Power-Dry II™ Dry-Type, Small Power Transformers

225–15,000 kVA Three-Phase, 600 V–35 kV Primary Voltage, 120 V–15 kV Secondary Voltage

Class 7420

Retain for future use.

Introduction

Power-Dry II™ dry-type transformers meet requirements for most industrial and commercial applications. They use a Underwriters Laboratories (UL) listed 220 °C insulation system, regardless of temperature rating.

The transformer coils are vacuum-pressure-impregnated in high temperature polyester (VPI) or silicone (VPE) varnish. The process includes oven drying to remove moisture, complete submersion in varnish under vacuum and pressure, and regulated curing using statistically process-controlled equipment to ensure consistency. The core is manufactured from high permeability, cold-rolled, grain-oriented, silicon steel laminations using a step-lap mitered core construction to ensure optimum performance and minimal sound levels. Magnetic flux densities are kept well below the saturation point.

Environmental Information

- Intended for relatively clean environments
- No special waste disposal considerations
- Excellent replacement for PCB-filled and gas-filled transformers

Ratings

- 225–15,000 kVA three-phase (fan cooling allows higher kVA ratings)
- Primary voltage: 600 V–35 kV
- Primary BIL: Up to 150 kV
- Secondary voltage: 120 V to 15 kV
- Secondary BIL: Up to 75 kV
- Temperature rise: 150 °C (standard); 80 °C (optional); 115 °C (optional); 80/115 °C (optional); 80/150 °C (optional)

Certifications

- ISO 9001 registered
- UL (standard); CSA (optional)
- DOE 2016 Energy Efficient (225–2500 kVA)

Special Design Options

- Seismic qualifications
- Special sound requirements
- Low X/R ratios
- Higher overload capacity
- Special altitude requirements
- Retrofit designs
- Higher efficiency requirements
- Special ambient conditions

Applicable Standards

- IEEE C57.12.01™—Standard General Requirements for Dry-Type Distribution and Power Transformers Including Those With Solid Cast and/or Resin-Encapsulated Windings
- ANSI C57.12.50—Requirements for Ventilated Dry-Type Distribution Transformers, 1–500 kVA Single-Phase and 15–500 kVA Three-Phase, with High Voltage 601–34,500 Volts, Low Voltage 120–600 Volts
- IEEE C57.12.51™—Requirements for Ventilated Dry-Type Power Transformers, 501 kVA and larger Three-Phase, with High Voltage 601–34,500 Volts, Low Voltage 20BY/120–4,160 Volts
- ANSI C57.12.55—Conformance Standard for Transformers—Dry-Type Transformers Used in Unit Installations, Including Unit Substations
- IEEE C57.12.56™—Standard Test Procedure for Thermal Evaluation of Insulation Systems for Ventilated Dry-Type Power and Distribution Transformers
- IEEE C57.12.58™—Guide for Conducting a Transient Voltage Analysis of a Dry-Type Transformer Coil
- IEEE C57.12.59™—Guide for Dry-Type Transformer Through-Fault Current Duration
- IEEE C57.12.70™—Terminal Markings and Connections for Distribution and Power Transformers
- IEEE C57.12.80™—Standard Terminology for Power and Distribution Transformers
- IEEE C57.12.91™—Test Code for Dry-Type Distribution and Power Transformers
- IEEE C57.94™—Recommended Practice for Installation, Application, Operation, and Maintenance of Dry-Type General Purpose Distribution and Power Transformers
- IEEE C57.96™—Guide for Loading Dry-Type Distribution and Power Transformers

Specifications

A. The transformer(s) shall be the unit substation type with side-mounted primary and secondary terminations.

B. Primary terminations shall be designed for close coupling to [a metal enclosed air load break switch section] [a switchgear section] [an air terminal chamber to be provided with the transformer]. Secondary terminations shall be designed for close coupling to [a switchgear section] [a switchboard section] [an air terminal chamber to be provided with the transformers].

C. Orientation shall be primary on the [left] [right] when facing the transformer front.

D. The [VPI] [VPE] transformer(s) shall be rated [_____kVA AA] [_____/_____kVA AA/FFA] [_____/ _____kVA AA/FA]. Primary voltage _____volts delta. Secondary voltage _____volts [wye] [delta], [3-wire] [4-wire], 60 Hz with two 2½% full-capacity above normal and two 2½% full-capacity below normal primary taps. Impedance shall be [_____%] [manufacturer's standard impedance], ±7½%. All transformers shall have an average temperature rise of [80] [115] [150] [80/115] [80/150] °C above a 40 °C maximum, 30 °C average ambient.

E. The basic impulse levels (BIL) shall be a minimum of [60 kV for the 15 kV class] [optional 95 kV BIL available] [10 kV for the 1.2 kV class]. Primary and secondary BIL shall be _____kV and _____kV respectively.

F. The coils and all clamping structures shall be assembled on the core, and then dried at atmospheric pressure in an oven through which hot air is continuously circulated. The totally assembled core and coil assembly shall be vacuum pressure impregnated in varnish. The varnish shall be cured on the core and coil assembly following an established temperature versus time baking cycle in a hot air circulating oven. The process shall effectively impregnate the entire core and coil assembly which results in a unit which is virtually impermeable to moisture, dust, dirt, salt air, and other industrial contaminants.

G. The coils shall be wound with [aluminum] [copper] conductors.

H. All insulating materials are to be in accordance with IEEE C57.12.01™ for 220 °C UL insulation system.

I. All cores to be constructed of high grade, grain-oriented, non-aging silicon steel with high magnetic permeability, and low hysteresis and eddy current losses. Magnetic flux densities are to be kept well below the saturation point. Core lamination shall be miter cut at the core corners to reduce hot spots, core loss, excitation current, and sound level. The laminations shall be clamped together using insulated bolts through the core laminations to provide proper pressure throughout the length of the core.

J. The transformer enclosures shall be ventilated [indoor] [outdoor] and fabricated of heavy gauge, sheet steel construction. Enclosures are to be provided with lifting devices bolted or welded to the base structure and shall have jacking pads designed to be flush with the enclosure. The base is to be constructed of structural steel members to permit skidding or rolling in any direction. There shall be no metal-to-metal contact. Rubber vibration isolation pads shall be installed by the manufacturer between the core and coil and the enclosure. The core shall be visibly grounded to the ground bus or ground pad by means of a flexible grounding conductor sized in accordance with applicable UL and NEC® standards.

K. The enclosure shall be constructed of heavy gauge sheet steel and shall be finished with [ANSI 49] [ANSI 61] paint color. The paint shall be applied using an electrostatically deposited dry powder paint system. All ventilating openings shall be in accordance with NEMA and the NEC standards for ventilated enclosures.

L. Transformer sound levels shall be warranted by the manufacturer not to exceed the values specified in IEEE C57.12.01™.

M. The transformer(s) shall be provided [with lightning arresters] [without lightning arresters]. If provided, metal-oxide, gapless-type distribution class lightning arresters shall be installed by the manufacturer on the high voltage side of the transformer to provide additional protection against high voltage lightning or switching surges.

N. The transformer(s) shall be designed for use [without fans] [with fans to increase the kVA capacity by 33%]. If provided, fan cooling equipment shall include an electronic-winding temperature monitor controlled automatically by a Type K thermocouple placed in the low voltage air duct. The temperature monitor must contain yellow and red indicating lights. The yellow and red lamps signal that fan and alarm contacts have been activated. Alarm contacts shall be provided for fans, alarm, and trip function. An audible alarm must sound when the highest phase temperature exceeds a preset point. The fans must be able to operate in either manual or automatic mode. A minimum of six fans shall be provided and shall be controlled automatically by the sensor in the low voltage air duct. The forced air cooling system shall include: fans, control wiring, controller with test switch, current limiting fuses in the power supply to the controller, indication lights, alarm silencing relay, auto/manual switch, and necessary accessories to properly control the system.

O. Testing shall be conducted in accordance with IEEE C57.12.91™ and shall include, at a minimum, the following tests:

1. Ratio
2. Polarity
3. Phase rotation
4. No-load loss
5. Excitation current
6. Impedance voltage
7. Load loss
8. Applied potential
9. Induced potential
10. Quality control impulse
11. Temperature (typical data from previous unit is acceptable)
12. Sound (typical data from previous unit is acceptable)

Technical Data

Table 1 – Standard Transformer Ratings, Primary Voltage Class 2.3–46 kV, 150 °C Rise, 30 °C Ambient

kVA 3-Phase			Secondary Voltage		
Self-Cooled	Fan-Cooled Ventilated Dry	Fan-Cooled Weather Resistant Ventilated	208Y/120 V 240 V Delta	480Y/277 V 480 V Delta	4160Y/2400 V 4160 V Delta 2400 V Delta
225	300	300	X	X	X
300	400	400	X	X	X
500	667	667	X	X	X
750	1000	1000	X	X	X
1000	1333	1333	X	X	X
1500	2000	2000	X	X	X
2000	2666	2666		X	X
2500	3333	3333		X	X
3750	4687	4687			X
5000	6250	6250			X
7500	9375	9375			X
10000	12000	12000			X

The above combinations are based on standard designs. Other than standard designs may place further restrictions on the availability of voltage and kVA combinations. Consult the factory for final determination.

Table 2 – Altitude Derating Factor [1]

Altitude (FT)	kVA Correction		BIL Correction
	VPI (AA)	Forced Air (FA)	
3300	1.00	1.00	1.00
4000	0.994	0.989	0.98
5000	0.985	0.974	0.95
6000	0.975	0.959	0.92
7000	0.966	0.944	0.89
8000	0.957	0.929	0.86
9000	0.948	0.914	0.83
10,000	0.939	0.898	0.80
11,000	0.930	0.883	0.77
12,000	0.921	0.868	0.75
13,000	0.912	0.853	0.72
14000	0.903	0.838	0.70
15,000	0.894	0.823	0.67

[1] 3.28 feet = 1 meter

Table 3 – Audible Sound Levels

Self-Cooled	
Equivalent Two-Winding kVA	**Class AA Rating**
0–9	40
10–50	45
51–150	50
151– 300	55
301–500	60
501–700	62
701–1000	64
1001–1500	65
1501–2000	66
2001–3000	68
3001–4000	70
4001–5000	71
5001–6000	72
6001–7500	75
7501–10000	79
10001–15000	82

Forced Air-Cooled	
Equivalent Two-Winding kVA	**Class FA/AFA Rating**
0–1167	67
1168–1667	68
1668–2000	69
2001–3333	71
3334–5000	73
5001–6667	74
6668–8333	75
8334–10000	78
10001–13333	82

Table 4 – System Voltages and Transformer BIL Ratings

Nominal L-L System Voltages (kV)	Standard and Optional Transformer BIL Ratings									
	10	**20**	**30**	**45**	**60**	**95**	**110**	**125**	**150**	**200**
0.25	None									
0.6	S	1	1							
1.2	S	1	1							
2.5		S	1	1						
5.0			S	1	1					
8.7				S	1	1				
15.0					S	1	1			
18.0						S	1	1		
25.0						2	S	1	1	
34.5								2	S	1

S = Standard value.

1 = Optional higher levels where exposure to overvoltage occurs and improved protective margins are required.

2 = Lower levels where protective characteristics of applied surge arresters have been evaluated and found to provide appropriate surge protection.

Table 5 – Performance Data

Typical Performance Data					Regulation			
kVA	**%IZ**	**%IR**	**%IX**	**X/R Ratio**	**1.0 PF**	**0.9 PF**	**0.8 PF**	**0.7 PF**
225	4.50	1.92	4.07	2.12	2.00	3.54	4.00	4.26
300	4.50	1.74	4.15	2.38	1.83	3.42	3.41	4.20
500	5.50	1.57	5.27	3.36	1.71	3.79	4.47	4.90
750	5.75	1.38	5.58	4.05	1.53	3.77	4.52	4.99
1000	5.75	1.31	5.60	4.28	1.47	3.72	4.47	4.96
1500	5.75	1.15	5.63	4.89	1.31	3.60	4.37	4.88
2000	5.75	1.05	5.65	5.40	1.21	3.51	4.31	4.82
2500	5.75	1.01	5.66	5.60	1.17	3.49	4.28	4.80
3000	5.75	1.07	5.65	5.28	1.29	3.58	4.36	4.87
3750	5.75	0.99	5.66	5.72	1.15	3.47	4.27	4.79
5000	5.50	0.80	5.44	6.80	0.95	3.20	3.98	4.50

Table 6 – Typical Performance Data: High Voltage—15 kV Class; Low Voltage—600 V Class

kVA	No Load Losses (Watts)	Full Load Losses [1] (Watts)	Total Losses (Watts)	Efficiency [1]					
				133%	**125%**	**100%**	**75%**	**50%[1]**	**25%**
225	800	3300	4100	97.83	97.93	98.21	98.45	98.75	98.24
300	1000	4000	5000	98.02	98.10	98.36	98.58	98.84	98.36
500	1200	6400	7600	98.15	98.24	98.50	98.74	99.04	98.74
750	1750	8200	9950	98.40	98.47	98.69	98.88	99.13	98.81
1000	2400	8300	10700	98.73	98.79	98.94	99.07	99.21	98.85
1500	2900	11000	13900	98.89	98.94	99.08	99.20	99.34	99.05
2000	3500	12800	16300	99.03	99.07	99.19	99.29	99.41	99.15
2500	3650	17000	20650	99.00	99.04	99.18	99.30	99.45	99.25
3000	7500	34000	41500	98.33	98.41	98.64	98.83	98.94	98.73
3750	9500	37000	46500	98.52	98.58	98.78	98.93	99.01	98.76
5000	11500	40000	51500	98.78	98.83	98.98	99.10	99.15	98.89

[1] Full load losses and efficiencies are at a reference temperature of 170 °C in accordance with IEEE Standard C57.12.91. The efficiencies of transformers with a 225–2,500 kVA rating at 50% load are at a reference temperature of 75 °C in accordance with DOE Test Procedure 10 CFR, Part 431, Subpart K, Appendix A.

Table 7 – Standard % Impedance

High Voltage BIL (kV)	Percent Impedance
95 and below	5.75
Above 95	7

Table 8 – Standard Enclosure Design Dimension and Weights [1,2]

kVA	Dimensions (inches)			Weight (lbs)
	Height	Width	Depth	
225	94.0	84.0	54.0	4200
300	94.0	84.0	54.0	4600
500	100.0	84.0	60.0	5039
750	100.0	84.0	60.0	6219
1000	100.0	84.0	60.0	7267
1500	100.0	96.0	60.0	9374
2000	100.0	96.0	60.0	11400
2500	100.0	102.0	60.0	15700
3000	100.0	108.0	60.0	13500
3750	100.0	108.0	60.0	16000
5000	124.0	144.0	66.0	25000

1 Values listed are typical and should not be used for construction purposes.

2 Dimensions are based on standard BIL and 150 °C temperature rise.

Loading

Power-Dry II transformers are designed to operate at rated load with rated voltage and frequency applied in “usual service” conditions. It is possible to carry overloads without loss of life expectancy. The following table shows the permissible overloads that may be carried without loss of transformer life expectancy only if occurring once in any 24-hour period given a 150 °C rise transformer in a 30 °C ambient.

ANSI/IEEE Loading Guide

Table 9 – Daily Loads Above Rating to Give Normal Life Expectancy

	Transformer Load Before and After Overload		
Peak Load Time in Hours	90%	70%	50%
0.5	1.33	1.43	1.49
1	1.21	1.25	1.28
2	1.14	1.15	1.16
4	1.09	1.10	1.10
8	1.05	1.06	1.06

Example 1: A 1000 kVA transformer loaded at 90% (900 kVA) could be loaded up to 1330 kVA for 30 minutes without loss of transformer life if loading returns to 900 kVA or less after the overload.

Example 2: A 1000 kVA transformer loaded at 50% (500 kVA) could be loaded up to 1280 kVA for 60 minutes without loss of transformer life if loading returns to 500 kVA or less after the overload.

Heat Contribution

Heat contribution is the heat a transformer may contribute to its environment. This may represent additional air conditioning burden in summer months, or may be used in calculating heating requirements during winter months. This heat is the result of transformer losses and is a function, in part, of loading. The following table demonstrates the effect of loading on heat contribution.

Table 10 – Typical Heat Contribution: High Voltage—15 kV Class; Low Voltage—480Y/277 V

kVA	% Load	BTU/Hour	kVA	% Load	BTU/Hour
225	25	3436	2000	25	14685
	50	5549		50	22881
	75	9071		75	36541
	100	14002		100	55665
	125	20341		125	80253
	133	22666		133	89275
300	25	4269	2500	25	16093
	50	6830		50	26979
	75	11099		75	45121
	100	17075		100	70520
	125	24759		125	103176
	133	27578		133	115158
500	25	5464	3000	25	32869
	50	9562		50	54640
	75	16392		75	90924
	100	25954		100	141723
	125	38248		125	207034
	133	42759		133	230999
750	25	7726	3750	25	40340
	50	12977		50	64031
	75	21728		75	103517
	100	33979		100	158798
	125	49731		125	229872
	133	55511		133	255952
1000	25	9968	5000	25	47810
	50	15282		50	73423
	75	24140		75	116110
	100	36541		100	175873
	125	52484		125	252710
	133	58335		133	280904
1500	25	12251			
	50	19295			
	75	31034			
	100	47469			
	125	68599			
	133	76352			

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