

## 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 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); 80/115 °C (optional)

## Certifications

- ISO 9001 registered
- Optional UL and CSA certification
- DOE 2010 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
- ANSI 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 C57.12.5S™—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 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] °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 polyester varnish. The total VPI process shall apply a one (1) cycle polyester protective shield of varnish to the coils and a protective shield to the bus, core, and support structure. 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 VPI 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. 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. 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, 80 °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			X	X	
300	400	400	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 <sup>1</sup>**

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

<sup>1</sup> 3.28 feet = 1 meter

**Table 3: Audible Sound Levels**

Self-Cooled		Forced Air-Cooled	
Equivalent Two-Winding kVA	Class AA Rating	Equivalent Two-Winding kVA	Class FA/AFA Rating
0–9	40	0–1167	67
10–50	45	1168–1667	68
51–150	50	1668–2000	69
151–300	55	2001–3333	71
301–500	60	3334–5000	73
501–700	62	5001–6667	74
701–1000	64	6668–8333	75
1001–1500	65	8334–10000	78
1501–2000	66	10001–13333	82
2001–3000	68		
3001–4000	70		
4001–5000	71		
5001–6000	72		
6001–7500	75		
7501–10000	79		
10001–15000	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 <sup>1</sup> (Watts)	Total Losses (Watts)	Efficiency <sup>1</sup>					
				133%	125%	100%	75%	50% <sup>1</sup>	25%
225	800	4320	5120	97.26	97.39	97.78	98.12	98.58	98.13
300	1000	5230	6230	97.50	97.61	97.97	98.28	98.68	98.48
500	1300	7840	9140	97.77	97.88	98.20	98.50	98.89	98.59
750	2000	10340	12340	98.01	98.16	98.38	98.63	98.95	98.61
1000	2400	13090	15490	98.11	98.20	98.47	98.71	99.03	98.73
1500	3300	17280	20580	98.33	98.41	98.65	98.86	99.13	98.85
2000	4100	20950	25050	98.48	98.55	98.76	98.95	99.20	98.93
2500	4800	25270	30070	98.53	98.60	98.81	99.00	99.24	98.99
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

<sup>1</sup> 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**

kVA	IEEE Standard (Nominal)	Square D (Nominal)	Optional Range
225	Not specified	4.00–5.00	3.00–6.00
300	Not specified	4.00–5.00	3.00–6.00
500	Not specified	4.00–6.00	4.00–7.00
750–5000	5.75	5.75	4.50–8.00
5000	5.50	5.50	5.50–8.00

**Table 8: Standard Enclosure Design Dimension and Weights <sup>1</sup>**

kVA	Dimensions (inches)			Weight (lbs)
	Height	Width	Depth	
225	94.0	66.0	54.0	5500
300	94.0	66.0	54.0	6000
500	94.0	78.0	54.0	6250
750	94.0	72.0	54.0	7000
1000	94.0	84.0	54.0	7500
1500	94.0	90.0	54.0	9500
2000	100.0	96.0	54.0	10200
2500	100.0	102.0	54.0	11000
3000	100.0	108.0	66.0	14200
3750	100.0	108.0	66.0	19200
5000	124.0	144.0	66.0	23000

<sup>1</sup> Values listed are typical and should not be used for construction purposes.

## 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

Daily loads above rating to give normal life expectancy. Following and followed by a constant load of:

Peak Load Time in Hours	Times Rated kVA		
	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

## 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 9: Typical Heat Contribution: High Voltage—15 kV Class;  
Low Voltage—480Y/277 V**

kVA	% Load	BTU/Hour	kVA	% Load	BTU/Hour
225	25	3650	2000	25	18475
	50	6420		50	31890
	75	11030		75	54245
	100	17500		100	85545
	125	25800		125	125800
	133	28830		133	140560
300	25	4530	2500	25	21785
	50	7880		50	37970
	75	13460		75	64935
	100	21275		100	102690
	125	31320		125	151230
	133	35010		133	169040
500	25	6110	3000	25	32840
	50	11130		50	54590
	75	19500		75	90840
	100	31210		100	141600
	125	46275		125	206850
	133	51800		133	230790
750	25	9040	3750	25	40260
	50	15660		50	63975
	75	26700		75	103420
	100	42140		100	158660
	125	62000		125	229670
	133	69300		133	255730
1000	25	11000	5000	25	47770
	50	19370		50	73360
	75	33340		75	116010
	100	52900		100	175720
	125	78040		125	252490
	133	87270		133	280640
1500	25	14960			
	50	26020			
	75	44460			
	100	70280			
	125	103475			
	133	115655			

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