Substation Transformers

COOPER Power Systems

Electrical Apparatus

210-90

PEAK™ Substation Transformers

GENERAL

Cooper Power Systems PEAK™ Substation Transformers are a class of transformer technologies that are designed to improve performance in terms of kVA rating, compact dimensions, lighter weight, safety, and sustainability.

Flexibility in design, combined with the highest quality manufacturing processes, equipment, and testing procedures, enable Cooper Power Systems to provide a product optimized to the customer's requirements. All units meet applicable American National Standards Institute (ANSI®), Institute of Electrical and Electronics Engineers, Inc. (IEEE®) and National Electrical Manufacturers Association (NEMA®) standards, as well as National Electric Code (NEC®), Department of Energy (DOE) and Canadian Standards Association (CSA) specifications.

PEAK substation transformers are available with cover-mounted bushings or enclosed sidewall-mounted bushings for connections to primary and/or secondary switchgear. Conventional transformers operate at 65 °C for the Average Winding Rise (AWR) at full load. PEAK transformers are currently available with ratings up to 75 °C AWR.

PEAK transformers are IEEE Std C57.154™-2012 standard compliant, available with all current conventional transformer options. They are offered in either 65/75 °C slash rated or 75 °C rise rated configurations. A 65/75 °C rated PEAK transformer is comparable in size to a conventional transformer but has nameplated overload capability. A 75 °C rise rated PEAK transformer is smaller in size but delivers the same kVA as its conventional counterpart.

All PEAK transformers use Envirotemp™ FR3™ dielectric fluid. Envirotemp™ FR3™ has a higher flash point than conventional transformer fluids which increases PEAK transformers fire protection. Envirotemp™ FR3™ fluid increases the life span of the transformer insulation to a point where the overall life expectancy for PEAK transformers is significantly increased.

Figure 1.
PEAK substation transformer equipped with low-voltage transition flange and high-voltage full height air terminal chamber.

In addition, PEAK transformers meet Occupational Safety and Health Administration (OSHA) and Section 450.23, 2008 NEC® requirements.

Electrical codes recognize the advantages of using Envirotemp™ FR3™ fluid both indoors and outdoors for fire-sensitive applications.

PRODUCT SCOPE

Type	Three-Phase or Single-Phase, 50 or 60 Hz (65 °C/75 °C, 75 ºC Optional)
Fluid Type	Envirotemp™ FR3™ fluid
Size	Three-Phase: 300 – 12,000 kVA
	Single-Phase: 500 – 6667 kVA
Primary Voltage	2400 – 46,000 V
Secondary Voltage	208Y/120 V to 24,940 V Wye
Specialty Designs	Inverter/Rectifier Bridge
	Zig Zag
	K-Factor (up to K-19)
	Hazardous Location (Class 1 Div 2)
	Solar/Wind Designs
	Differential Protection
	Automation Solutions

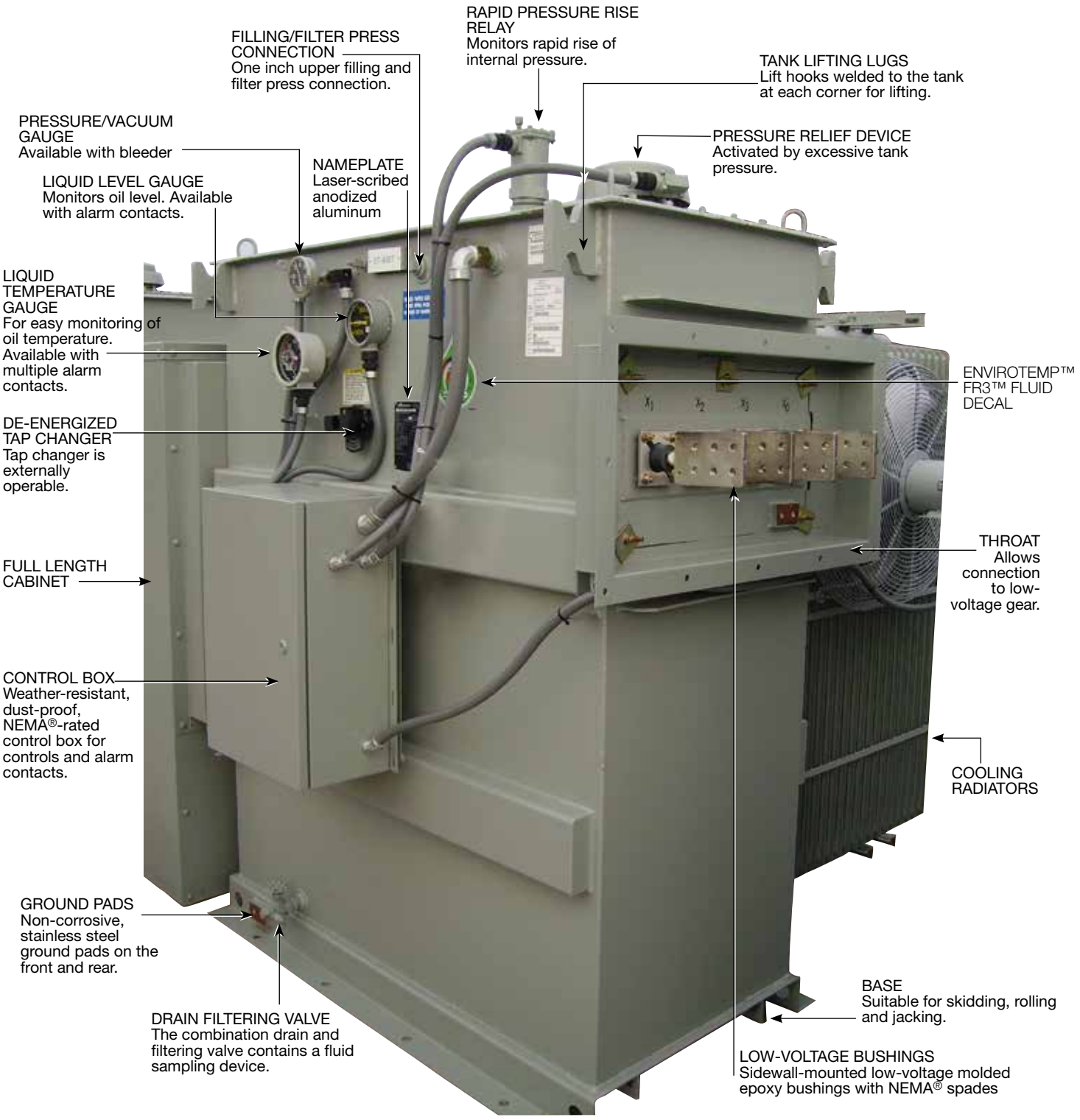

Figure 2.
PEAK substation transformer with standard features and optional accessories.

TABLE 1
Three-Phase, Single Temperature kVA Ratings

Three-Phase kVA Self-Cooled and Forced-Air Cooled with 75 ºC Temperature Rise		
75 ºC Rise KNAN		75 ºC Rise KNAN/ KNAF
500	+15%	575
750		863
1000		1150
1500		1725
2000		2300
2500	+25%	3125
3750		4688
5000		6250
7500		9375
10000		12500
12000	+33%	16000

TABLE 2
Percentage Impedance Voltage[1]

kV BIL Class	Low Voltage	
	<= 600 V	> 600 V
45-150	5.75[2]	6.5[3]
200	7.25	7
250	7.75	7.5

1 The standard tolerance is ± 7.5%.
2 Option for 6.75% is available.
3 Option for 5.75% is available.

TABLE 3
Audible Sound Levels

Self-Cooled, Two Winding kVA Rating	NEMA® Average	
	dB, KNAN	dB, KNAF
500	56	67
501-700	57	67
701-1000	58	67
1001-1500	60	67
1501-2000	61	67
2001-2500	62	67
2501-3000	63	67
3001-4000	64	67
4001-5000	65	67
5001-6000	66	68
6001-7500	67	70
7501-10000	68	71
12500	69	71

TABLE 4
Three-Phase, Dual or Triple Temperature kVA Ratings

Three-Phase kVA Self-Cooled and Forced-Air Cooled with PEAK Triple Rated 55 ºC/65 ºC/75 ºC Temperature Rise							
55 ºC Rise KNAN		65 ºC Rise KNAN		75 ºC Rise KNAN	55 ºC Rise KNAN/ KNAF	65 ºC Rise KNAN/ KNAF	75 ºC Rise KNAN/ KNAF
500	+12%	560	+9%	610	575	644	702
750		840		916	863	966	1053
1000		1120		1221	1150	1288	1404
1500		1680		1831	1725	1932	2106
2000		2240		2442	2300	2576	2808
2500		2800		3052	3125	3500	3815
3750		4200		4578	4688	5250	5723
5000		5600		6104	6250	7000	7630
7500		8400		9156	9375	10500	11445
10000		11200		12208	12500	14000	15260
12000		13440		14650	16000	17920	19533

TABLE 5
Insulation Test Levels

kV Class	Induced Test 180 or 400 Hz 7200 Cycle	kV BIL		Applied Test 60 Hz (kV)
		Distribution	Power	
1.2	TWICE RATED VOLTAGE	30	45	10
2.5		45	60	15
5		60	75	19
8.7		75	95	26
15		95	110	34
25 (Grd Y Only)		125	150	40
25		150	150	50
34.5 (Grd Y Only)		125	150	50
34.5		150	200	70
46		200	250	95

TABLE 6
Temperature Rise Ratings 0-3300 feet (0-1000 meters)

	Standard	Optional
Unit Rating	75 ºC	65/75 ºC, 75 °C
Maximum Ambient Temperature Rise	40 ºC	40 ºC
Ambient Temperature 24 Hour Av.	30 ºC	30 ºC
Temperature Rise Winding[1]	75 ºC	65 ºC

[1] Average Rise by resistance. Refer to IEEE Std C57.12.00™-2010 standard.

Note: Derate kVA by 0.4% for each 100 M (330 ft.) that the altitude is above 1000 M (3300 ft.).

TABLE 7
Fluid-Filled—Aluminum Windings 75 °C Rise[1]

	Drawing Dimensions (in.)										
kVA	A	B	C	D	E	F	G	H	J	Gallons	Weight
500	66	51	26	47	45	45	29	58	35	290	5400
750	66	55	26	52	55	55	31	62	35	330	6200
1000	66	59	26	52	55	55	33	66	35	360	7200
1500	75	59	26	52	55	55	33	66	35	370	9200
2000	75	63	50	78	55	55	35	70	35	400	11000
2500	75	67	56	85	55	55	37	74	37	460	12300
3750	85	75	64	95	65	65	41	82	41	730	18500
5000	85	83	66	107	65	65	45	90	45	820	22600
7500	99	87	67	120	75	75	47	94	47	1100	31000
10000	99	95	70	142	75	75	51	102	53	1360	38000
12000	99	103	75	152	75	75	55	110	57	1550	45000

[1] Weights, gallons of fluid, and dimensions are for reference only and not for construction. Please contact Cooper Power Systems for exact dimensions.

TABLE 8
Fluid-Filled—Copper Windings 75 °C Rise[1]

	Drawing Dimensions (in.)										
kVA	A	B	C	D	E	F	G	H	J	Gallons	Weight
500	66	47	26	47	45	45	27	54	35	280	5200
750	66	51	26	52	55	55	29	58	35	340	6300
1000	66	55	26	52	55	55	31	62	35	360	7400
1500	75	59	26	52	55	55	33	66	35	410	9700
2000	75	59	55	83	55	55	33	66	35	420	11200
2500	75	63	61	89	55	55	35	70	35	460	12800
3750	75	71	64	95	55	55	39	78	41	590	17200
5000	85	79	66	105	65	65	43	86	45	880	23700
7500	85	87	67	120	75	75	47	94	47	990	30800
10000	99	91	69	140	75	75	49	98	51	1310	37000
12000	99	95	74	150	75	75	51	102	55	1430	43000

[1] Weights, gallons of fluid, and dimensions are for reference only and not for construction. Please contact Cooper Power Systems for exact dimensions.

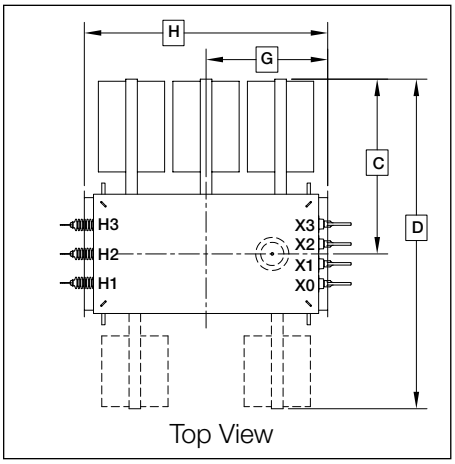

Figure 3.
High-Voltage left (Segment 2) shown. High-Voltage right (Segment 4) also available.

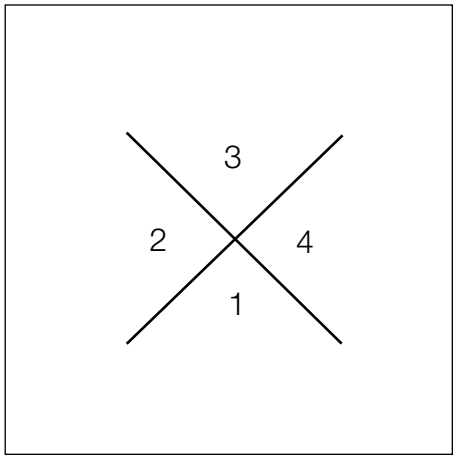

Figure 4.
ANSI® segment designation.

TABLE 9
Fluid-Filled—Aluminum Windings 65/75 degree C Rise[1]

	Drawing Dimensions (in.)										
kVA	A	B	C	D	E	F	G	H	J	Gallons	Weight
500	66	51	26	45	45	45	29	58	35	300	5500
750	66	55	26	52	55	55	31	62	35	350	6600
1000	66	59	26	52	55	55	33	66	35	390	7800
1500	75	59	50	78	55	55	33	66	35	400	9400
2000	75	63	55	84	55	55	35	70	37	450	11600
2500	85	67	62	91	55	55	37	74	35	520	14000
3750	85	75	64	104	65	65	41	82	41	770	19600
5000	85	83	66	120	65	65	45	90	45	920	24000
7500	99	91	68	137	75	75	49	98	49	1260	33300
10000	99	99	70	141	75	75	53	106	53	1550	40000
12000	99	103	75	152	75	75	55	110	57	1670	47000

[1] Weights, gallons of fluid, and dimensions are for reference only and not for construction. Please contact Cooper Power Systems for exact dimensions.

TABLE 10
Fluid-Filled—Copper Windings 65/75 degree C Rise[1]

	Drawing Dimensions (in.)										
kVA	A	B	C	D	E	F	G	H	J	Gallons	Weight
500	66	47	26	45	45	45	27	54	35	290	5600
750	66	55	26	52	55	55	31	62	35	360	7000
1000	66	59	26	52	55	55	33	66	35	390	8200
1500	75	55	50	78	55	55	31	62	35	410	9900
2000	75	63	61	89	55	55	35	70	35	450	12000
2500	75	67	61	89	55	55	37	74	35	480	13600
3750	85	75	65	110	65	65	41	82	43	740	20000
5000	85	83	66	120	65	65	45	90	45	960	25000
7500	99	91	68	137	75	75	49	98	49	1250	34000
10000	99	95	70	141	75	75	51	102	53	1520	41000
12000	99	103	75	152	75	75	55	110	57	1740	46000

[1] Weights, gallons of fluid, and dimensions are for reference only and not for construction. Please contact Cooper Power Systems for exact dimensions.

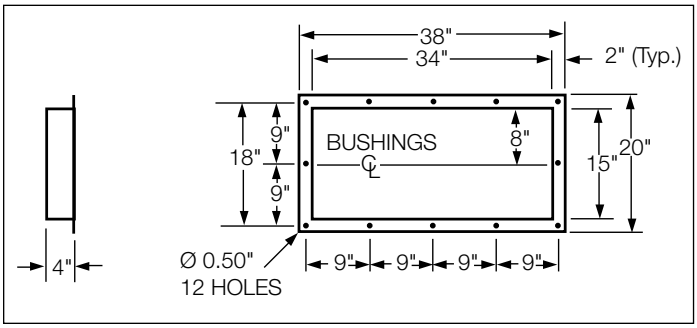

Figure 5.
Throat.

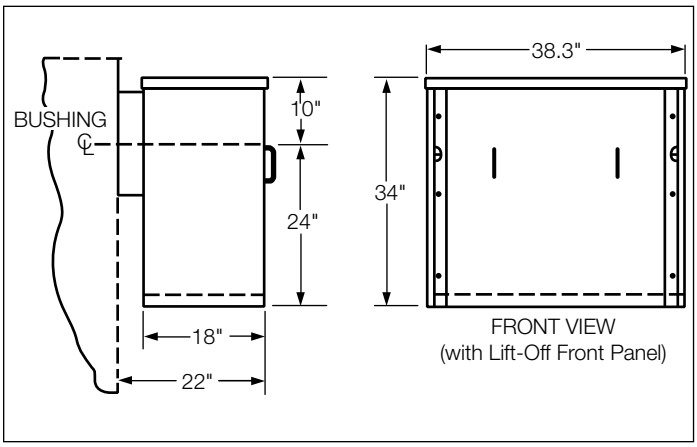

Figure 6.
Air terminal chamber-bottom entry.

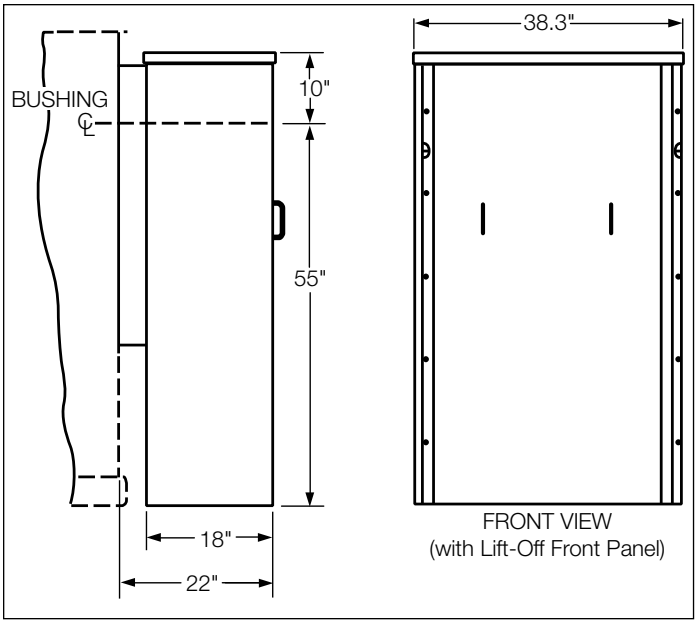

Figure 7.
Full length cabinet-bottom entry.

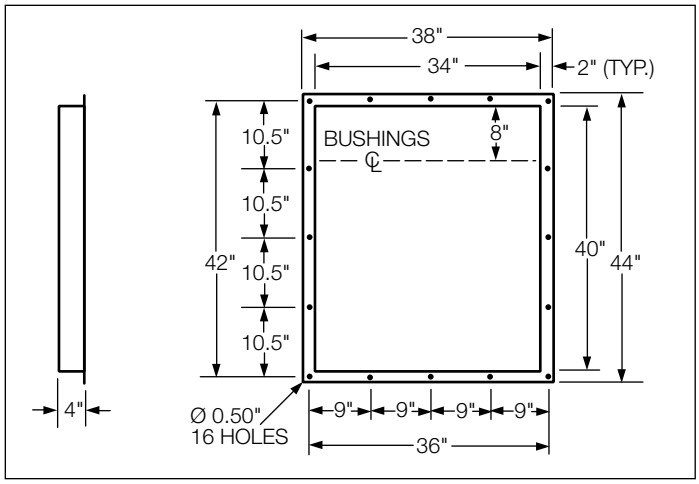

Figure 8.
Flange.

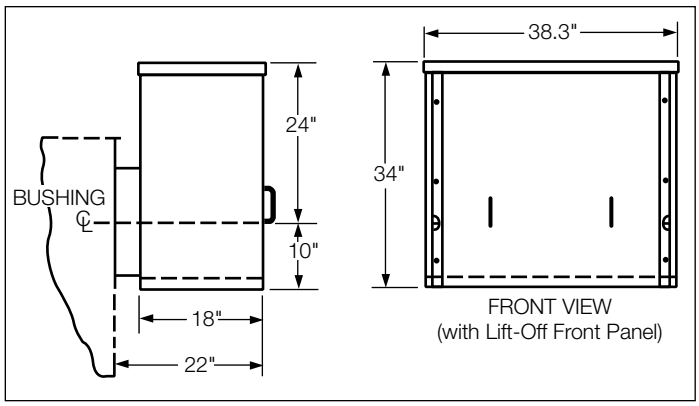

Figure 9.
Air terminal chamber-top entry.

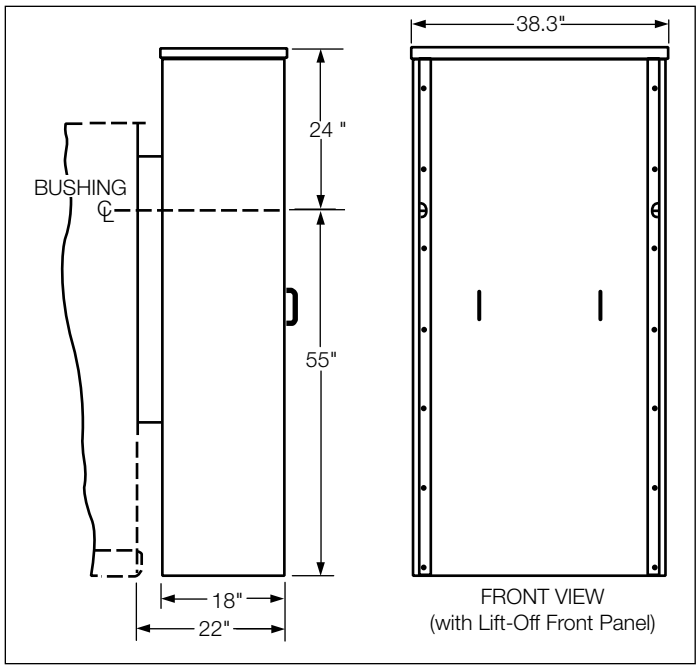

Figure 10.
Full length cabinet-top entry.

STANDARD FEATURES

Fluid

- Envirotemp™ FR3™ fluid

Mechanical Features

- De-energized tap changer, externally operable

High- and Low-Voltage Bushings

- Cover or sidewall-mounted high-voltage porcelain bushings.
- Cover or sidewall-mounted low-voltage molded epoxy bushings with NEMA® spades

Tank

- Tank bases designed for skidding or rolling in any direction
- Extra-heavy, welded-in-place lifting lugs and jack pads (4)
- Stainless steel grounding pads (4)
- Cooling radiators are welded directly to the tank

Gauges and Devices

- Dial-type thermometer
- Dial-type liquid level gauge
- Pressure vacuum gauge
- Cover-mounted automatic pressure relief device
- Pressure test connection

Valves/Plugs

- 1” upper fill plug with filter press connection
- 1” drain valve with sampler combination (2500 kVA and below)
- 2” drain valve with sampler (over 2500 kVA)
- 1” upper filter valve (over 2500 kVA)

Coatings (Paint)

- ANSI® #61 Light Gray
- ANSI® #70 Sky Gray
- Special paint available per request

Nameplate

- Laser-scribed anodized aluminum nameplate

Figure 11.
Automation solutions for remote monitoring.

Figure 12.
12-pulse application with bushing supports.

OPTIONAL FEATURES

Bushing Enclosure Options

- Throat
- Flange
- Top- or bottom-entry air terminal chamber
- Top- or bottom-entry full length cabinet

Gauges and Devices

- With Alarm Contacts
- Dial-type thermometer (Standard with Fan Package)
- Liquid level gauge
- Pressure/vacuum gauge
- Cover-mounted pressure relief device
- Winding temperature indicator
- Rapid pressure rise relay with optional seal-in panel
- Nitrogen gas preservation system

Valves/Plugs

- Pressure vacuum bleeder valve
- Detachable, bolt-on radiators with valves

Control Boxes

- Control box (NEMA® 4, NEMA® 4X, NEMA® 7)

Forced-Air Fan Control Package

- Forced-air fan control package includes fans, NEMA® control box, fan controls, dial-type thermometer with alarm contacts.

Overcurrent Protection

- Visible Break Switch
- Bay-O-Net Fuse with Isolation Link
- Bay-O-Net Fuse with Partial Range Current Limiting Fuse
- Primary air disconnect switch with fuses

Overvoltage Protection

- Distribution-, Intermediate-, or Station-class surge arresters
- Elbow arresters (for dead-front connections)

CONSTRUCTION

Core

The three-legged, step-lap mitered core construction is manufactured using a high-quality cutting machine. For maximum efficiency, cores are precisely stacked, virtually eliminating gaps in the corner joints.

Five-legged wound core or shell-type triplex designs are used for wye-wye connected transformers, and other special transformer designs.

Cores are manufactured with precision cut, burr-free, grain-oriented silicon steel. Many grades of core steel are available for optimizing core loss efficiency.

Coils

Substation transformers feature a rectangular coil configuration with wire-wound, high-voltage primaries and sheet-wound secondaries. The design minimizes axial stress developed by short circuits and provides for magnetic balancing of tap connections.

Coils are wound using the highest quality winding machines providing exacting tension control and conductor placement for superior short-circuit strength and maximum efficiency.

Extra mechanical strength is provided by diamond pattern, epoxy coated paper insulation, used throughout the coil, with additional epoxy at heavy stress points. The diamond pattern distribution of the epoxy and carefully arranged ducts, provide a network of passages through which cooling fluid can freely circulate.

Coil assemblies are heat-cured under calculated hydraulic pressure to ensure performance against short-circuit forces.

Core and Coil Assemblies

Substation transformer core and coil assemblies are braced with heavy steel ends to prevent the rectangular coil from distorting under fault conditions. Plates are clamped in place using presses, and welded or bolted to form a solid core and coil assembly. Core and coil assemblies exceed ANSI® and IEEE® requirements for short-circuit performance. Due to the rigidity of the design, impedance shift after short-circuit is comparable to that of circular wound assemblies.

Tanks

Transformer tanks are designed for high strength and ease of handling, installation, and maintenance. Tanks are welded using precision-cut, hot rolled, pickled and oiled steel. They are sealed to protect the insulating fluid and other internal components.

Transformer tanks are pressure-tested to withstand 7 psig without permanent distortion and 15 psig without rupture.

Tank Finish

An advanced multi-stage finishing process exceeds IEEE Std C57.12.28™-2005 standard. The eight-stage pre-treatment process assures coating adhesion and retards corrosion. It converts tank surfaces to a nonmetallic, water insoluble iron phosphate coating.

The paint method consists of three distinct layers of paint. The first is an epoxy primer (E-coat) layer which provides a barrier against moisture, salt and corrosives. The two-component urethane final coat seals and adds ultraviolet protection.

Vacuum Processing

Transformers are dried and filled with filtered insulating fluid under vacuum, while secondary windings are energized. Coils are heated to drive out moisture, ensuring maximum penetration of fluid into the coil insulation system.

Cooling System

Less Flammable Liquid-Air (KNAN) cooling is provided with transformers rated 500 kVA. A choice of KNAN/Future KNAF (Future Forced-Air) or KNAN/KNAF (Forced-Air) cooling is provided with units rated 750 kVA and above.

Insulating Fluid

Transformers from Cooper Power Systems are available with Envirotemp™ FR3™ fluid. The highly refined fluid is tested and degassed to assure a chemically inert product with minimal acid ions. Special additives minimize oxygen absorption and inhibit oxidation. To ensure high dielectric strength, the fluid is re-tested for dryness and dielectric strength, refiltered, heated, dried, and stored under vacuum before being added to the completed transformer.

Cooper Power Systems transformers filled with Envirotemp™ FR3™ fluid enjoy unique fire safety, environmental, electrical, and chemical advantages, including insulation life extending properties.

A bio-based, sustainable, natural ester dielectric coolant, Envirotemp™ FR3™ fluid quickly and thoroughly biodegrades in the environment and is non-toxic per acute aquatic and oral toxicity tests.

Building for Environmental and Economic Sustainability (BEES) total life cycle assessment software, utilized by the US Dept. of Commerce, reports its overall environmental performance impact score at 1/4th that reported for mineral oil. Envirotemp™ FR3™ fluid has also earned the EPA Environmental Technology Verification of transformer materials.

ABS Type Approved Substation Transformers

Cooper Power Systems offers liquid-filled substation and pad-mounted distribution-class transformers from 0.5 to 10 MVA with type-approved certification from the American Bureau of Shipping (ABS®) for marine and off-shore applications.

SPECIALTY DESIGNS

Inverter/Rectifier Bridge

Cooper Power Systems complements its range of applications for substation transformers by offering dual winding designs. These designs are intended for connection to 12-pulse rectifier bridges.

Zig Zag

Cooper Power Systems is providing a cost-effective and an alternative solution for earthing ungrounded systems and applications where a transformation with 0 degree phase shift is required.

Hazardous Locations (Class 1 Div 2)

Hazardous locations can be defined as areas where combustible materials are present. Cooper Power Systems is offering explosion proof designs that prevent gasses from coming in contact with switching arcs. These explosion proof control boxes are made of cast aluminum and are designed to contain an arc.

K-Factor

Cooper Power Systems is designing substations with appropriate K-factor correction to mitigate the effects of non-linear harmonic loading conditions.

Solar/Wind Designs

Cooper Power Systems is offering custom designs for renewable energy power generation. Cooper Power Systems manufactures Generator Step-Up (GSU) transformers at the base of every wind turbine. Additionally, grounding transformers are available for wind power generation. For the solar photovoltaic industry, Cooper Power Systems is offering standard step-up transformers and dual secondary designs.

SPECIAL PROTECTION FEATURES

Primary Air Disconnect Switch

- Provides economical, visible disconnect primary load break switching.
- Fully coordinated and packaged with the transformer by Cooper Power Systems.
- Meets IEEE Std C37.20.3™-2001 standard, NEMA® SG-5 and related standards.
- Standard features
  - Switch
    - Three-pole, two-position, gang-operated air interrupter, unfused
- Standard ratings
  - 600 A continuous and load break; 40 kA fault close and momentary
  - 5 kV (60 kV BIL) or 15 kV (95 kV BIL)
- Enclosure
  - Standardized modular self supporting, bolted design
  - Mechanical safety interlock prevents access when switch is closed or closing of switch when door is open.
- Optional features
  - 1200 A continuous and load break current rating; 61 kA fault close and momentary. Requires 1200 A copper bus option.
  - Key interlocks (single cylinder) for interlocking primary switch with secondary main circuit protective device.
  - Auxiliary switch for remote indication of primary switch position
  - Where high interrupting ratings and short-circuit protection are desired: current-limiting non-expulsion power fuses
  - Where lower interrupting ratings are adequate:
    - Non-disconnect power fuses
    - Disconnect power fuses

TESTING

Cooper Power Systems performs routing testing on each transformer manufactured including the following tests:

- **Insulation Power Factor:** This test verifies that vacuum processing has thoroughly dried the insulation system to required limits.
- **Ratio, Polarity, and Phase Relation:** Assures correct winding ratios and tap voltages; check insulation of HV and LV circuits. Check entire insulation system to verify all live-to-ground clearances.
- **Resistance:** This test verifies the integrity of internal high-voltage and low-voltage connections; provides data for loss upgrade calculations.
- **Applied Potential:** Applied to both high-voltage and low-voltage windings, this test stresses the entire insulation system to verify all live-to-ground clearances.
- **Induced Potential:** 3.46 times normal plus 1000 volts for reduced neutral designs.
- **Loss Test:** These design verification tests are conducted to assure that guaranteed loss values are met and that test values are within design tolerances. Tests include no-load loss and excitation current along with impedance voltage and load loss.
- **Leak Test:** Pressurizing the tank to 7 psig assures a complete seal, with no weld or gasket leaks, to eliminate the possibility of moisture infiltration or oil oxidation.

Design Performance Tests

Design performance tests include the following:

- **Temperature Rise:** Our automated heat run facility ensures that any design changes meet ANSI® and IEEE® temperature rise criteria.
- **Audible Sound Level:** Ensures compliance with NEMA® requirements.
- **Lightning Impulse:** To assure superior dielectric performance, this test consists of one reduced wave, two chopped waves and one full wave in sequence, precisely simulating the harshest conditions.

THOMAS A EDISON RESEARCH AND TEST FACILITY

We are constantly striving to introduce new innovations to the transformer industry, bringing you the highest quality transformer for the lowest cost. Cooper Power Systems Transformer Products is ISO 9001 compliant, emphasizing process improvement in all phases of design, manufacture, and testing. We have invested millions of dollars in the Thomas A. Edison Technical Center, our premier research facility in Franksville, Wisconsin affirming our dedication to introducing new innovations and technologies to the transformer industry. Headquarters for the Systems Engineering Group of Cooper Power Systems, this research facility is fully available for use by our customers to utilize our advanced electrical and chemical testing labs.

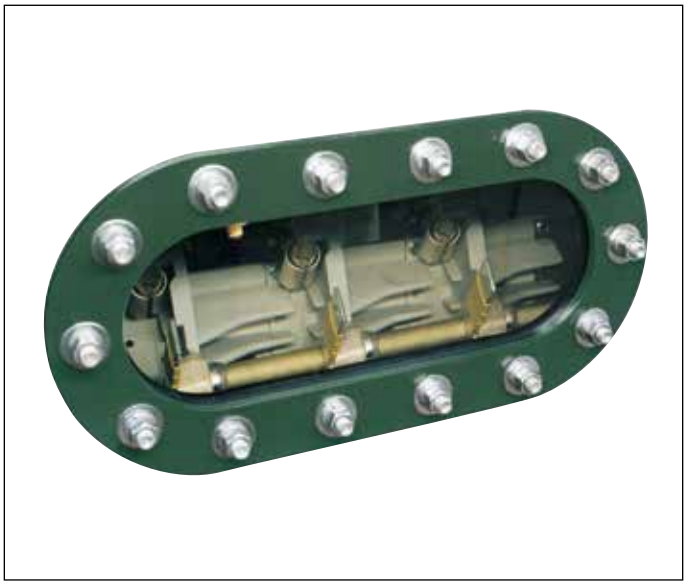

Figure 13.
Substation transformer with visible break technology.

Figure 14.
Substation transformer with customer-specific coordination and accessories.

Figure 15.
Triplex Indoor Power Center comprising of energy efficient and low noise single-phase substation transformers in a ganged setup.

Figure 16.
Class 1 Div 2 hazardous duty substation transformer.

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COOPER Power Systems

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