings will fall on the customer.

Caution

- Avoid routing high-voltage cables directly in front of the coils.
- Keep conductors away from hot surfaces and sharp edges.
- Do not obstruct the lower ventilation grilles with excessive cable bundles, as this may restrict airflow and affect transformer performance.



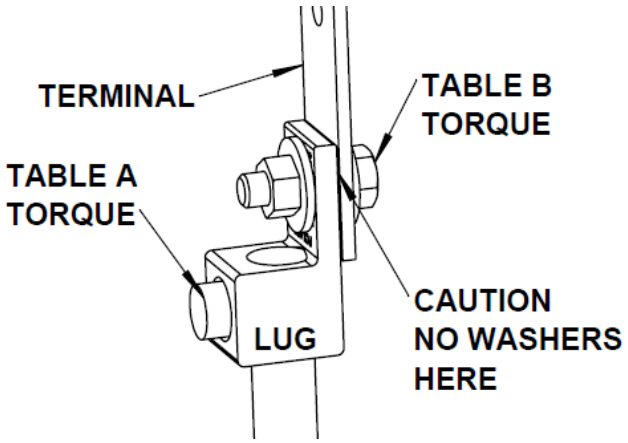
Conductors and Torque

The most common failure mode is overheating caused by poor mechanical connection. The following procedure is recommended to prevent it:

1. Carefully strip the insulation from the end of the conductor to the required length without damaging it.
2. Apply an approved antioxidant compound to the exposed conductor, such as PENETROX A, ALNOX-UG, T&B 21059, or an equivalent product suitable for electrical connections.
3. Insert the conductor into the lug and tighten the set screw following the torque values indicated in Table 1.
4. Wipe off any excess antioxidant compound.
5. After tightening, wait a few minutes and recheck the torque, as the metal tends to relax.
6. Coat the contact surfaces with a compound suitable for copper–aluminum connections.
7. Insert the bolt in the following order: flat washer → lug → terminal → flat washer → lock washer → nut.
8. Use two wrenches—one to hold the nut and the other to turn the bolt—and tighten the assembly according to Table 2.
9. Arrange the conductors so that the minimum electrical clearances required by NEC-373-11 are maintained. If separation is not possible, exposed connections must be protected.

TABLE 1	
Wire size	**Torque Value** (+/- 5 %)
14-8	75 in-lbs
6-4	100 in-lbs
3-1	125 in-lbs
1/0-2/0	150 in-lbs
3/0-200	200 in-lbs
250-400	250 in-lbs
500-750	300 in-lbs

TABLE 2	
Screw/bolt Size. (Grade 2)	**Torque Value** (+/- 5 %)
6-32	10 in-lbs
6-40	12 in-lbs
8-32	19 in-lbs
8-36	20 in-lbs
10-24	27 in-lbs
10-32	31 in-lbs
1/4-20	66 in-lbs
1/4-28	76 in-lbs
5/16-18	11 ft-lbs
5/16-24	12 ft-lbs
3/8-16	20 ft-lbs
3/8-24	23 ft-lbs
7/16-14	30 ft-lbs
7/16-20	35 ft-lbs
1/2-13	50 ft-lbs
1/2-20	55 ft-lbs
9/16-12	70 ft-lbs
9/16-18	80 ft-lbs
5/8-11	100 ft-lbs
5/8-18	110 ft-lbs



7. CONNECTIONS

Electrical Configuration

In power distribution applications, selecting the proper configuration is critical. For three-phase systems, the Delta–Wye (Δ–Y) arrangement is preferred over Delta–Delta (Δ–Δ). It is important to note that if a Delta secondary with a center tap is used for lighting, the load must not exceed 5% of the transformer's kVA rating.

Single-phase systems offer versatility by allowing up to four terminals per side; this makes it possible to standardize the primary input and choose between a single-voltage or dual-voltage secondary output with a neutral.

The physical integrity of the installation depends on strict compliance with the nameplate and applicable standards:

- Identification: NEMA ST-20 must be observed, designating "H" for high voltage and "X" for low voltage.
- Connections: Dual-rated (Al/Cu) mechanical or compression lugs sized for the design current are mandatory.
- Conductors: Conductor gauge must be selected using the 75 °C column of NEC Table 310-16.

Taps

Transformers include primary taps to adjust the output according to the actual utility voltage (e.g., two above and two below nominal, FCAN/FCBN).

To install them correctly, follow this procedure.

Important: This task must only be performed by a qualified electrician.

- Measure the line voltage with the system energized but under no load.
- DE-ENERGIZE the unit completely.
- Move the jumpers to the correct position according to the nameplate.

Clean any varnish or debris from the tap contact surface before tightening the jumper to ensure low resistance.

Grounding

Most transformers include an identified main grounding point; otherwise, the contractor must install and verify the required grounding connections.

- Core and Enclosure: Both must be bonded to ground. Verify that the factory-installed flexible grounding jumper between the core and the enclosure is secure.
- Electrostatic Shield: If present, it must be properly grounded.
- Neutral: If the application requires it (e.g., Wye/Star configuration), the neutral must be grounded according to local code (NEC 250).
- Before energizing: Ground the transformer prior to making any connections.
- Code compliance: Follow all applicable local and national electrical codes and standards.

8. OPERATION AND LOADING

Operating Parameters

Dry-type transformers are designed for continuous operation at their full rated capacity (kVA), as indicated on the nameplate, provided that normal operating conditions are met.

- Temperature: The unit is designed to operate at full load with an average ambient temperature of 30 °C (maximum 40 °C). Operating above this requires load reduction.
- Altitude: When installed above 1,000 m (3,300 ft) above sea level, air-cooling capacity decreases. A load-correction factor must be applied (approx. 0.3% for every additional 100 m). For more information, consult the Altitude Correction Factor in IEEE C57.96.
- Apparent overheating: It is normal for the top cover to reach temperatures up to 65 °C above ambient. “Hot to the touch” does not necessarily indicate a failure, but the presence of burnt varnish odor or paint discoloration should be investigated.
- Cooling: Any additional cooling using fans must comply with the manufacturer’s guidelines. Improper installation can redirect airflow and significantly reduce insulation life.
- Overloads: Overloads are acceptable if short in duration and preceded and followed by operation below the nominal kVA rating. To correctly determine transformer loading capability, load profile and operating conditions must be known. Refer to the IEEE C57.96 Dry-Type Transformer Loading Guide.

9. MAINTENANCE

Although dry-type transformers are low-maintenance equipment, they require periodic inspections—annually or more frequently in severe environments—to ensure proper operation and service life.

Critical Safety

- Internal Work: Opening the enclosure while energized is strictly prohibited. Any internal maintenance requires the equipment to be de-energized, isolated, locked/tagged out, and grounded.
- External Work: Surface cleaning and peripheral visual inspection may be performed with the unit in operation, provided no objects are inserted into the vents and no covers are removed.

Key Inspection Points

- Connections: Verify the torque of all bolted connections and splices. Use Table 2: Conductor Preparation and Torque in this manual.
- Physical Integrity: Inspect for corrosion, paint condition, oxidation, loose connections, arcing, or overheating (use of thermal imaging is recommended).
- Ventilation: Ensure there are no obstructions such as ice, snow, or debris blocking airflow.

Transformer Service Life

The service life of a transformer depends on the thermal degradation of the insulation system, which is determined by winding temperature and operating duration. Improper use or inadequate conditions can significantly reduce service life.

Factors affecting transformer life include:

- Line voltage
- Load current
- Load cycle
- Ambient temperature
- Environmental conditions (humidity, corrosive atmosphere, vibration)
- Maintenance

Cleaning and Filters

- Coils and Air Ducts: With the unit deenergized, clean the air ducts from top to bottom using a vacuum cleaner or dry compressed air at low pressure (<20 psi).
- Filter Management: In units equipped with filters (e.g., 3RE+ or outdoor enclosures), filters must be cleaned or replaced frequently to avoid overheating. Never operate the unit without filters properly installed.

Moisture Drying

If a transformer has been exposed to moisture, whether from condensation or direct water exposure, it must not be energized until a proper drying process has been completed.

Drying may be performed through controlled heating using warm air, radiant heat, or internal heating directed at the windings. The heating must be maintained for a prolonged period (up to 24 hours), even after visible moisture has disappeared.

In situations where the unit has been subjected to flooding, direct rain, or fire-suppression systems, drying alone may not be sufficient. In such cases, it is essential to verify that insulation resistance values between:

- core and windings,
- primary and secondary

exceed the minimum acceptable limits (>10,000 ohms).

If these conditions are not met, contact the manufacturer for specific instructions before placing the transformer into service.

10. ACCESSORIES

Dry-type distribution transformers offer significant versatility using specific, readily available accessories. Below are the specifications for mounting, environmental protection, insulation, and electrical connectivity.

Wall Mounting and Structural Safety

Although ventilated transformers are primarily designed for floor installation, flexible options exist for vertical mounting (walls, columns, or beams):

- Capacity and Kits: Depending on the cabinet design, units up to 75 kVA may include built-in wall-mounting capability or require a specific mounting-bracket kit. It is essential to consult the nameplate to verify seismic ratings and weight limitations.
- Load Verification: Before installation, it must be confirmed that both the supporting structure (wall) and the anchoring bolts can sustain the total weight of the operating unit.
- Safety (Drip Plate): For any unit installed at height (suspended or wall-mounted), a drip plate must be installed beneath the equipment. Its purpose is to protect personnel and equipment below by catching hot particles that may fall through the ventilation grille in the event of a severe internal fault.

Noise and Vibration Control

To optimize acoustic comfort and reduce mechanical stress:

- Isolation: It is recommended to place isolation pads between the transformer base and the mounting surface.
- Materials: Typically made of molded neoprene and steel plates, these pads are highly effective at mechanically decoupling the equipment, preventing vibration transmission, and reducing operational sound levels.

Protection Kits

It is possible to modify the environmental rating of certain ventilated enclosures for outdoor use:

- NEMA Conversion: By installing weather shields, a standard NEMA 1 enclosure can be upgraded to a NEMA 3R rating (rain and ice resistant).
- Compatibility: These kits are specific to each enclosure. The kit part number must match the information on the transformer's data plate. The equipment must never be operated outdoors without these shields installed correctly.

Lugs and Terminals

The connection panels offer flexibility for different conductor types and configurations:

- Conductors: Terminals are compatible with Copper (Cu) or Aluminum (Al) cables.
- Best Practices: Installation must strictly follow local electrical codes. It is critical to clean conductor surfaces and apply anti-oxidant/electrical compound at all joints to ensure long-term reliability.
- Lug Replacement: Customers may replace the factory-installed lugs with alternatives better suited to their specific application. This does not prevent the warranty nor factory approvals if the new lugs are certified for the transformer's design current.