National Electrical Manufacturers Association

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Purchasing Specifications Guide
Dry-Type Transformers Medium-Voltage (2.4kV–35kV)

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Overview

This document was produced by manufacturers of electrical transformers to assist customers in developing clear purchasing specifications for the type and rating of the transformer indicated above. While comprehensive, it is not intended to be exhaustive or cover every possible feature that a customer may wish to include in an order. NEMA Members encourage customers to review this document and, where applicable, use the content to guide the development of their own purchasing specification materials.

Disclaimer

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a. **Power Rating**. The transformer capacity should be selected based upon an analysis of the existing load to be served combined with any future load growth. Please define the rated capacity in units of kVA or MVA, which can be determined by multiplying the line current by the phase to neutral voltage. If the transformer is a single-phase design, the figure derived from the above equation is the rated capacity in VA (or kVA/MVA). If the transformer is a three-phase design, multiply the figure by 3 for the total capacity.

b. Frequency. Specify the correct frequency for the transformer.

c. Temperature Rise. Specify the average temperature rise rating for the transformer. The most common rating is 150°C. Other common optional ratings are 115°C and 80°C.

d. **Winding Conductor.** Specify whether aluminum or copper windings are required.

e. **Single-Phase vs. Three-Phase**. Specify which phase is required.

f. **Step-up vs. Step-down**. Specify the transformer's intended function.

g. **Winding Connections/Vector Group.** Please provide the following information:

1. Specify a combination of Wye, Delta, and/or Zig-Zag. Common combinations and applications are below, but others exist as well:
    a. Delta-Wye: the most common winding connection used widely for distribution and Industrial & Commercial applications.
    b. Other common combinations and applications
        1. Wye-Wye: used in utility transformers and some special applications
        2. Wye-Delta: used in generator step-up, high voltage transmission step-down, and grounding transformers
        3. Delta-Delta: special applications (i.e., large, low-voltage transformers when a neutral phase is not required)
        4. Zig-Zag: used in grounding transformers
        5. Delta – Zig-Zag or Wye – Zig-Zag: used in phase-shifting and power flow control applications

2. Specify whether a neutral terminal or bushing is required

3. Specify whether a stabilizing winding is required

4. For single-phase, specify additive or subtractive polarity

h. **Primary Taps.** Taps are used to match the transformer input voltage with the system voltage to maintain proper output voltage on the secondary. The most common tap configurations are (two above and four below at 2.5%), (two above and below at 2.5 %.), (one above and below at 5%). The manufacturer will notify the customer when design limitations prevent certain tap configurations. Taps shall be changed via removable links unless otherwise specified.

i. **Standards.** Please list the Standards that the transformer(s) must meet. We recommend the following: IEEE C57.12.01 and C57.12.91.

If the transformer is for a special application, please consider referencing one of the following Standards:

1. C57.12.52 – Sealed Dry-Type Power Transformers, 501 kVA, and Higher, Three-Phase, with High-Voltage 601 to 34500 Volts, Low-Voltage 208Y/120 to 4160 Volts

2. C57.12.51 – Ventilated Dry-Type Power Transformers, 501 kVA and Larger, Three-Phase, with High- Voltage 601 V to 34 500 V; Low- Voltage 208Y/120 V to 4160 V

j. **Insulation**. Basic impulse levels should be specified in accordance with Table 3 of IEEE C57.12.01.

k. **Terminals**. Please specify all the electrical characteristics and physical details required for the terminals. Options include:

1. Live front or dead front

2. Bushing type or Spade / Busbar type

Other important specifications may include:

1. Maximum TOV withstand capability for the bushing/terminal. This is important to specify if temporary or transient overvoltage conditions occur on the system where the transformer will be connected.

2. The current rating (if different than maximum transformer load current), including provision for emergency overloading conditions. This is mostly applicable to loop/ring feed configurations where the bushings/terminals need to be rated for the network current rather than only the transformer current.

3. Addition of cable support brackets or bus support insulators (if mechanical cable loading will exceed bushing capability). The customer should calculate what mechanical loading from the power cables or busbars applies to the bushings. This is important to ensure that bushings are not subject to cantilever loading, which exceeds the bushing capability. Overloading can lead to mechanical and/or electrical bushing failure and/or leaking.

4. Physical location of all the terminals and whether they will be enclosed by a cable termination cabinet/box or whether they will be open-air terminals. If a cable termination cabinet is required with a different rating than the transformer, the customer should specify the following:
    a. level of protection (NEMA 1, 3, 3R, 3X, 4, 4R, 4X, etc.) required
    b. materials (steel, aluminum, stainless steel, etc.) to be used for construction
    c. door sizes and types
    d. coating (galvanizing, paint, etc.)
    e. locking mechanism/method required

Whether Neutral terminals will be grounded by the supplier and what method and materials to use for grounding the neutral terminals

l. **Accessories**. Please specify all the accessories required. The following list of options should be helpful:

1. Enclosure type
    a. Indoor
    b. Outdoor
    c. Tank (for sealed transformers) and insulating gas
    d. Category
    e. Material
    f. Paint color
    g. Lights
        1. Interior
        2. Exterior

h. Bushings and Terminal Enclosures or Air Terminal Compartment (ATC) Primary or Secondary
    1. Flanged throat for connections (primarily for outdoor applications)
    2. Full height or not
    3. Space heaters required with or without thermostats
    4. Measurement requirements, which could include:
        a. Full height or not
        b. Space heater required
        c. Ammeter
        d. Thermostat
        e. Indicator light
    5. Cable entry locations
    6. Close coupling to switches

2. Grounding Pads and Material

3. Cooling Provisions
    a. Fans/Blowers required
    b. Provisions for future fans
    c. Remote alarm contact
    d. Power supply controlled by a transformer
    e. Lockable fan control switch
    f. Fans controlled by winding temperature

4. Current Transformers
    a. Primary
        1. Quantity
        2. Multi-ratio?
        3. Metering – accuracy class
    b. Secondary
        1. Quantity
        2. Multi-ratio?
        3. Metering – accuracy class

5. Potential Transformers

6. Alarms

7. Control Devices
    a. Nameplate Material
    b. Labels
    c. Monitors
    d. Winding temperature indicators

8. Control Cabinet: Specify the location, wiring connections, and contents of a control cabinet. Include any special terminal block connection requirements. Options may include:
    a. Branch circuit protection
    b. Rigid conduits:
        1. Galvanized
        2. Liquid-tight
    c. Space heater
    d. Ammeter
    e. Thermostat
    f. Indicator light

9. Tap Changer
    a. Off-load
    b. On-load

10. Protection
    a. Snubber circuits
    b. Lightning arresters

When identifying required accessories, please also provide the following information for each accessory:

11. Approved accessory manufacturers

12. Approved models/types of accessories for each application

13. Required features for each accessory

14. Minimum requirements
    a. Contacts
    b. Communications ports
    c. Accuracy (i.e., meters, potential or current transformers, etc.)
    d. Longevity (design life)
    e. Others if applicable

15. Location where accessory shall be mounted/installed

16. Wiring required
    a. What needs to be connected
    b. Type of wire to be used
    c. Type of terminals to be used
    d. Type of crimped lugs to be used
    e. Others if applicable

17. Peripheral accessory requirement
    a. Conduit for wiring type
        1. size specifications
        2. rigid vs. flex

18. Specific optional features required for each accessory (as applicable)

a. **Types of Cooling**: Please specify the cooling media using the following letter combinations based on IEEE C57.12.01:

Description	Cooling Class
Ventilated self-cooled	AN
Ventilated forced air-cooled	AF
Ventilated self-cooled/forced air-cooled	AN/AF
Non-ventilated self-cooled	ANAN
Sealed self-cooled	GNAN

b. **Sound Levels**. Please reference the appropriate standards and tables to indicate sound level requirements: IEEE C57.12.01, Tables 6, 7, and 8.

c. **Tap Ranges and Locations.** Taps are used to match the transformer input voltage with the system voltage to maintain proper output voltage on the secondary. The most common tap configuration is two tap settings above and two tap settings below nominal voltage, with each tap setting representing 2.5% of the nominal voltage. Another common configuration for solar and other renewable applications is two above and four below at 2.5%. Where more voltage flexibility is required, other tap configurations may be specified as applicable.

d. **Impedance**. Please specify the acceptable impedance range, which may be identified through a system fault or arc flash study.

e. **Short-Circuit Withstand Characteristics and Capabilities**. Please reference the following Standards: IEEE Standard C57.12.01 and C57.12.91.

f. **Overload Profiles**. Please specify the overload criteria as a % of rated load for time, duration, and frequency (i.e., 120% of load for 4 hours, once every six hours).

g. **Rating Plate**. Please specify the appropriate Standard and any other information required to be displayed on the rating plate.

    1. Standard: IEEE C57.12.01 Table 12

    2. Other information not covered under the Standards, as determined by the customer

h. **Ambient Conditions**. Provide the following information:

    1. Elevation above sea level

    2. Atmospheric contamination

    3. Ambient temperature (minimum and maximum)

    4. Bus/isophase duct temperature

    5. Other relevant environmental factors

    6. Location – indoor or outdoor

i. **Seismic Requirements**. If a seismic rating is required, provide the following information:

    1. G-force level required

    2. Installation location (ground level, rooftop, etc.)

    3. Maximum lean angle on bushings

    4. Seismic certifying body

j. **Special Requirements**. Provide the following information:

    a. Transport requirements

    b. Geomagnetically induced current withstand requirements Harmonics requirements (K Factor or Non-Linear Load Factor per IEEE C57.110)

k. **Tests and Test Levels**. Factory tests should include all Standard production tests as specified in IEEE C57.12.01 Table 17.

The following optional tests may also be provided:

1. Insulation power factor test on all windings
2. Basic Impulse Level (BIL) test on all windings
3. Audible sound level
4. Temperature rise test
5. Partial discharge (required for solid cast transformers)
6. Mechanical leak test on the transformer tank (sealed transformers only)
7. Pressure test on transformer tank (sealed transformers only)
8. Short-circuit capability

Other tests as required by the customer should be specified.

l. **Supply-Voltage Wave Shape**. If the supply voltage is not approximately sinusoidal, specify what the transmission supply voltage wave shape is and what the maximum voltage and current distortion is that the transformer can be exposed to or needs to be designed for. Reference IEEE 519 and explain its applicability to the design and if there will be conditions exceeding the IEEE 519 limits.

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