Uni-Cast II™ Cast Transformers

150–3,000 kVA, 2.5–46 kV Primary Voltage, 120–600 V Secondary Voltage Class 7310

Retain for future use.

Introduction

Uni-Cast II™ cast-epoxy, unit substation-type transformers are particularly suited for applications requiring a dry-type transformer with superior performance characteristics. These transformers provide the rugged durability needed for harsh environments where chemical fumes, dust, or vibration may be present.

The high voltage coils are cast in epoxy in a mold, using a computer-controlled mixing and casting process that ensures the absence of voids. The epoxy used in the casting process is mineral-filled epoxy that is Underwriters Laboratories (UL) approved.

The windings are also fiberglass reinforced to provide additional mechanical strength. Each winding is partial-discharged tested using induced voltage to ensure that it is void-free. The low voltage windings are wound with epoxy-preimpregnated insulation. After the coils are completed, they are baked to dry the moisture from the windings and to cure the insulation. This curing process binds the coils together to form solid winding blocks. The ends of the coils are then sealed with epoxy for added protection.

The core is manufactured from high permeability, cold-rolled, grain-oriented silicon steel 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, but can be used in some harsher environments
- No special waste disposal considerations
- Excellent replacement for PCB-filled transformers

Ratings

- 150–3,000 kVA (fan cooling allows higher kVA ratings)
- Primary voltage: 2.5–46 kV
- Primary BIL: Up to 250 kV
- Secondary voltage: 120–600 V
- Secondary BIL: Up to 30 kV
- Temperature rise: 100 °C (standard); 80 °C (optional); 115 °C (optional); 80/115 °C (optional)

Certifications

- ISO 9001 registered
- UL (standard); CSA (optional)
- DOE 2016 Energy Efficient (150–2500 kVA)

Special Design Options

- Seismic qualifications
- Special sound requirements
- 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 208Y/120–4,160 Volts
- ANSI C57.12.55—Conformance Standard for Transformers—Dry-Type Transformers Used in Unit Installations, Including Unit Substations
- IEEE C57.12.59™—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 C57.96™—Guide for Loading Dry-Type Distribution and Power Transformers
- IEEE C57.124-1991™—Recommended Practice for the Detection of Partial Discharges and the Measurement of Apparent Charge in Dry-Type Transformers

Specifications

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

B. Transformer(s) shall be of Uni-Cast II, dry-type construction, mounted in a suitable, ventilated [indoor] [outdoor] enclosure.

C. The average temperature rise of the transformer windings shall not exceed [100] [80] [115] [80/115] °C when the transformer is operated at full nameplate AA and FA rating. The transformer(s) shall be capable of carrying 100% of nameplate kVA rating in a 40 °C maximum, 30 °C average ambient as defined by IEEE C57.12.01™.

D. Terminations shall be side-wall mounted for: [close-coupling to high and low voltage switchgear sections] [close-coupling to high voltage switchgear on the primary side and terminating in an air-filled terminal chamber for cable connections to the low voltage side] [close-coupling to low voltage switchgear on the secondary side and termination in an air-filled terminal compartment on the primary side for cable entrance] [terminations within air-filled terminal chambers on both high voltage and low voltage side for cable entrance and exit].

E. Primary and secondary locations shall be as follows: [primary: ANSI Segment 2, *i.e.,* to observer's left when facing the transformer front; secondary: ANSI Segment 4, *i.e.,* to observer's right when facing the transformer front] [primary: ANSI Segment 4, *i.e.,* to observer's right when facing the transformer front; secondary: ANSI Segment 2, *i.e.,* to observer's left when facing the transformer front].

F. 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%. Sound level shall not exceed [the maximum specified by NEMA TR-1,1980 for the applicable kVA size of dry-type transformer] [______dB].

G. Forced air cooling shall increase the allowable full-load kVA by 33⅓%.

H. Both high and low voltage windings shall be of [copper] [aluminum] conductors. Each high voltage winding shall be cast as one rigid tubular coil. Each cast coil shall use a mineral-filled epoxy reinforced with fiberglass mat, and cast to provide complete, void-free resin impregnation throughout the entire insulation system. The low voltage windings shall be wound separately and shall be wound using epoxy resin impregnated sheet insulation. The low voltage coils shall be hermetically sealed with epoxy.The coil supports shall maintain constant pressure during thermal expansion and contraction of the coils. There shall be no rigid mechanical connection between high and low voltage coils.

I. The impulse rating of the high voltage windings must be at least equal to the basic impulse level specified by IEEE C57.12.00™ for liquid-filled distribution transformers of the same voltage class, without the use of supplemental surge arresters.

J. The impulse rating of the low voltage winding must be at least 10 kV for low voltage windings rated 1.2 kV and below.

K. The transformer core shall be constructed of high-grade, grain-oriented, silicone steel laminations, with high magnetic permeability. Magnetic flux density is to be kept well below the saturation point. The core shall be cruciform in shape, with mitered joints to keep core losses, excitation current, and noise level at a minimum. The outside surfaces of the core shall be protected against corrosion by painting with a suitable coating after assembly. Core dipping is not acceptable.

L. The enclosure(s) shall be constructed of heavy-gauge sheet steel. All ventilating openings shall be in accordance with NEMA and NEC® standards for ventilated enclosures. The cabinet shall have a minimum of four [hinged doors] [removable panels; removable panels shall have handles].

M. The base(s) shall be constructed to permit rolling or skidding in any direction, and shall be equipped with jacking pads designed to be flush with the transformer enclosure.

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 shall have a universal power supply and must contain yellow and red indicating lights. The yellow and red lamps signal that fan and alarm contacts have been activated. A 4–20 milliampere output is required for remote indication. 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. 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. Provision for future forced air cooling equipment shall include mounting provision for fans, bussing sized to the fan-cooled rating, and provisions for mounting the fan control system.

P. Low voltage bus shall be silver flash-plated [aluminum] [copper] throughout.

Q. The transformer shall comply with all applicable portions of NEMA TR-1 and IEEE C57.12.01™.

R. 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. The transformer windings must be free of partial discharge up to at least 1.3 times the rated line-to-ground voltage. All coils shall be subjected to a partial discharge test.
11. Quality control impulse
12. Temperature (typical data from previous unit is acceptable)
13. Sound (typical data from previous unit is acceptable)

Technical Data

Table 1: Standard Transformer Ratings, Primary Voltage Class 2.3–46 kV, 100 °C Rise, 30 °C Ambient

kVA Self-Cooled	kVA Fan-Cooled	Secondary Voltage		
		208Y/120 V 240 V Delta	480Y/277 V 480 V Delta	4160Y/2400 V 4160 V Delta 2400 V Delta
150	200	X	X	
225	300	X	X	
300	400	X	X	
500	667	X	X	X
750	1000	X	X	X
1000	1333	X	X	X
1500	2000	X	X	X
2000	2667		X	X
2500	3333		X	X
3000	4000		X	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

Forced Air-Cooled	
Equivalent Two-Winding kVA	Class FA/AFA Rating
0–1167	67
1168–1667	68
1668–2000	69
2001–3000	71

Table 4: System Voltages and Transformer BIL Ratings

Nominal System Voltage (kV)	BIL Ratings in Common Use (kV crest)										
	10	30	45	60	75	95	110	125	150	200	250
1.2	S	1									
2.5			S	1							
5.0				S	1						
8.7					S	1					
15.0						S	1				
25.0								S	1		
34.5									S	1	

S = Standard value.

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

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	5.75	1.28	5.61	4.40	1.43	3.69	4.45	4.94
300	5.75	1.38	5.58	4.06	1.53	3.77	4.52	4.99
500	5.75	0.87	5.68	6.53	1.03	3.37	4.19	4.72
750	5.75	0.63	5.72	9.12	0.79	3.17	4.02	4.58
1000	5.75	0.80	5.69	7.10	0.96	3.32	4.14	4.69
1500	5.75	0.76	5.70	7.46	0.93	3.29	4.11	4.66
2000	5.75	0.74	5.70	7.66	0.91	3.27	4.10	4.65
2500	5.75	0.64	5.71	8.91	0.80	3.19	4.03	4.59
3000	5.75	0.57	5.72	10.03	0.73	3.12	3.98	4.55

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%	112%	100%	75%	50%[1]	25%
225	875	2680	3555	98.16	98.35	98.44	98.61	98.69	98.18
300	1035	3325	4360	98.30	98.47	98.57	98.73	98.81	98.37
500	1500	4600	6100	98.57	98.72	98.79	98.92	98.99	98.59
750	2100	5500	7600	98.83	98.94	99.00	99.09	99.12	98.71
1000	2675	5800	8475	99.00	99.09	99.13	99.18	99.20	98.75
1500	3400	7700	11100	99.15	99.23	99.27	99.32	99.30	98.98
2000	3700	11400	15100	99.11	99.20	99.25	99.33	99.36	99.13
2500	4700	12000	16700	99.16	99.24	99.27	99.33	99.41	99.02
3000	9000	17000	26000	99.03	99.11	99.14	99.18	99.12	98.68

[1] Full load losses and efficiencies are at a reference temperature of 100 °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	108.0	84.0	60.0	6400
300	108.0	84.0	60.0	7000
500	118.0	90.0	66.0	8200
750	118.0	96.0	66.0	8600
1000	118.0	102.0	66.0	10200
1500	118.0	108.0	66.0	13300
2000	118.0	114.0	66.0	14700
2500	114.0	132.0	66.0	23600
3000	112.0	118.0	60.0	24000

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

2 Dimensions are based on standard BIL and 100 °C temperature rise.

Loading

Uni-Cast 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 100 °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	1.47	1.59	1.65
1	1.30	1.36	1.39
2	1.20	1.23	1.25
4	1.13	1.15	1.16
8	1.07	1.09	1.09

Example 1: A 1000 kVA transformer loaded at 90% (900 kVA) could be loaded up to 1470 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 1390 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	3560	1500	25	13255
	50	5276		50	18185
	75	8136		75	26402
	100	12140		100	37907
	125	17288		125	52698
	133	19177		133	58125
300	25	4224	2000	25	15069
	50	6373		50	22368
	75	9921		75	34534
	100	14889		100	51567
	125	21276		125	73465
	133	23620		133	81500
500	25	6104	2500	25	21194
	50	9050		50	29454
	75	13959		75	43221
	100	20831		100	62495
	125	29668		125	87275
	133	32910		133	96367
750	25	8345	3000	25	34363
	50	11867		50	45249
	75	17736		75	63391
	100	25954		100	88790
	125	36519		125	121446
	133	40396		133	133428
1000	25	10843			
	50	14685			
	75	21088			
	100	30052			
	125	41578			
	133	45807			

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