Classes 7200, 7300, 7400

MARCH, 1995

Medium Voltage Transformers

Specification Guide

SQUARE D

GROUPE SCHNEIDER

Medium Voltage Transformers Table of Contents

PAD-MOUNTED

Page 5

PAD-MOUNTED transformers, liquid-filled and dry-type, are best suited for commercial applications in public access areas and where underground service is required.

Design Life

- 20 years*—compact, low profile design and rectangular construction provide years of service.

Environmental Information

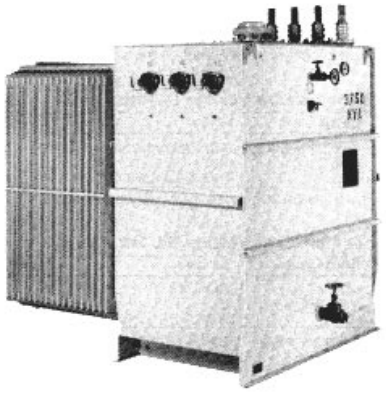
- Sealed tank construction on fluid-filled units
- Special waste disposal considerations for fluid-filled units

Ratings

- 75–5,000 kVA
- 2.5 to 46 kV primary
- 120°C insulation temperature limit

Cost of Ownership

- Low initial costs
- Some cost associated with maintenance to ensure proper fluid levels on liquid-filled units
- Virtually no maintenance on dry-type units



SUBSTATION

Page 13

SUBSTATION liquid-filled transformers are ideal for use in light to medium industrial applications.

Design Life

- 20 years*—standard rectangular construction optimizes the dielectric value of the insulating fluid.

Environmental Information

- Sealed tank construction
- Suitable for some poor environments
- Special waste disposal considerations for fluid-filled units

Ratings

- 225–10,000 kVA (fan cooling allows higher kVA ratings)
- 2.5 to 46 kV primary
- 120°C insulation temperature limit

Cost of Ownership

- Low initial costs
- Some cost associated with maintenance to ensure proper fluid levels

* Design life is a function of operating conditions and maintenance. This does not constitute any expressed or implied warranty.

POWER-DRY™

Page 21

POWER-DRY dry-type transformers meet requirements for commercial applications such as multiple-floor buildings and rooftop installations.

Design Life

- 20 years*—compact, barrel-wound rectangular construction for long service life. Circular windings provide higher BIL ratings.

Environmental Information

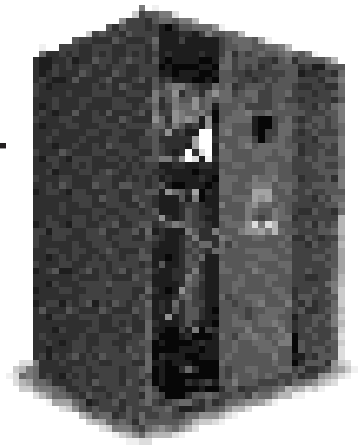
- Intended for relatively clean environments
- No fluids translates to low fire risks
- No special waste disposal considerations
- Excellent replacement for PCB-filled and gas-filled transformers

Ratings

- 67–1333 kVA single-phase
  225–5000 kVA three-phase (fan cooling allows higher kVA ratings)
- 2.5 to 25 kV primary
- 220°C insulation temperature limit

Cost of Ownership

- Low initial costs
- Virtually no maintenance



UNI-CAST™

Page 27

UNI-CAST transformers combine the best of cast-coil construction with power-dry engineering. UNI-CAST transformers are best suited for light to medium industries such as food and beverage, high-technology, pharmaceuticals, and pulp and paper.

Design Life

- 30 years*—cast-coil primary winding construction provides long-lasting durability. Circular windings infused with epoxy improve short circuit strength.

Environmental Information

- Intended for relatively clean environments, but can be used in some harsher environments
- No fluids translates to low fire risks
- No special waste disposal considerations
- Excellent replacement for PCB-filled transformers

Ratings

- 500–3,000 kVA (fan cooling allows higher kVA ratings)
- 2.5 to 35 kV primary
- 185°C insulation temperature limit

Cost of Ownership

- Moderate cost when long life expectancy is considered
- Virtually no maintenance

POWER-CAST®

Page 33

POWER-CAST transformers provide the rugged durability needed for harsh environments where chemical fumes, dust, or vibration may be present in industries such as automotive, shipping, and rapid transit.

Design Life

- 40 years*—cast-coil construction coupled with standard copper windings provides long-lasting durability. Cast primary and secondary windings are designed with superior mechanical reinforcement throughout the full length of the coils.

Environmental Information

- Intended for the harshest environments where long-term dependability is a must.
- No fluids translates to low fire risks
- No special waste disposal considerations
- Excellent replacement for PCB-filled transformers

Ratings

- 500–10,000 kVA (fan cooling allows higher kVA ratings)
- 2.5 to 46 kV primary
  185°C insulation temperature limit

Cost of Ownership

- Investment in reliability lowers the overall cost over its long life span
- Virtually no maintenance

* Design life is a function of operating conditions and maintenance. This does not constitute any expressed or implied warranty.

Notice

Words and figures in brackets are alternatives; select only one.

Metric Conversion Factors

- Inches (in) x 25.4 = millimeters (mm).
- Square inches (sq in; in^2) x 645.16 = square millimeters (mm^2).
- Cubic inches (cu in; in^3) x 16.387 = cubic centimeters (cc; cm^3).
- Feet (ft) x 0.305 = meters (m).
- Pound inches (lb in) x 0.113 = Newton meters (N•m).
- Pounds per square inch (psi) x 0.068 = atmospheres (atm).

Description

Three-phase, pad-mounted transformers, for use on underground power distribution systems, meet modern design requirements for flexibility, and provide a visually pleasing installation. Construction allows installation in locations accessible to the general public without the need for protective fencing or vaults. These units are ideally suited for apartment buildings, schools, hospitals, shopping centers, commercial buildings, or industrial sites. Standard liquid-filled sizes range from 75–5,000 kVA with primary ratings from 2,400V to 46,000V. For dry-type units, standard sizes range from 225–750 kVA with primary rating from 2,400V to 15,000V. These designs meet all applicable industry standards of ANSI, NEMA, CSA, and IEEE.

Applicable Standards

A. ANSI C37.47—Specifications for Distribution Fuse Disconnecting Switches, Fuse Supports, and Current-Limiting Fuses.

B. IEEE C57.12.00—Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers (ANSI).

C. IEEE C57.12.01—Standard General Requirements for Dry-Type Distribution and Power Transformers.

D. ANSI C57.12.22—Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers with High Voltage Bushings; 2,500 kVA and Smaller: High Voltage, 34,500 GrdY/19,920 Volts and Below; Low Voltage, 480 Volts and Below—Requirements.

E. ANSI C57.12.26—Standard for Transformers—Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers for use with *Separable Insulated High Voltage Connectors*: High Voltage, 34,500 GrdY/19,920 Volts and Below; 2,500 kVA and Smaller.

F. ANSI C57.12.28—Switchgear and Transformers, Pad-Mounted Equipment—Enclosure Integrity.

G. 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.

H. 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.

Applicable Standards (cont.)

I. IEEE C57.12.90—Standard Test Code for Liquid-Immersed Distribution Power, and Regulating Transformers and Guide for Short-Circuit Testing of Distribution and Power Transformers (ANSI).

J. IEEE C57.12.91—Test Code for Dry-Type Distribution and Power Transformers.

K. IEEE C57.13—Requirements for Instrument Transformers.

L. ANSI/IEEE 386—Separable Insulated Connector Systems for Power Distribution Systems Above 600V.

M. ASTM D877—Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.

N. NEMA AB1—Molded Case Circuit Breakers.

O. CAN/CSA-C88-M90—Electrical Power Systems and Equipment.

Specifications—Pad-Mounted Liquid-Filled Transformers

A. The transformer(s) shall be compartment type, self-cooled, for mounting on a pad and shall comply with the latest applicable standards.

B. The average temperature rise of the windings, measured by the resistance method, shall be [55˚C] [65˚C] when the transformer is operated at rated kVA output in a 40˚C ambient. The transformer shall be capable of being operated at rated load in a 30˚C average, 40˚C maximum ambient, as defined by ANSI C57.12.00 without loss of service life expectancy.

C. Coolant and insulating fluid shall be [inhibited mineral oil.] [high fire point hydrocarbon] [dimethyl polysiloxane 561™ silicone transformer fluid by Dow Corning].

D. The high and low voltage compartments shall be located side by side, separated by a steel barrier. When facing the transformer, the low voltage compartments shall be on the right. Terminal compartments shall be full height, air-filled, with individual doors. The high voltage door fastenings shall not be accessible until the low voltage door has been opened.

E. The following accessories shall be provided as standard on all transformers:
   1. Nameplate in low voltage compartment, 1" upper filter press and filling plug, [1” drain plug] [1” drain valve with sampling device].
   2. Drain plug provided on 75–500 kVA. Drain valve provided on units rated 750 kVA and above.
   3. (Lightning arrester mounting provisions in live front units only.) Tap changer, for de-energized operation only, which is externally operable and padlockable. The front of both compartments shall be removable to allow the transformer to be rolled or skidded into position over conduit stubs. ANSI tank grounding provisions shall be furnished in both compartments.

F. The transformer(s) shall be rated [_____] kVA self cooled (OA). Primary voltage _____ [delta] [wye]. Secondary voltage _____ [delta] [wye], [3-wire] [4-wire], 60 Hz with two 2-1/2% full capacity above normal and two 2-1/2% below normal taps. Impedance shall be [_____%] [manufacturer’s standard impedance], ±7-1/2%. Basic impulse level of the primary winding shall be [_____kV] [as specified in ANSI C57.12.00 for comparable kV class].

G. The transformer shall be of sealed-tank construction or sufficient strength to withstand a pressure of 7 psi without permanent distortion. The cover shall be welded and the fastenings tamper-resistant. The transformer shall remain effectively sealed for a top oil temperature range of –5˚C to 105˚C. When required, cooling panels will be provided on the back and sides of the tank. Lifting eyes and packing pads will be provided.

Specifications—Pad-Mounted Liquid-Filled Transformers (cont.)

H. Coils shall be wound with [copper] [aluminum] conductors.

I. Core and coil assembly shall be the five-legged wound core type, using high grade, grain-oriented silicon steel laminations carefully annealed after fabrication to restore high magnetic permeability. Magnetic flux is to be kept well below the saturation point.

J. Transformers connected wye-wye shall be built with five-legged core-type design to avoid the tank heating problems sometimes associated with wye-wye connections.

K. The high voltage terminations and equipment shall be [live front and conform to ANSI C57.12.22] [dead front and conform to ANSI C57.12.26].

L. Live front bushings shall be porcelain with [clamp-type connector] [blade terminals incorporating a 2-hole drilling pattern]. Bushings shall be externally clamped and front removable.

M. Dead front bushings shall be either universal wells or one-piece integrated for use with separable connectors. Bushings shall be externally clamped and front removable.

N. The low voltage bushings shall be molded epoxy, and provided with blade-type spade terminals with NEMA standard hole spacing arranged for vertical take-off. The low voltage neutral shall be an insulated bushing, grounded to the tank by a removable ground strap.

O. Wye-wye transformers shall have the high and low voltage neutrals internally tied, with a removable strap.

P. Provide a load break, gang operated, liquid immersed switch that is externally operable from the high voltage compartment through the use of a distribution hot-stick.

Q. Switch to be [2-position "OFF-ON" type for use on a radial feed-system] [3-position for use on an alternate feed system with feed-from-the-left, feed-from-the-right, or off] [4-position "sectionalizing" type for use on an extended radial or loop-feed system with feed-from-the-left, feed-from-the-right, isolated-from-either-side, or through-feed to both sides] [2-position switches to be used as "sectionalizing" switches on extended radial or loop-feed systems with feed-from-the-left, feed-from-the-right, isolated-from-either-side, or through-feed-to-both-sides].

R. Liquid-immersed switch to be rated at: [200A] [300A] [600A].

S. Select one of the following options for fusible protection:
   1. Provide internal oil immersed cartridge fuses sized at [_____amperes] [approximately three times the full-load primary current].
   2. Provide Bay-O-Net® oil immersed fuses that are externally replaceable with a hot-stick without opening the transformer tank.
   3. Provide Bay-O-Net oil immersed fuses in series with oil immersed current-limiting fuses. Bay-O-Net fuses are to be externally replaceable with a hot-stick without opening the transformer tank.
   4. Provide Bay-O-Net oil immersed current limiting fuses that are externally replaceable with a hot-stick without opening the transformer tank.
   5. Provide dry-well canister mounted current limiting fuses that are externally replaceable with a distribution hot-stick without opening the transformer tank.
   6. Provide McGraw-Edision type NX Arc Strangler® fuses or switchblades in series with NX fuses mounted for cold-sequence connection of incoming radial feed line.

T. Surge Protection—Provide three _____kV distribution class lightning arresters for surge protection. Arresters are to be mounted in the high voltage compartment.

Specifications—Pad-Mounted Liquid-Filled Transformers (cont.)

U. Accessories
1. 1” drain valve with sampling device, 75–500 kVA only standard on units above 500 kVA.
2. Dial type thermometer.
3. Magnetic liquid-level gauge.
4. Pressure vacuum gauge.
5. Pressure relief valve.
6. Automatic pressure relief device (self resealing with indicator).
7. Mounting provisions for low voltage current transformers and potential transformers.
8. Busway opening into the low voltage compartment to accommodate Square D I-LINE® Busway.
9. Molded case circuit breaker in the low voltage compartment rated _____ amperes—2000 amperes maximum rating.
10. Sudden pressure relay.
11. Key interlock to high voltage door.
12. kWH meter socket with hinge cover externally mounted on the side of the low voltage compartment.

V. Testing—Tests shall be conducted in accordance with the provisions of ANSI C57.12.90 and shall include, as 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. QA Impulse Test

Specifications—VPI Pad-Mounted Dry-Type Transformers

A. The transformer(s) shall be compartment type, self-cooled, for mounting on a pad and shall comply with the latest applicable standards.

B. Transformer coils shall be of the continuous wound construction and impregnated utilizing the VPI process. The coils shall be preheated and subjected to a dry vacuum of no less than 29.7” of mercury. Precatalyzed resin shall be introduced into the coil with vacuum maintained during the process. The coils shall then be subjected to a pressure of 75 psi for a suitable length of time to provide complete impregnation of the coils with no voids or air pockets which can create hot spots or cause corona formation. The coils shall then be cured in ovens forming non-hydroscopic coils with a minimum 2 mils coating over Nomex® insulated conductors. The coils shall be wound with [aluminum] [copper] conductors.

C. All transformers shall have a maximum temperature rise of [150°C] [115°C] [80°C] above a 40°C maximum ambient.

D. Primary taps shall be full capacity, with a minimum of two 2-1/2% above and below rated voltage.

E. kVA sizes, voltages, and taps shall be as shown on the electrical plans or on the transformer schedule.

F. The basic impulse levels (BIL) shall be a minimum of [60 kV for the 15 kV class] [optional 95 kV BIL available] [30 kV for the 5 kV class] [20 kV for the 2.5 kV class] [10 kV for the 1.2 kV class]. Primary and secondary BIL shall be _____ kV and _____ kV respectively.

G. All coils shall 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 laminations shall be miter cut at the core

Specifications—VPI Pad-Mounted Dry-Type Transformers (cont.)

corners to reduce hot spots, core loss, excitation current, and sound level. The laminations shall be clamped together utilizing insulated bolts through the core laminations to provide proper pressure throughout the length of the core.

H. Provision shall be made to completely isolate the core and coil from the enclosure. 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 base. 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 NEC standards.

I. Dry-type transformers shall be mounted in a heavy gauge sheet steel enclosure consisting of three isolated sections, high voltage compartment, low voltage compartment, and transformer compartment on a common base to form an integral load center. The enclosure is to be of NEMA Type 3R rated rain-resistant construction. Indoor enclosures with weathershields are not acceptable.

J. The high voltage termination section shall contain spade type terminals with standard NEMA type hole patterns. (Available options include main breaker and I-LINE® panelboard with or without main breaker.)

K. The low voltage termination section shall contain spade type terminals with standard NEMA type hole patterns. (Available options include hook-stick operated and individual-pole load break fused disconnects with current limiting fuses.)

L. The enclosure base is to be constructed of structural steel members to permit rolling or skidding in any direction. The base shall also be provided with lifting devices and jacking pads designed to be flush with the enclosure.

M. Access to the transformer section is to be through a removable panel equipped with padlock hasps to prevent entry by unauthorized personnel when padlocks are installed. Entrance to the high voltage compartment shall not be possible until the low voltage compartment door is open and interlocking screws are released. The low voltage compartment shall have 3-point latching and padlocking provisions.

N. Any parts of the enclosure that do not have padlocking provisions shall be secured with either tamper-resistant hardware or carriage bolts with nuts inside the enclosure to prevent removal by unauthorized personnel.

O. The entire enclosure shall be finished utilizing a continuous process consisting of degreasing, cleaning, and phosphatizing, followed by electrostatic deposition of a polymer polyester powder coating and baking cycle to provide uniform, weather-resistant coating of all edges and surfaces. The coating shall be UL recognized for outdoor use. The coating color shall be green.

P. 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.

Q. Transformers are to be manufactured and tested in accordance with IEEE standards C57.12.01, C57.12.91, C57.12.50, and C57.12.51, and shall include, as 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. QA Impulse Test

Liquid-Filled Application*

Standard Combinations of High and Low Voltages For Given kVA Range

High Voltage Class	Low Voltage Rating	kVA Range
2.5 kV	208Y/120V 240V 480Y/277V 480V 600Y347V 600V	75–1,500 kVA 75–2,000 kVA 75–2,000 kVA 75–2,000 kVA 75–2,000 kVA 75–2,000 kVA
5.0 kV	208Y/120V 240V 480Y/277V 480V 600Y/347V 600V	75–1,500 kVA 75–2,500 kVA 75–3,000 kVA 75–3,000 kVA 75–3,000 kVA 75–3,000 kVA
8.7 kV	208Y/120V 240V 480Y/277V 480V 600Y/347V 600V 2400V, 4160V, 4800V	75–1,500 kVA 75–2,500 kVA 75–5,000 kVA 75–5,000 kVA 75–5,000 kVA 75–5,000 kVA 225–5,000 kVA
15.0 kV	208Y/120V 240V 480Y/277V 480V 600Y/347V 600V 2400V, 4160V, 4800V	75–1,500 kVA 75–2,500 kVA 75–5,000 kVA 75–5,000 kVA 75–5,000 kVA 75–5,000 kVA 225–5,000 kVA
25.0 kV	208Y/120V 240V 480Y/277V 480V 600Y/347V 600V 2400V, 4160V, 4800V	75–1,500 kVA 75–2,500 kVA 75–5,000 kVA 75–5,000 kVA 75–5,000 kVA 75–5,000 kVA 225–5,000 kVA
34.5 kV	208Y/120V 240V 480Y/277V 480V 600Y/347V 600V 2400V, 4160V, 4800V	225–1,500 kVA 225–2,500 kVA 225–5,000 kVA 225–5,000 kVA 225–5,000 kVA 225–5,000 kVA 225–5,000 kVA

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 factory for final determination.

Basic Insulations Levels (BIL)

kV Class	Standard BILs			Optional BILs		
	BIL (kV)	Induced Voltage Test	Applied Voltage Test (kV)	BIL (kV)	Induced Voltage Test	Applied Voltage Test (kV)
1.2	30	Twice Normal Voltage	10	45	Twice Normal Voltage	15
2.5	45		15	60		19
5.0	60		19	75		26
7.2	60		19	75		26
8.7	75		26	95		34
15.0	95		34	110		34
25.0	125		40	150		50
35.0	150		50	200		70

Sound Levels

kVA Rating	Self Cooled Rating (dB)	kVA Rating	Self Cooled Rating (dB)
75 kVA	51	1000 kVA	58
112.5 kVA	55	1500 kVA	60
150 kVA	55	2000 kVA	61
225 kVA	55	2500 kVA	62
300 kVA	55	3000 kVA	63
500 kVA	56	3750 kVA	64
750 kVA	58	5000 kVA	66

*See page 21 for POWER-DRY dry-type transformer application.

Liquid-Filled Application (cont.)

Typical Performance Data — High Voltage–15 kV Class, Low Voltage–600V Class

kVA	No Load Losses (Watts)	Full Load Losses (Watts)	Total Losses (Watts)	Efficiency					Maximum Efficiency
				112%	100%	75%	50%	25%	
75	450	985	1435	98.03	98.12	98.25	98.18	97.34	98.26 @67.69% Load
112	620	1,350	1970	98.19	98.27	98.38	98.32	97.55	98.39 @67.77% Load
150	775	2,430	3,205	97.77	97.91	98.13	98.19	97.59	98.20 @56.47% Load
225	800	3,280	4,085	98.09	98.22	98.46	98.58	98.24	98.63 @49.39% Load
300	975	4,120	5,095	98.20	98.33	98.56	98.68	98.38	98.68 @48.65% Load
500	1,330	5,550	6,880	98.64	98.64	98.83	98.92	98.68	98.92 @48.95% Load
750	1,840	9,300	11,040	98.43	98.55	98.77	98.91	98.73	98.91 @44.72% Load
1,000	2,000	12,025	14,025	98.60	98.62	98.84	99.01	98.91	99.03 @40.78% Load
1,500	2,880	15,700	18,580	98.67	98.78	98.97	99.10	98.98	99.11 @42.83% Load
2,000	3,550	21,750	25,300	98.64	98.75	98.96	99.11	99.03	99.13 @40.40% Load
2,500	4,400	23,750	28,150	98.79	98.89	99.06	98.18	99.07	99.19 @43.04% Load
3,000	5,385	28,450	33,835	98.79	98.88	99.06	99.17	99.05	99.18 @43.61% Load
3,750	7,700	34,850	42,550	98.79	98.88	99.04	99.13	98.96	99.13 @47.00% Load
5,000*	8,240	33,020	41,260	99.12	99.18	99.29	99.34	99.18	99.34 @49.95% Load

*5000 kVA is listed with 5 kV secondary.

Typical Performance Data

kVA	%IZ	%IR	%IX	X/R Ratio	Regulation			
					1.0 PF	.9 PF	.8 PF	.7 PF
75	3.50	1.31	3.24	2.47	1.37	2.62	3.01	3.25
112	3.50	1.21	3.29	2.73	1.26	2.55	2.95	3.20
150	3.75	1.62	3.39	2.09	1.68	2.96	3.34	3.56
225	4.00	1.46	3.51	2.41	1.52	2.87	3.29	3.54
300	4.00	1.37	3.76	2.74	1.44	2.91	3.38	3.66
500	4.50	1.11	4.36	3.93	1.21	2.96	3.54	3.92
750	5.75	1.24	5.61	4.53	1.40	3.67	4.43	4.92
1,000	5.75	1.20	5.62	4.67	1.36	3.64	4.41	4.90
1,500	5.75	1.05	5.65	5.40	1.21	3.51	4.31	4.82
2,000	5.75	1.08	5.65	5.19	1.25	3.55	4.33	4.82
2,500	5.75	0.95	5.67	5.96	1.11	3.44	4.24	4.77
3,000	5.75	0.95	5.37	5.98	1.11	3.44	4.24	4.77
3,750	5.75	0.93	5.68	6.11	1.09	3.42	4.23	4.76
5,000	5.75	0.66	5.71	8.05	0.82	3.20	4.04	4.60

Standard Impedance Ratings*

kVA Range	Low Voltage	Typical	Optional Range
75 kVA	240V, 208V	3.50% IZ	2.00–5.00% IZ
	480V, 600V	3.50% IZ	2.00–5.00% IZ
112 kVA	240V, 208V	3.50% IZ	2.00–5.00% IZ
	480V, 600V	3.50% IZ	2.00–5.00% IZ
150 kVA	240V, 208V	3.75% IZ	2.00–5.00% IZ
	480V, 600V	3.75% IZ	2.00–5.00% IZ
225 kVA	240V, 208V	4.00% IZ	3.00–5.50% IZ
	480V, 600V	3.80% IZ	3.00–5.50% IZ
	2400–4800V	3.80% IZ	3.00–5.50% IZ
300 kVA	240V, 208V	4.00% IZ	3.00–5.50% IZ
	480V, 600V	4.00% IZ	3.00–5.50% IZ
	2400–4800V	3.80% IZ	3.50–5.50% IZ
500 kVA	240V, 208V	4.50% IZ	3.50–5.50% IZ
	480V, 600V	4.50% IZ	3.50–5.50% IZ
	2400–4800V	4.00% IZ	3.00–5.50% IZ
		Standard	
750–5000 kVA	240V, 208V	5.75% IZ	5.00–8.00% IZ
	480V, 600V	5.75% IZ	5.00–8.00% IZ
	2400–4800V	5.50% IZ	5.00–8.00% IZ

* Tolerance: ±7.5% (per ANSI C57.12.00). For other impedance ratings, contact factory.

Liquid-Filled Application (cont.)

Available Fuses

3Ø Xfmr kVA Rating	Primary Ø-Ø Voltage														
	2400	4160	4800	7200	8320	12000	12470	13200	13800	14400	20780Y/ 1200	22960Y/ 13200	24940Y/ 14400	26400	34500Y/ 19920
75	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G, I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A^1,B^1,C^1, D^2,E^2,G^2, I,J,O,P	A^1,B^1,C^1, D^2,E^2,G^2, I,J,O,P	A^1,B^1,C^1, D^3,E^2,G^2, I^2,J^2,O,P	O,P	D^2,E^2,G^2, I^2,O,P
112	A,B,C,D, G,I,J,L, M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A^1,B^1,C^1, D^2,E^2,G^2, I,J,O,P	A^1,B^1,C^1, D^2,E^2,G^2, I,J,O,P	A^1,B^1,C^1, D^3,E^2,G^2, I^2,J^2,O,P	O,P	D^2,E^2,G^2, I^2,O,P
150	A,B,C,G, J,K,L,M, O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A^1,B^1,C^1, D^2,E^2,G^2, I,J,O,P	A^1,B^1,C^1, D^2,E^2,G^2, I,J,O,P	A^1,B^1,C^1, D^3,E^2,G^2, I^2,J^2,O,P	O,P	D^2,E^2,G^2, I^2,O,P
225	A,B,C,H, J,K,L,M, O,P	A,B,C,D, G,J,K,L, M,O,P	A,B,C,D, G,I,J,L, M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A^1,B^1,C^1, D^2,E^2,G^2, I,J,O,P	A^1,B^1,C^1, D^2,E^2,G^2, I,J,O,P	A^1,B^1,C^1, D^3,E^2,G^2, I^2,J^2,O,P	O,P	D^2,E^2,G^2, I^2,O,P
300	A,B,C,H, L,M,O,P	A,B,C,G, J,K,L,M, O,P	A,B,C,D, G,J,K,L, M,O,P	A,B,C,D, E,G,I,L, M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A^1,B^1,C^1, D^2,E^2,G^2, I,J,O,P	A^1,B^1,C^1, D^2,E^2,G^2, I,J,O,P	A^1,B^1,C^1, D^3,E^2,G^2, I^2,J^2,O,P	O,P	D^2,E^2,G^2, I^2,O,P
500	A,N,O,P	A,B,C,H, M,O,P	A,B,C,H, K,M,O,P	A,B,C,D, G,K,M, O,P	A,B,C,D, G,I,M,O, P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, E,G,I,J, L,M,O,P	A,B,C,D, F,G,I,J, L,M,O,P	A,B,C,D, F,G,I,J, L,M,O,P	A,B,C,D, F,G,I,J, L,M,O,P	A^1,B^1,C^1, D^2,E^2,G^2, I,J,O,P	A^1,B^1,C^1, D^2,E^2,G^2, I,J,O,P	A^1,B^1,C^1, D^3,E^2,G^2, I^2,J^2,O,P	O,P	D^2,E^2,G^2, I^2,O,P
750	P	A,N,O,P	A,B,C,N, O,P	A,B,C,H, K,N,O,P	A,B,C,H, K,M,O,P	A,B,C,D, H,I,M,O, P	A,B,C,D, H,I,J,M,O P	A,B,C,D, G,I,M,O, P	A,B,C,D, G,I,M,O, P	A,B,C,D, G,I,M,O, P	A^1,B^1,C^1, D^2,F^2,G^2, I,O,P	A^1,B^1,C^1, D^2,E^2,G^2, I,O,P	A^1,B^1,C^1, D^3,E^2,G^2, I^2,O,P	O,P	D^2,I^2,O,P
1000		N,O,P	A,N,O,P	A,B,C,H, N,O,P	A,B,C,H, K,M,O,P	A,B,C,H, K,M,O,P	A,B,C,H, K,M,O,P	A,B,C,H, K,M,O, P	A,B,C,D, H,K,M, O,P	A,B,C,D, H,K,M, O,P	B^1,D^2,F^2, G^2,I,O,P	B^1,D^2,F^2, G^2,I,O,P	B,C,F^2, G^2,I^2,O, P	O,P	D^2,I^2,O,P
1500		P	P	A,N,O,P	A,N,O,P	A,C,H,K, M,O,P	A,C,H,K, M,O,P	A,C,H,K, M,O,P	A,C,H,K, M,O,P	A,C,H,K, M,O,P	D^2,H^2,K, O,P	D^2,K,O,P	K^2,O,P	O,P	I^2,O,P
2000		P	P	P	N,O,P	N,O,P	N,O,P	C,N,O,P	C,N,O,P	N,O,P	K,O,P	K,O,P	K^2,O,P	O,P	K^2,O,P
2500				P	P	N,O,P	N,O,P	N,O,P	N,O,P	N,O,P	P	P	P	O,P	K^2,O,P
3000				P	P	P	N,O,P	N,O,P	N,O,P	N,O,P	P	P	P	P	K^2,O,P
3750					P	P	P	P	P	P	P	P	P	P	O,P
5000						P	P	P	P	P	P	P	P	P	P

[1] Recommended fuse is limited to GNDY/GNDY transformers with no more than **25%** delta connected secondary load and with neutral internally grounded.
[2] Recommended fuse is limited to GNDY/GNDY transformers with no more than **50%** delta connected secondary load and with neutral internally grounded.
[3] Recommended fuse is limited to GNDY/GNDY transformers with no more than **80%** delta connected secondary load and with neutral internally grounded.

KEY:

A. Weak Link Expulsion Fuse
B. Bay-O-Net Overload Sensing Fuse
C. Bay-O-Net Fault Sensing Fuse
D. Bay-O-Net Current Limiting Fuse
E. Bay-O-Net Overload Sensing Fuse in Series with Current Limiting Fuse
F. Bay-O-Net Overload Sensing Fuse in Series with Parallel Current Limiting Fuse
G. Bay-O-Net Fault Sensing Fuse in Series with Current Limiting Fuse
H. Bay-O-Net Fault Sensing Fuse in Series with Parallel Current Limiting Fuse
I. Drywell Canisters with Current Limiting Fuses
J. Drywell Canisters with Load Break Current Limiting Fuses
K. Drywell Canisters with Current Limiting Fuses (Parallel)
L. McGraw Edison Arc Strangler Disconnects with Hinge Mounted Current Limiting Fuses
M. McGraw Edison Arc Strangler Disconnects with Clip Mounted Current Limiting Fuses (100 A maximum)
N. McGraw Edison Arc Strangler Disconnects with Parallel Mounted Current Limiting Fuses (200 A maximum)
O. Clip Mounted Current Limiting Fuses for use with Load Break Oil Switch
P. E Rated Power Fuses

Description

Liquid-filled, three-phase, substation type transformers are used in a wide variety of commercial and light industrial applications. All units are manufactured in accordance with applicable ANSI C57.12.00 standards. The transformers are offered with one of three different fluids:

- Mineral oil—biodegradable oil for outdoors
- R-Temp® by Cooper Industries
- 561™ silicone fluid (dimethyl polysiloxane) by Dow Corning

Applicable Standards

A. IEEE C57.12.00—Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.

B. ANSI C57.12.10-1988, Safety Requirements 230 kV and Below 833/958 Through 8333/10 417 kVA, Single-Phase, and 750/862 Through 60 000/80 000/100 000 kVA, Three-Phase Without Load Tap Changing; and 3750/4687 Through 60 000/80 000/ 100 000 kVA with Load Tap Changing.

C. ANSI C57.12.70-1978 (Reaff 1993), Terminal Markings and Connections for Distribution and Power Transformers.

D. ANSI C57.12.28—Switchgear and Transformers, Pad-Mounted Equipment—Enclosure Integrity.

E. IEEE C57.12.80-1978 (Reaff 1992), Standard Terminology for Power and Distribution Transformers (ANSI).

F. IEEE C57.12.90—Test Code for Liquid-Immersed Distribution Power, and Regulating Transformers and Guide for Short-Circuit Testing of Distribution and Power Transformers (ANSI).

G. IEEE C57.105-1978 (Reaff 1992), Guide for Application of Transformer Connections in Three-Phase Distribution Systems (ANSI).

H. IEEE C57.109-1993, Guide for Liquid-Immersed Transformer Through-Fault-Current Duration (ANSI).

I. IEEE C57.111-1989, Guide for Acceptance of Silicone Insulating Fluid and Its Maintenance in Transformers.

J. IEEE C57.121-1988, Guide for Acceptance and Maintenance of Less Flammable Hydrocarbon Fluid in Transformers (ANSI).

K. CSA-C88 Power Transformers and Reactors.

L. CSA-C50 Insulating Oils—Electrical for Transformers and Switches.

Specifications

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

B. The average temperature rise of the windings, measured by the resistance method, shall be [55˚] [65˚] C when the transformer is operated at rated kVA output in a 40˚C ambient. The transformer(s) shall be capable of being operated at rated load in a 30˚C average, 40˚C maximum ambient, as defined by ANSI C57.12.00, without loss of service life expectancy.

C. Coolant and insulating fluid shall be [inhibited mineral oil] [high fire point hydrocarbon R-Temp fluid manufactured by Cooper Industries] [dimethyl polysiloxane 561 silicone transformer fluid by Dow Corning].

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 locators 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 left when facing the transformer front; secondary: ANSI Segment 2, i.e. to observer's left when facing the transformer front].

F. Bushing location and phase rotation shall be coordinated with primary and secondary switchgear to provide correct alignment when switchgear and transformer are connected in the field.

G. The transformer(s) shall be rated [_____kVA OA] [_____/_____kVA OA/FFA] [_____/_____kVA OA/FA]. Transformer identification number(s)_____. Primary voltage _____ [delta] [wye], secondary voltage _____ [delta] [wye], [3-wire] [4-wire], 60 Hz with two 2-1/2% full capacity above normal and two 2-1/2% full capacity below normal taps. Impedance shall be [_____%] [Manufacturer's standard impedance], ±7-1/2%. Basic impulse level of the primary winding shall be [_____kV]. As specified in IEEE C57.12.00 for comparable kV class.

Sound level, as measured by the NEMA audible sound-level test procedure, shall be less than the values specified in the following table when the transformer(s) (is) (are) operated at normal voltage and frequency and no load.

kVA	225	500	750	1000	1500	2000	2500	3000	3750	5000
dB	55	56	58	58	60	61	62	63	64	66

H. The transformers shall be of sealed-tank construction of sufficient strength to withstand a pressure of 7 psi without permanent distortion. The cover shall be welded. The transformer shall remain effectively sealed for a top oil temperature range of –5˚C to 105˚C. When required, cooling panels will be provided on the back and front of the tank. Lifting eyes and jacking pads will be provided.

I. Coils shall be wound with [copper] [aluminum] conductors.

J. Core and coil assembly shall be the [wound core type, providing 5-legged construction] [stacked core type, providing 3-legged construction]. Cores shall be fabricated of high grade, grain-oriented, silicon steel laminations, carefully annealed after fabrication to restore high magnetic permeability. Magnetic flux is to be kept well below the saturation point.

Specifications (cont.)

K. Tank, radiators, and terminal chambers, if provided, shall be treated to remove oil and scale by either shotblast or phosphatizing treatment to provide proper paint adhesion. All exterior surfaces shall be primed, using a high quality solid two-paint catalyzed epoxy. Minimum dry film thickness shall be 2 mils. A durably hard polyurethane top coat with a minimum dry film thickness of 1 mil shall be applied to all primed surfaces. The color of the finish coat shall be [ANSI 49] [ANSI 61] [ANSI 70] [ANSI 24] and shall be coordinated with the switchgear manufacturer in order to match the color of the switchgear.

L. Accessories—The following accessories shall be included on all substation transformers:
1. Padlockable tap changer for de-energized operation
2. 1” upper filling plug and filter press connection
3. 1” drain valve with a 3/8” sampler
4. Dial type thermometer
5. Pressure/vacuum gauge [with] [without] bleeder connection
6. Magnetic liquid level gauge
7. Pressure relief valve, with manual bleeder and automatic resealing, set to operate at 10 psi with a flow rate of [35 scfm] [50 scfm]
8. Alarm contacts on [all gauges] [dial thermometer] [liquid level gauge] [pressure vacuum gauge]
9. Pressure relief diaphragm to operate at 10 psi and relieve 10,000 scfm at 15 psi
10. Sudden pressure relay permitting remote alarm or trip due to a predetermined rate of pressure rise [with] [without] seal-in delay

M. The transformer(s) shall be designed for use with fans to increase the current carrying capability in accordance with the ratings of paragraph 2.01 G preceding. The transformer shall be equipped with forced air cooling or be designed for the future addition of forced air cooling. The fan control equipment will be actuated by contacts that sense [the temperature of the top oil] [the average winding temperature] of the transformer. Temperature sensors, motor starter for fan motors, test modes of operation, as well as fans and fan motors, will be provided on units designated OA/FA. Temperature sensors and details for future mounting of fans and controls will be provided on units designated OA/FFA. Fan motors will operate from a 240V, single-phase, 60 Hz source of power provided by the user.

N. Testing—Tests shall be conducted in accordance with the provisions of IEEE C57.12.90 and shall include, as 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. Impulse Test
11. Temperature Test (typical data from previous unit is acceptable)
12. Sound Test (typical data from previous unit is acceptable)

Application

Standard Combinations of High and Low Voltages For Given kVA Range

High Voltage Class	Low Voltage Class	kVA Range
2.5 kV	208Y/120V 240V 480Y/277V 480V 600Y/347 600V	225–1,500 kVA 225–2,000 kVA 225–2,000 kVA 225–2,000 kVA 225–2,000 kVA 225–2,000 kVA
5.0 kV	208Y/120V 240V 480Y/277V 480V 600Y/347V 600V	225–1,500 kVA 225–3,000 kVA 225–3,000 kVA 225–3,000 kVA 225–3,000 kVA 225–3,000 kVA
8.6 kV	208Y/120V 240V 480Y/277V 480V 600Y/347 600V 2400V, 4160V, 4800V	225–1,500 kVA 225–2,500 kVA 225–5,000 kVA 225–5,000 kVA 225–5,000 kVA 225–5,000 kVA 750–5,000 kVA
15.0 kV	208Y/120V 240V 480Y/277V 480V 2400V, 4160V, 4800V	225–1,500 kVA 225–2,500 kVA 225–3,750 kVA 225–3,750 kVA 500–10,000 kVA
25.0 kV	208Y/120V 240V 480Y/277V 480V 600Y/347 600V 2400V, 4160V, 4800V	225–1,500 kVA 225–2,500 kVA 225–3,750 kVA 225–3,750 kVA 225–5,000 kVA 225–5,000 kVA 500–10,000 kVA
34.5 kV	208Y/120V 240V 480Y/277V 480V 600Y/347 600V 2400V, 4160V, 4800V	225–1,500 kVA 225–2,500 kVA 225–3,750 kVA 225–3,750 kVA 225–5,000 kVA 225–5,000 kVA 500–10,000 kVA

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 factory for final determination.

Basic Insulations Levels (BIL)

kV Class	Standard BILs			Optional BILs		
	BIL (kV)	Induced Voltage Test	Applied Voltage Test (kV)	BIL (kV)	Induced Voltage Test	Applied Voltage Test (kV)
1.2	30	Twice Normal Voltage	10	45	Twice Normal Voltage	15
2.5	45		15	60		19
5.0	60		19	75		26
7.2	60		19	75		26
8.7	75		26	95		34
15.0	95		34	110		34
25.0	125		40	150		50
35.0	150		50	200		70

Application (cont.)

Sound Levels

kVA Rating	Self Cooled Rating (dB)	Fan Cooled Rating (dB)
225-300 kVA	55	61
500 kVA	56	61
750 kVA	58	61
1,000 kVA	58	61
2,000 kVA	60	63
2,000 kVA	62	64
2,500 kVA	62	65
3,000 kVA	63	66
3,750 kVA	64	67
5,000 kVA	66	70
7,500 kVA	67	70
10,000 kVA	68	71

Typical Performance Data — High Voltage –15 kV Class, Low Voltage–600V Class

kVA	No Load Losses (Watts)	Full Load Losses (Watts)	Total Losses (Watts)	Efficiency						Maximum Efficiency
				140%	125%	100%	75%	50%	25%	
225	760	3,400	4,160	97.70	97.89	98.18	98.44	98.59	98.30	98.69@47.23%
300	900	4,635	5,535	97.68	97.87	98.19	98.47	98.65	98.44	98.66@44.07%
500	1,330	5,540	6,870	98.29	98.43	98.61	98.83	98.93	98.68	98.93@49.00%
750	1,735	9,875	11,610	98.03	98.20	98.48	98.72	98.89	98.76	98.91@41.92%
1,000	2,000	12,025	14,025	98.21	98.36	98.62	98.84	99.01	98.91	99.03@40.78%
1,500	2,900	15,720	18,620	98.42	98.66	98.77	98.97	99.10	98.98	99.11@42.95%
2,000	3,535	21,750	25,285	98.38	98.62	98.75	98.96	99.11	99.03	99.13@40.31%
2,500	4,400	23,750	28,150	98.67	98.69	98.89	99.06	99.18	99.07	99.19@43.04%
3,000	5,385	28,450	33,835	98.67	98.69	98.88	99.06	99.17	99.05	99.18@43.61%
3,750	7,700	34,850	42,550	98.67	98.69	98.88	99.04	99.13	98.96	99.13@47.00%
5,000*	9,650	46,750	56,400	98.67	98.69	98.88	99.05	99.15	99.00	99.16@45.43%
7,500*	11,950	56,500	68,450	98.85	98.94	99.10	99.23	99.31	99.18	99.31@45.99%
10,000*	16,515	66,923	83,440	98.96	99.04	99.17	99.28	99.34	99.18	99.34@49.68%

*5,000; 7,500; 10,000 kVA are listed with 5 kV secondaries.

Typical Performance Data

kVA	%IZ	%IR	%IX	X/R Ratio	Regulation			
					1.0 PF	.9 PF	.8 PF	.7 PF
225	4.00	1.52	3.72	2.46	1.58	3.01	3.45	3.71
300	4.00	1.55	3.69	2.39	1.61	3.03	3.47	3.73
500	4.50	1.11	4.37	3.94	1.20	2.96	3.54	3.92
750	5.75	1.32	5.60	4.05	1.41	3.12	3.67	4.02
1,000	5.75	1.20	5.63	4.68	1.36	3.64	4.41	4.90
1,500	5.75	1.05	5.65	5.39	1.21	3.51	4.31	4.82
2,000	5.75	1.09	5.64	5.19	1.25	3.55	4.33	4.84
2,500	5.75	0.95	5.67	5.97	1.11	3.44	4.24	4.77
3,000	5.75	0.95	5.67	5.98	1.11	3.44	4.24	4.77
3,750	5.75	0.93	5.68	6.11	1.09	3.42	4.23	4.76
5,000	5.75	0.94	5.68	6.08	1.10	3.42	4.23	4.76
7,500	5.50	0.75	5.45	7.23	0.90	3.16	3.95	4.47
10,000	5.50	0.67	5.47	8.17	0.82	3.09	3.89	4.42

Application (cont.)

Standard Impedance Ratings

kVA Range	Low Voltage	Typical	Optional Range
225 kVA	240V, 208V	4.00% IZ	3.00–5.50% IZ
	480V, 600V	3.80% IZ	3.00–5.50% IZ
	2,400–4,800V	3.80% IZ	3.00–5.50% IZ
300 kVA	240V	4.00% IZ	3.00–5.50% IZ
	480V, 600V	4.00% IZ	3.00–5.50% IZ
	2,400–4,800V	3.80% IZ	3.50–5.50% IZ
500 kVA	240V, 208V	4.50% IZ	3.50–5.50% IZ
	480V, 600V	4.50% IZ	3.50–5.50% IZ
	2,400–4,800V	4.00% IZ	3.00–5.50% IZ
		Standard	
750–5,000 kVA	240V, 208V	5.75% IZ	5.00–8.00% IZ
	480V, 600V	5.75% IZ	5.00–8.00% IZ
	2,400–4,800V	5.50% IZ	5.00–8.00% IZ
7,500–10,000 kVA	2,400–4,800V	6.50% IZ	6.50–8.00% IZ

Tolerance: ±7.5 (per ANSI C57.12.00). For other impedance ratings, contact factory.

Loading

Liquid-filled substation transformers are designed to operate at rated load with rated voltage and frequency applied in “usual service” conditions. Overloads may be carried with normal to moderate effects on the life of the transformer. The following table shows the permissible overloads that may be carried only if occurring once in any 24-hour period without loss of transformer life expectancy given an 65˚C rise transformer in a 30˚C ambient.

Following and followed by a constant load of:

Peak Load Time	90%	70%	50%
1/2 hr.	1.80	2.00	2.00
1 hr.	1.56	1.78	1.88
2 hr.	1.38	1.54	1.62
4 hr.	1.22	1.33	1.38
8 hr.	1.11	1.17	1.20

Improvement in Self-Cooled Rating with Forced Air Cooling*

kVA Range	Rating Increase
225–2000 kVA	15%
2,500–10,000 kVA	25%

*Optional 33% is available for CAN/CSA - C88.

Application (cont.)

Heat Contribution

Heat contribution is the heat that 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 upon heat contribution.

Typical Heat Contribution High Voltage — 15 kV Class, Low Voltage — 600V Class

kVA	% Load	BTU/HR	kVA	% Load	BTU/HR
225 kVA	25%	3,307	2500 kVA	25%	20,007
	50%	5,474		50%	35,148
	75%	9,087		75%	60,382
	100%	14,144		100%	95,710
	125%	20,647		125%	141,132
	140%	25,242		140%	173,230
300 kVA	25%	4,045	3000 kVA	25%	24,355
	50%	7,000		50%	42,492
	75%	11,924		75%	72,720
	100%	18,819		100%	115,039
	125%	27,683		125%	169,450
	140%	33,948		140%	207,900
500 kVA	25%	5,699	3750 kVA	25%	33,586
	50%	9,231		50%	55,803
	75%	15,117		75%	92,831
	100%	23,358		100%	144,670
	125%	33,953		125%	211,321
	140%	41,441		140%	258,420
750 kVA	25%	7,997	5000 kVA*	25%	42,744
	50%	14,293		50%	72,548
	75%	24,785		75%	122,219
	100%	39,474		100%	191,760
	125%	58,360		125%	281,169
	140%	71,706		140%	344,352
1000 kVA	25%	9,355	7500 kVA*	25%	52,636
	50%	17,021		50%	88,655
	75%	29,798		75%	148,686
	100%	47,685		100%	232,730
	125%	70,683		125%	340,786
	140%	86,935		140%	417,146
1500 kVA	25%	13,200	10,000 kVA*	25%	70,372
	50%	23,222		50%	113,036
	75%	39,925		75%	184,141
	100%	63,308		100%	283,689
	125%	93,373		125%	411,679
	140%	114,618		140%	502,126
2000 kVA	25%	16,641	*5,000; 7,500; 10,000 kVA are listed with 5 kV secondaries.		
	50%	30,507			
	75%	53,616			
	100%	85,969			
	125%	127,566			
	140%	156,961			

Description

POWER-DRY™ vacuum-pressure impregnated transformers are particularly suited for a wide range of commercial applications. Vacuum pressure impregnation (VPI) of the windings includes a preheat, dry vacuum cycle; vacuum immersion; vacuum hold cycle; pressure cycle; and curing. This VPI process saturates the dielectric material, which contributes to its long life and durability. The secondary windings are constructed with sheet or wire conductors and Nomex® insulation. The primary windings are wound over the secondary winding in either barrel or disc construction. These processes make the POWER-DRY transformer ideal for office buildings, hotels, and shopping malls.

Applicable Standards

A. IEEE C57.12.01—Standard General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid Cast and/or Resin-Encapsulated Windings.

B. ANSI C57.12.51-1981 (Reaff 1989), Requirements for Ventilated Dry-Type Power Transformers, 501 kVA and Larger, Three-Phase, with High Voltage 601 to 34,500 Volts, Low Voltage 208Y/120 to 4160 Volts.

C. 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.

D. 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 208Y/120–4160 Volts.

E. ANSI C57.12.55-1987, Conformance Standard for Transformers—Dry-Type Transformers Used in Unit Installations, Including Unit Substations.

F. IEEE C57.12.56-1986 (Reaff 1993), Standard Test Procedure for Thermal Evaluation of Insulation Systems for Ventilated Dry-Type Power and Distribution Transformers (ANSI).

G. IEEE C57.12.58-1991, Guide for Conducting a Transient Voltage Analysis of a Dry-Type Transformer Coil (ANSI).

H. IEEE C57.12.59-1989, Guide for Dry-Type Transformer Through-Fault Current Duration (ANSI).

I. ANSI C57.12.70-1978 (Reaff 1993), Terminal Markings and Connections for Distribution and Power Transformers.

J. IEEE C57.12.80-1978 (Reaff 1992), Standard Terminology for Power and Distribution Transformers (ANSI).

Applicable Standards (cont.)

K. IEEE C57.12.91—Test Code for Dry-Type Distribution and Power Transformers.

L. IEEE C57.94-1982 (Reaff 1987), Recommended Practice for Installation, Application, Operation, and Maintenance of Dry-Type General Purpose Distribution and Power Transformers.

M. IEEE C57.96-1989, Guide for Loading Dry-Type Distribution and Power Transformers (ANSI).

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 2-1/2% full-capacity above normal and two 2-1/2% full-capacity below normal primary taps. Impedance shall be [_____%] [manufacturer's standard impedance], ±7-1/2%. All transformers shall have an average temperature rise of [150˚C] [80˚C] [115˚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 coil design shall be the type to provide the most efficient, reliable, and compact winding. Transformer coils shall be of the continuous wound construction and impregnated utilizing the VPI process, achieving 100% impregnation in one cycle. The coils shall be preheated and subjected to a dry vacuum of no less than 29.7" of mercury. Precatalyzed, 100% reactive-type polyester resin shall be introduced into the coil with vacuum maintained during the process. The coils shall then be subjected to a pressure of 75 psi for a suitable length of time to provide complete impregnation of the coils with no voids or air pockets that can create hot spots or cause corona formation. The coils shall then be cured in ovens with a minimum 2 mils coating over all Nomex insulated conductors.

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

H. All insulating materials are to be in accordance with IEEE Standard 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 utilizing insulated bolts through the core laminations to provide proper pressure throughout the length of the core.

Specifications (cont.)

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. Provisions shall be made to completely isolate the core and coil from the enclosure. 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 entire enclosure shall be finished utilizing a continuous process consisting of degreasing, cleaning, and phosphatizing, followed by electrostatic deposition of a polymer polyester powder coating and baking cycle to provide uniform coating of all edges and surfaces. The coating shall be UL recognized. The coating color shall be [ANSI 49] [ANSI 61].

L. Transformer sound levels shall be warranted by the manufacturer not to exceed the following values:

151 to 300 kVA —— 58 dB	301 to 500 kVA —— 60 dB
501 to 700 kVA —— 62 dB	701 to 1000 kVA — 64 dB
1001 to 1500 kVA — 65 dB	1501 to 2000 kVA — 66 dB
2001 to 3000 kVA — 68 dB	3001 to 4000 kVA — 70 dB

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 included B-phase electronic winding temperature monitor controlled automatically by a Type K thermocouple placed in the low voltage airduct. The temperature monitor must contain green, yellow, and red indicating lights. The green lamp indicates power, while 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. Minimum 6 fans shall be provided. Each must have a minimum 6” diameter blade and shall be controlled automatically by the sensor in the low voltage air duct. Forced air cooling system shall include: fans, control wiring, controller with test switch, current limiting fuses in the power supply to the controller, indications lights, alarm silencing relay, auto/manual switch, and necessary accessories to properly control the system.

O. Testing—Tests shall be conducted in accordance with the provisions of IEEE C57.12.91 and shall include, as 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. Impulse Test (typical data from previous unit is acceptable)
   11. Temperature Test (typical data from previous unit is acceptable)
   12. Sound Test (typical data from previous unit is acceptable)

Application

Standard Combinations of High and Low Voltages For Given kVA Range

High Voltage Class	Low Voltage Rating	kVA Range
2.5 kV	208Y/120V 240V 480Y/277V, 600Y/346 480V, 600V	75–1,500 kVA 75–2,000 kVA 75–2,500 kVA 75–2,500 kVA
5.0 kV	208Y/120V 240V 480Y/277V 480V 600Y/347V 600V	75–1,500 kVA 75–2,000 kVA 75–3,750 kVA 75–3,750 kVA 75–3,750 kVA 75–3,750 kVA
8.6 kV	208Y/120V 240V 480Y/277V, 600Y/347 480V, 600V 2400V, 4160V, 4800V	75–1,500 kVA 75–2,000 kVA 75–3,750 kVA 75–3,750 kVA 75–5,000 kVA
15.0 kV	208Y/120V 240V 480Y/277V, 600Y/347 480V, 600V 2400V, 4160V, 4800V	225–1,500 kVA 225–2,000 kVA 225–3,750 kVA 225–3,750 kVA 225–5,000 kVA
25.0 kV	208Y/120V 240V 480Y/277V, 600Y/347 480V, 600V 2400V, 4160V, 4800V	750–1,500 kVA 750–2,000 kVA 750–3,000 kVA 750–3,000 kVA 750–3,000 kVA

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 factory for final determination.

Basic Insulations Levels (BIL)

kV Class	Standard BILs			Optional BILs		
	BIL (kV)	Induced Voltage Test	Applied Voltage Test (kV)	BIL (kV)	Induced Voltage Test	Applied Voltage Test (kV)
1.2	10	Twice Normal Voltage	4	30	Twice Normal Voltage	12
2.5	20		10	45		19
5.0	30		12	60		31
7.2	30		12	60		31
8.7	45		19	95		34
15.0	60		31	95		34
25.0	110		37	125		40

Sound Level

kVA Rating	Self Cooled Rating (dB)	Fan Cooled Rating (dB)
225–300 kVA 500 kVA	58 60	67 67
750 kVA 1,000 kVA	64 64	67 67
2,000 kVA 2,000 kVA	65 66	68 69
2,500 kVA 3,000 kVA	68 68	71 71
3,750 kVA 5,000 kVA	70 71	73 74

Application (cont.)

Typical Performance Data High Voltage — 15 kV Class, Low Voltage — 600V Class

kVA	No Load Losses (Watts)	Full Load Losses (Watts)	Total Losses (Watts)	Efficiency						Maximum Efficiency
				133%	125%	100%	75%	50%	25%	
225	1,200	5,300	6,500	96.59	96.74	97.19	97.58	97.80	97.35	97.81 @ 48% Load
300	1,400	6,200	7,600	96.99	97.13	97.53	97.87	98.07	97.67	98.07 @ 48% Load
500	2,200	8,150	10,350	97.56	97.67	97.97	98.22	98.33	97.88	98.33 @ 52% Load
750	2,500	12,700	15,200	97.56	97.67	98.01	98.31	98.51	98.27	98.52 @ 44% Load
1,000	3,200	16,000	19,200	97.69	97.79	98.12	98.40	98.28	98.35	98.59 @ 45% Load
1,500	4,700	19,600	24,300	98.06	98.15	98.41	98.62	98.74	98.44	98.74 @ 49% Load
2,000	5,300	23,900	29,200	98.24	98.32	98.56	98.77	98.89	98.66	98.89 @ 47% Load
2,500	6,800	24,000	30,800	98.54	98.60	98.78	98.93	98.99	98.69	98.99 @ 53% Load
3,000	7,900	27,000	34,900	98.62	98.69	98.85	98.98	99.03	98.74	99.04 @ 54% Load

Tolerance: ±7.5% (per ANSI C57.12.00). For other impedance ratings, contact factory.

Typical Performance Data

kVA	%IZ	%IR	%IX	X/R Ratio	Regulation			
					1.0 PF	.9 PF	.8 PF	.7 PF
225	4.50	2.36	3.83	1.62	2.43	3.82	4.20	4.39
300	4.50	2.07	4.00	1.93	2.15	3.64	4.07	4.31
500	5.50	1.63	5.25	3.22	1.77	3.84	4.51	4.92
750	5.75	1.69	5.50	3.25	1.84	4.01	4.71	5.14
1,000	5.75	1.60	5.52	3.45	1.75	3.94	4.65	5.10
1,500	5.75	1.31	5.60	4.27	1.46	3.72	4.47	4.96
2,000	5.75	1.20	5.62	4.69	1.35	3.63	4.40	4.90
2,500	5.75	0.96	5.67	5.91	1.12	3.44	4.25	4.77
3,000	5.75	0.90	5.68	6.31	1.06	3.40	4.21	4.74

Standard % Impedances

kVA	ANSI Std. (Nominal)	Square D (Nominal)	Optional Range
225	Not Specified	4.0–5.0	3.0–6.0
300	Not Specified	4.0–5.0	3.0–6.0
500	Not Specified	5.0–6.0	4.0–7.0
750–3,750	5.75	5.75	4.5–8.0
5,000	5.50	5.50	5.5–8.0

Loading

POWER-DRY 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 which may be carried only if occurring once in any 24-hour period without loss of transformer life expectancy given a 150˚C rise transformer in a 30˚C ambient.

Following and followed by a constant load of:

Peak Load Time	90%	70%	50%
1/2 hr.	1.33	1.43	1.49
1 hr.	1.21	1.25	1.28
2 hr.	1.14	1.15	1.10
4 hr.	1.09	1.10	1.10
8 hr.	1.05	1.06	1.06

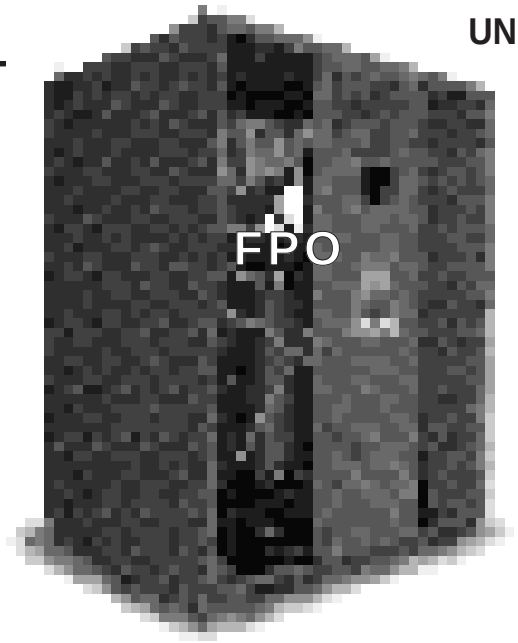
Application (cont.)

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.

Typical Heat Contribution High Voltage — 15 kV Class, Low Voltage — 480Y/277V

kVA	% Load	BTU/HR
225 kVA	25%	5,206
	50%	8,585
	75%	14,216
	100%	22,100
	125%	32,236
	133%	35,956
300 kVA	25%	6,078
	50%	10,030
	75%	16,618
	100%	25,840
	125%	37,698
	133%	42,048
500 kVA	25%	9,212
	50%	14,408
	75%	23,067
	100%	35,190
	125%	50,777
	133%	56,496
750 kVA	25%	11,199
	50%	19,295
	75%	32,789
	100%	51,680
	125%	75,969
	133%	84,881
1000 kVA	25%	14,280
	50%	24,480
	75%	41,480
	100%	65,280
	125%	95,880
	133%	107,108
1500 kVA	25%	20,145
	50%	32,640
	75%	53,465
	100%	82,620
	125%	120,105
	133%	133,860
2000 kVA	25%	23,099
	50%	38,335
	75%	63,729
	100%	99,280
	125%	144,989
	133%	161,761
2500 kVA	25%	28,220
	50%	43,520
	75%	69,020
	100%	104,720
	125%	150,620
	133%	167,462
3000 kVA	25%	32,598
	50%	49,810
	75%	78,498
	100%	118,660
	125%	170,298
	133%	189,245



Description

UNI-CAST™ transformers are an ideal choice for industries such as pharmaceuticals, food and beverage, and medical, as well as other industrial and commercial installations. UNI-CAST transformers combine the best features of vacuum cast-coil transformers with conventional vacuum-pressure impregnated (VPI) dry-type transformers. The primary windings are completely impregnated with epoxy resin which, in combination with fiberglass cloth and tape, forms the solid dielectric system. The secondary windings are wrapped in epoxy-impregnated Nomex® insulation and baked to bond the conductor and Nomex insulation. Then, the windings are encapsulated using the VPI process and the end cavities are sealed with air-dried epoxy. This combination provides not only high reliability, but an economical solution for many applications.

Applicable Standards

A. IEEE C57.12.01—Standard General Requirements for Dry-Type Distribution and Power Transformers Including Those With Solid Cast and/or Resin-Encapsulated Windings.

B. 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.

C. 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 208Y/120-4160 Volts.

D. ANSI C57.12.55-1987, Conformance Standard for Transformers—Dry-Type Transformers Used in Unit Installations, Including Unit Substations.

E. IEEE C57.12.59-1989, Guide for Dry-Type Transformer Through-Fault Current Duration (ANSI).

F. ANSI C57.12.70-1978 (Reaff 1993), Terminal Markings and Connections for Distribution and Power Transformers.

G. IEEE C57.12.80-1978 (Reaff 1992), Standard Terminology for Power and Distribution Transformers (ANSI).

H. IEEE C57.12.91—Test Code for Dry-Type Distribution and Power Transformers.

I. IEEE C57.96-1989, Guide for Loading Dry-Type Distribution and Power Transformers (ANSI).

J. IEEE C57.124-1991, Recommended Practice for the Detection of Partial Discharges and the Measurement of Apparent Charge in Dry-Type Transformers (ANSI).

Specifications

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

B. Transformer(s) shall be UNI-CAST, dry-type construction, mounted in a suitable, ventilated [indoor] [outdoor] enclosure.

C. The average temperature rise of the transformer windings shall not exceed 100˚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 C57.12.02.

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 locators 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 left 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 2-1/2% full-capacity above normal and two 2-1/2% full-capacity below normal primary taps. Impedance shall be [_____%] [manufacturer's standard impedance] ±7-1/2%. 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 33-1/3%.

H. Both high voltage and low voltage windings shall be of [aluminum] [copper] conductors. HV windings shall each be separately cast as one rigid tubular coil, and arranged coaxially. Each primary coil shall be fully reinforced with glass cloth, and cast under vacuum to provide complete, void-free resin impregnation throughout the entire insulation system. Reinforcement with suspended particulate matter (filled resin) is not acceptable. The coil supports shall maintain constant pressure during thermal expansion and contraction of the coils. There shall be no rigid mechanical connection between high voltage and low voltage coils. The low voltage windings shall be made with full width sheet. The secondary windings shall be completely wrapped in epoxy-impregnated Nomex®. Then, the windings shall be encapsulated using a vacuum pressure impregnation. To seal the end cavities, the coil ends shall be potted with an air-dried epoxy.

I. The impulse rating of the high voltage windings must be at least equal to the basic impulse level specified by IEEE C57.12.91 for oil-filled 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.

Specifications (cont.)

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, minimum 12 gauge. Units with ratings greater than 3,750 kVA shall have I-beam construction bases. All ventilating openings shall be in accordance with NEMA and NEC standards for ventilated enclosures. Ventilation openings for outgoing air shall be through side panel louvers. Incoming air flow shall be through the base for optimum air flow to the transformer. The cabinet shall have a minimum of four [hinged doors] [removable panels; removable panels shall have Bakelite handle]. The cabinet shall also have door sills for easy panel installation.

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 included B-phase electronic winding temperature monitor controlled automatically by a Type K thermocouple placed in the low voltage airduct. The temperature monitor must contain green, yellow, and red indicating lights. The green lamp indicates power, while 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. Minimum 6 fans shall be provided. Each must have a minimum 6” diameter blade and shall be controlled automatically by the sensor in the low voltage air duct. Forced air cooling system shall include: fans, control wiring, controller with test switch, current limiting fused in the power supply to the controller, indications 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. The transformer shall comply with all applicable portions of NEMA TR-1 and IEEE C57.12.01.

Q. Testing shall be done in accordance with ANSI C57.12.91 and shall included, as the 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 1.2 times the rated line-to-ground voltage. Each high voltage coil shall be subjected to a partial discharge test to verify its partial discharge.
   11. Impulse Test
   12. Temperature Test (typical data from previous unit is acceptable)
   13. Sound Test (typical data from previous unit is acceptable)

Application

Standard Combinations of High and Low Voltages For Given kVA Range

High Voltage Class	Low Voltage Rating	kVA Range
2.5 kV	208Y/120V	500–1,500 kVA
	240V	500–1,500 kVA
	480Y/277V, 600Y/347	500–2,500 kVA
	480V, 600V	500–2,500 kVA
5.0 kV	208Y/120V	500–1,500 kVA
	240V	500–1,500 kVA
	480Y/277V	500–3,750 kVA
	480V	500–3,750 kVA
	600Y/347V	500–3,750 kVA
	600V	500–3,750 kVA
8.7 kV	208Y/120V	500–1,500 kVA
	240V	500–1,500 kVA
	480Y/277V, 600Y/347	500–3,750 kVA
	480V, 600V	500–3,750 kVA
15.0 kV	208Y/120V	500–1,500 kVA
	240V	500–1,500 kVA
	480Y/277V, 600Y/347	500–3,750 kVA
	480V, 600V	500–3,750 kVA
25.0 kV	208Y/120V	750–1,500 kVA
	240V	750–1,500 kVA
	480Y/277V, 600Y/347	750–3,750 kVA
	480V, 600V	750–3,750 kVA
34.5 kV	208Y/120V	1,000–1,500 kVA
	240V	1,000–1,500 kVA
	480Y/277V, 600Y/347	1,000–3,750 kVA
	480V, 600V	1,000–3,750 kVA

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 factory for final determination.

Basic Insulations Levels (BIL)

kV Class	Standard BILs			Optional BILs		
	BIL (kV)	Induced Voltage Test	Applied Voltage Test (kV)	BIL (kV)	Induced Voltage Test	Applied Voltage Test (kV)
1.2	10	Twice Normal Voltage	4	30	Twice Normal Voltage	10
2.5	45		15	60		19
5.0	60		19	75		26
7.2	60		19	75		26
8.7	75		26	95		34
15.0	95		34	110		34
25.0	125		40	150		50
35.0	150		50	200		70

Sound Level

kVA Rating	Self Cooled Rating (dB)	Fan Cooled Rating (dB)
500 kVA	60	67
750 kVA	64	67
1000 kVA	64	67
1500 kVA	65	68
2000 kVA	66	69
2500 kVA	68	71
3000 kVA	68	71
3750 kVA	71	73

Typical Performance Data High Voltage — 15 kV Class, Low Voltage — 600V Class

kVA	No Load Losses (Watts)	Full Load Losses (Watts)	Total Losses (Watts)	Efficiency						Maximum Efficiency
				133%	125%	100%	75%	50%	25%	
500	2,200	7,700	9,900	97.68	97.77	98.06	98.29	98.38	97.90	98.45% @ 51.00% Load
750	2,700	11,000	13,700	97.83	97.92	98.21	98.44	98.57	98.23	98.57% @ 49.50% Load
1,000	3,400	12,000	15,400	98.18	98.26	98.48	98.66	98.74	98.37	98.74% @ 53.20% Load
1,500	4,700	15,000	19,700	98.46	98.52	98.70	98.85	98.89	98.52	98.89% @ 55.98% Load
2,000	6,100	20,000	26,100	98.46	98.53	98.71	98.86	98.90	98.55	99.91% @ 55.23% Load
2,500	7,700	21,000	28,700	98.67	98.72	98.87	98.97	98.97	98.58	98.99% @ 60.55% Load

Application (cont.)

Typical Performance Data

kVA	%IZ	%IR	%IX	X/R Ratio	Regulation			
					1.0 PF	.9 PF	.8 PF	.7 PF
500	5.75	1.54	5.53	3.59	1.69	3.89	4.62	5.07
750	5.75	1.46	5.56	3.79	1.62	3.84	4.57	5.04
1000	5.75	1.20	5.63	4.68	1.36	3.63	4.41	4.90
1500	5.75	1.00	5.66	5.66	1.16	3.48	4.27	4.80
2000	5.75	1.00	5.66	5.66	1.16	3.48	4.27	4.80
2500	5.75	0.84	5.69	6.77	1.00	3.35	4.17	4.71

Standard Impedance Ratings

High Voltage BIL Ratings	Low Voltage Ratings	
	208Y/120V, 240V	480Y/277V, 480V
45–150 kV	5.75% IZ	5.75% IZ
200, 250 kV	7.5% IZ	6.75% IZ

Loading

UNI-CAST 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 only if occurring once in any 24-hour period without loss of transformer life expectancy given an 100˚C rise transformer in a 30˚C ambient.

Following and followed by a constant load of:

Peak Load Time	90%	70%	50%
1/2 hr.	1.33	1.43	1.50
1 hr.	1.21	1.25	1.28
2 hr.	1.15	1.15	1.16
4 hr.	1.12	1.12	1.12
8 hr.	1.10	1.10	1.10

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.

Typical Heat Contribution High Voltage — 15 kV Class, Low Voltage — 480Y/277V

kVA	% Load	BTU/HR	kVA	% Load	BTU/HR
500 kVA	25%	9,116	1500 kVA	25%	19,168
	50%	14,025		50%	28,730
	75%	22,206		75%	44,668
	100%	33,660		100%	66,980
	125%	48,386		125%	95,668
	133%	53,790		133%	106,194
750 kVA	25%	11,518	2000 kVA	25%	24,990
	50%	18,530		50%	37,740
	75%	30,218		75%	58,990
	100%	46,580		100%	88,740
	125%	67,618		125%	126,990
	133%	75,337		133%	141,025
1000 kVA	25%	14,110	2500 kVA	25%	30,643
	50%	21,760		50%	44,030
	75%	34,510		75%	66,343
	100%	52,360		100%	97,580
	125%	75,310		125%	137,743
	133%	83,731		133%	152,479

Description

The POWER-CAST® three-phase, cast-epoxy unit substation-type transformers are particularly suited for applications requiring a dry-type transformer with superior performance characteristics. The windings are completely impregnated with epoxy resin, which in combination with fiberglass cloth and tape, form the solid dielectric system. This system protects the windings from moisture and environmental airborne contaminants and provides exceptional strength to withstand extreme thermal shock and the mechanical forces of short circuit. These transformers meet the more stringent ANSI standards for liquid-filled transformers, but have the added advantages of a dry-type, making POWER-CAST transformers an ideal replacement for the PCB-filled or PCB-contaminated units. POWER-CAST units are available in both indoor or outdoor enclosures.
If required, special enclosures can be designed to rotate the unit 90° to better fit in space previously occupied by a PCB-filled unit.

Combustion byproducts of POWER-CAST transformers have been tested and documented to be environmentally safe and nonflammable. Each high voltage winding is partial-discharge tested to ensure the reliability of the high voltage dielectric system. All units manufactured receive the standard production test as prescribed by ANSI C57.12.91.

Applicable Standards

A. IEEE C57.12.01—Standard General Requirements for Dry-Type Distribution and Power Transformers Including Those With Solid Cast and/or Resin-Encapsulated Windings.

B. 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.

C. 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 208Y/120-416 Volts.

D. IEEE C57.12.91—Test Code for Dry-Type Distribution and Power Transformers.

Specifications—Cast Coil Substation Transformer

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

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

C. The average temperature rise of the transformer windings shall not exceed 80˚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 locators 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 left 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 2-1/2% full-capacity above normal and two 2-1/2% full-capacity below normal primary taps. Impedance shall be [_____%] [manufacturer's standard impedance], ±7-1/2%. 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 [33-1/3%] [50%]. NOTE: 50% increase is not available for transformers rated 500 kVA and 750 kVA or above 5000 kVA while also maintaining an 80˚C rise.

H. Both high and low voltage windings shall be of copper conductors. High and low voltage windings shall each be separately cast as one rigid tubular coil, and arranged coaxially. Each cast coil shall be fully reinforced with glass cloth, and cast under vacuum to provide complete, void-free resin impregnation throughout the entire insulation system. Reinforcement with suspended particulate matter (filled-resin) is not acceptable. 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 windings must not absorb moisture, and shall be suitable for both storage and operation in adverse environments, including prolonged storage in 100% humidity at temperature from –40˚C to +40˚C and shall be capable of immediately being switched on after such storage without predrying.

J. The impulse rating of the high voltage windings must be at least equal to the basic impulse level specified by ANSI C57.12.90 for oil-filled transformers of the same voltage class, without the use of supplemental surge arresters.

K. The impulse rating of the low voltage winding must be at least [30 kV for low voltage windings rated 1.2 kV and below] [45 kV for low voltage windings rated 2.5 kV and below] [60 kV for low voltage windings rated 5 kV and below].

Specifications—Cast Coil Substation Transformer (cont.)

L. 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.

M. The enclosure(s) shall be constructed of heavy-gauge sheet steel minimum 12-gauge. Units with ratings greater than 3,750 kVA shall have I-beam construction. All ventilating openings shall be in accordance with NEMA and NEC standards for ventilated enclosures. Ventilation openings for outgoing air shall be through side panel louvers. Incoming air flow shall be through the base for optimum air flow to the transformer. The cabinet shall have a minimum of four [hinged doors] [removable panels; removable panels shall have Bakelite handles]. The cabinet shall also have door sills for easy panel installation.

N. 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.

O. Fan cooling equipment shall include multi-phase electronic temperature monitor controlled automatically by sensors placed in the LV air ducts. The temperature monitor must contain green, yellow, and red indicating lights. The green lamp indicates power, while the yellow and red lamps signal that fan and alarm contacts have been activated. A 0–1 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. A fan exerciser circuit must operate the cooling fans for approximately one minute every six days. [Minimum 12 fans shall be provided; each fan must have an 8” diameter blade and develop a minimum 400 CFM at 1500 RPM] [Minimum six “squirrel cage” centrifugal blowers shall be required; each blower must develop a minimum 800 CFM at 1500 RPM] and shall be controlled automatically by sensors placed in the LV air ducts. 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, and necessary push buttons to properly control the system.

P. 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.

Q. Low voltage bus shall be tin-plated copper throughout.

R. The transformer shall comply with all applicable portions of NEMA TR-1, ANSI C57.12.00 and ANSI C57.12.01.

S. Testing—Testing shall be done in accordance with IEEE C57.12.91 and shall include, as the 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 1.2 times the rated line-to-ground voltage. Each high voltage coil shall be subjected to a partial discharge test to verify its partial discharge.
11. Impulse Test
12. Temperature Test (typical data from previous unit is acceptable)
13. Sound Test (typical data from previous unit is acceptable)

Application

Standard Combinations of High and Low Voltages For Given kVA Range

Voltage	Low Voltage Rating	kVA Range
2.5 kV	208Y/120V 240V 480Y/277V, 600Y/347 480V, 600V	300–1,500 kVA 300–1,500 kVA 300–2,000 kVA 300–2,000 kVA
5.0 kV	208Y/120V 240V 480Y/277V 480V 600Y/347 600V	300 –1,500 kVA 300–1,500 kVA 300–3,750 kVA 300–2,500 kVA 300–3,750 kVA 300–2,500 kVA
8.7 kV	208Y/120V 240V 480Y/277V, 600Y/347 480V, 600V 2400V, 4160V, 4800V	300–1,500 kVA 300–1,500 kVA 300–3,750 kVA 300–2,500 kVA 1,000–3,750 kVA
15.0 kV	208Y/120V 240V 480Y/277V, 600Y/347 480V, 600V 2400V, 4160V, 4800V	300–1,500 kVA 300–1,500 kVA 300–3,750 kVA 300–2,500 kVA 1,000–10,000 kVA
25.0 kV	208Y/120V 240V 480Y/277V, 600Y/347 480V, 600V 2400V, 4160V, 4800V	750–1,500 kVA 750–1,500 kVA 750–3,750 kVA 750–2,500 kVA 1,000–10,000 kVA
34.5 kV	208Y/120V 240V 480Y/277V, 600Y/347 480V, 600V 2400V, 4160V, 4800V	1,000–1,500 kVA 1,000–1,500 kVA 1,000–3,750 kVA 1,000–2,500 kVA 1,000–10,000 kVA

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 factory for final determination.

Basic Insulations Levels (BIL)

kV Class	Standard BILs			Optional BILs		
	BIL (kV)	Induced Voltage Test	Applied Voltage Test (kV)	BIL (kV)	Induced Voltage Test	Applied Voltage Test (kV)
1.2	30	Twice Normal Voltage	10	45	Twice Normal Voltage	15
2.5	45		15	60		19
5.0	60		19	75		26
7.2	60		19	75		26
8.7	75		26	95		34
15.0	95		34	110		34
25.0	125		40	150		50
35.0	150		50	200		70

Sound Level

kVA Rating	Self Cooled Rating (dB)	Fan Cooled Rating (dB)
500 kVA 750 kVA	60 64	67 67
1000 kVA 1500 kVA	64 65	67 68
2000 kVA 2500 kVA	66 68	69 71
3000 kVA 3750 kVA	68 71	71 73
5000 kVA 7500 kVA	71 73	74 76
10,000 kVA	80	83

Application (cont.)

Typical Performance Data High Voltage — 15 kV Class, Low Voltage — 600V Class

kVA	No Load Losses (Watts)	Full Load Losses (Watts)	Total Losses (Watts)	Efficiency						Maximum Efficiency
				133%	125%	100%	75%	50%	25%	
500	2,400	5,000	7,400	98.34	98.39	98.54	98.63	98.56	97.88	98.63% @ 69% Load
750	2,800	9,000	11,800	98.16	98.23	98.45	98.62	98.67	98.24	98.68% @ 56% Load
1,000	3,500	9,600	13,100	98.48	98.54	98.71	98.83	98.83	98.39	98.85% @ 60% Load
1,500	5,000	11,600	16,600	98.74	98.78	98.91	98.99	98.96	98.50	98.99% @ 66% Load
2,000	6,500	15,500	22,000	98.74	98.79	98.91	99.00	98.97	98.53	99.01% @ 65% Load
2,500	7,200	18,500	25,700	98.81	98.86	98.98	99.07	99.06	98.68	99.09% @ 63% Load
3,000	8,500	19,500	28,000	98.93	98.97	99.08	99.14	99.12	98.72	99.15% @ 66% Load
3,750	10,500	24,000	34,500	98.95	98.99	99.09	99.15	99.13	98.74	99.16% @ 66% Load
5,000*	14,000	25,500	39,500	99.12	99.15	99.22	99.25	99.19	98.77	99.25% @ 74% Load
7,500*	16,500	29,500	46,000	99.32	99.34	99.39	99.42	99.37	99.03	99.42% @ 75% Load
10,000*	22,000	33,000	55,000	99.40	99.41	99.45	99.46	99.40	99.05	99.46% @ 82% Load

* 5,000 kVA; 7,500 kVA; and 10,000 kVA are listed with 5 kV secondaries.

Typical Performance Data

kVA	%IR	%IX	X/R Ratio	Regulation			
				1.0 PF	.9 PF	.8 PF	.7 PF
500	1.00	5.66	5.66	1.16	3.48	4.27	4.80
750	1.20	5.63	4.68	1.36	3.63	4.41	4.90
1,000	0.96	5.67	5.90	1.12	3.44	4.25	4.77
1,500	0.77	5.69	7.36	0.94	3.29	4.12	4.67
2,000	0.77	5.69	7.35	0.94	3.30	4.12	4.67
2,500	0.74	5.70	7.70	0.90	3.27	4.10	4.65
3,000	0.65	5.71	8.79	0.81	3.19	4.04	4.60
3,750	0.64	5.71	8.93	0.80	3.19	4.03	4.59
5,000	0.51	5.48	10.74	0.66	2.96	3.78	4.33
7,500	0.39	5.49	14.07	0.54	2.86	3.69	4.26
10,000	0.33	5.49	16.61	0.48	2.81	3.65	4.22

Standard Impedance Ratings

High Voltage BIL Ratings	Low Voltage Ratings		
	208Y/120V, 240V	480Y/277V, 480V	2400-4800V
45–150 kV	6.5% IZ	5.75% IZ	5.5% IZ
200, 250 kV	7.5% IZ	6.75% IZ	6.5% IZ

Loading

POWER-CAST 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 only if occurring once in any 24-hour period without loss of transformer life expectancy given an 80˚C rise transformer in a 30˚C ambient.

Following and followed by a constant load of:

Peak Load Time	90%	70%	50%
1/2 hr.	1.86	1.60	1.68
1 hr.	1.30	1.35	1.37
2 hr.	1.20	1.20	1.22
4 hr.	1.15	1.15	1.15
8 hr.	1.12	1.12	1.12

Square D Company
1609 Airport Road,
Monroe, NC 28110 USA

Schneider Canada
19 Waterman Avenue
Toronto, Ontario, Canada M4B 1Y2

Order No. 0150SC9402 Printed in the USA
Replaces M0-16 25K DL 3/95

SQUARE D
GROUPE SCHNEIDER