Unit Substation Transformers

5 and 15 KV Class
DOE 2010 Efficiency Compliant

FEDERAL PACIFIC™

ISO9001
Registered

General Information

Description

Federal Pacific unit substation transformers are available in a wide variety of types and ratings to provide reliable and versatile electrical distribution.

Medium voltage dry-type transformers must comply with the new Department of Energy efficiency regulations published in Table 1.2 of the Federal Register/Vol. 72, No. 197 / Friday, October 12, 2007. This is the DOE 10 CFR 431 Section 196.

The changing needs and variable load densities of industrial and commercial power systems create the need to locate transformers close to the electrical center of the load — providing flexibility for change and economical distribution of power.

Federal Pacific dry-type transformers are ideally suited for these applications. The ventilated air-cooled construction eliminates the concern for contamination and toxicity of cooling liquids. They do not require the expensive vaults, fluid leakage containment provisions, or fire protection systems needed for liquid filled units to satisfy National Electric Code requirements.

Lower installed costs and minimum maintenance requirements make Federal Pacific Dry-Type Substation Transformers an ideal choice for new or existing installations.

Transformers are available in three phase ratings from 112-1/2 KVA to 10000 KVA. All standard primary and secondary voltage ratings are provided to match load requirements to the distribution system.

Units can be arranged for standard direct connection to high voltage and low voltage distribution protective equipment or provided as individual transformers.

Industry Standards

Federal Pacific Unit Substation Transformers are designed and tested in accordance with the following standards:

- IEEE C57.12.01 General Requirements for Distribution, Power and Regulating Transformers.
- IEEE C57.12.91 Standard Test Code for Dry-Type Distribution and Power Transformers.
- NEMA 210 Secondary Unit Substations.
- NEMA ST-20 Dry-Type Transformers for General Applications.
- NEMA TR-27 Commercial, Institutional and Industrial Dry-Type Transformers.
- IEEE 69302005 Seismic

Tested Performance

A high level of transformer reliability for trouble-free installation and operation, all transformers manufactured by Federal Pacific are tested in accordance with NEMA and IEEE Standards:

Ratio Test is performed on rated voltage connection and tap connections to assure proper turns ratio on all connections.

Polarity Test and phase relation tests are made to ensure proper polarity and marking because of their importance in paralleling or banking two or more transformers.

No-load (excitation) Loss Test determines the losses of a transformer which is excited at rated voltage and frequency, but which is not supplying a load. Transformer excitation loss consists mainly of the iron loss in the transformer core.

Load Loss Test determines the amount of losses in the transformer when carrying full rated load. These losses consist primarily of I^2R losses in the primary and secondary winding and ensure that specifications of the transformer design are met.

Excitation Current Test determines the current necessary to maintain transformer excitation.

Resistance Test is performed on the transformer windings and is used to determine I^2R loss.

Impedance Test is made to insure that transformer design standards are attained.

Dielectric Test (applied and induced potential) checks the insulation and workmanship to demonstrate that the transformer has been designed and manufactured to meet the insulation tests required by the standards.

Applied Potential Tests are made by impressing between windings and between each winding and ground, a low frequency voltage in accordance with the following:

Rated Voltage of Winding, Volts	Test Potential, RMS kV
250	4.0
600	4.0
2500	10.0
5000	12.0
8700	19.0
15000	34.0

Induced Potential Tests call for overexciting the transformer by applying between the terminals on one winding a voltage of twice the normal voltage developed in the winding for a period of 7200 cycles. Partial Discharge (PD) is performed during the induced potential test.

Unit Substation Arrangements

Arrangements

Federal Pacific unit substation transformers meet a wide variety of application requirements with the highest degree of service reliability. Federal Pacific substations are coordinated, engineered electrical centers designed to safely step down distribution voltage to utilization voltage.It usually supplies secondary voltages ranging from 208Y/120 to 600 volts and primary voltages of 2400 to 13800 volts. They typically provide power to industrial plants, office buildings, commercial buildings, public buildings, hospitals and schools. The form, rating, and characteristics of unit substations and their transformers are determined by the design of the electrical distribution system and the requirements of the particular loads and installation conditions.

Incoming Line Air Interrupter Switch

The Type Auto-jet II® air interrupter switch, two position (open-close), three pole with manually operated, stored-energy mechanism provides quick-make, quick-break operation for disconnecting the transformer incoming line. Utilized with power or current limiting fuses, the switch provides safe, fast, and reliable protection for high voltage circuits. The Auto-jet II® switch is rated 600 or 1200 amp continuous, 600 or 1200 amp load-break with a high fault closing capacity of 40,000 amp asymmetrical.

The 1200A switch is available with 61,000 amp asymmetrical rating (optional).

The switch compartment is bolted directly to the high voltage side of the transformer section. Cable entrance can be at top or bottom for either single or loop feed. Fuses, when specified, are located in a compartment under the interrupter switch. A hinged door allows access to fuses and is provided with a mechanical interlock to prevent the door opening unless the switch is in the "open" position. Standard fuses, when supplied, are the current limiting, non-disconnect type. Lightning arresters and key interlocks are optionally available.

Incoming Line Terminal Compartment

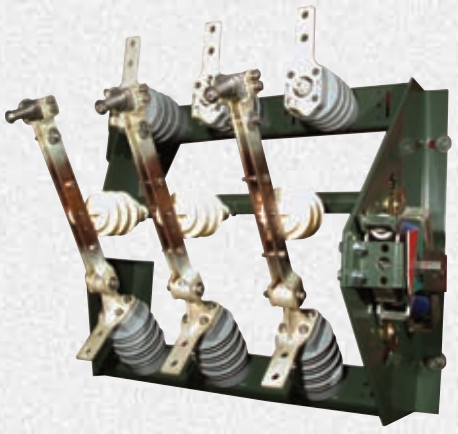
When a disconnect or overcurrent device is not required as an integral part of the lineup, an air-filled terminal compartment (ATC) is bolted directly to the high voltage end of the transformer section. The metal-enclosed ATC terminal compartment matches the height and depth of the transformer section and is provided with bolt-on end panels for accessibility to terminal connections. The compartment can be arranged for single or loop feed with potheads or clamp-type terminals for either top or bottom cable entrance. Lightning arresters can be supplied when required for protection against voltage surges.

Low Voltage Distribution Sections

A complete selection of distribution and protective equipment is available to meet application requirements. Unit substation transformers are arranged for direct connection to a variety of equipment including low voltage drawout switchgear, distribution switchboards, group mounted power panelboards and motor control centers.

For those applications where secondary distribution equipment is not required, an outgoing air-filled terminal compartment (ATC) can be provided for top or bottom cable entrance. The compartment bolts directly to the transformer and has removable end panels for accessibility. Provisions can also be made to accommodate busway.

NEMA 3-R



Auto- jet II® Switch

Features of Typical 15 kV Substation Transformer

1. Round cylindrical coils assure proper ventilation and provide mechanical strength for fault stresses. The units are either barrel wound or disc wound (depending on voltage) using aluminum conductor with insulated coil supports.
2. Core structures are fabricated in a "stepped" configuration from special high-grade, cold rolled, silicon steel. The steel laminations are clamped at the top and bottom to absorb vertical stresses on the core.
3. 220°C insulation systems using Nomex® paper and resin glass laminates provides long operating life and quiet operation. The complete core and coil assembly is impregnated with polyester varnish and oven cured to make the assembly highly resistant to moisture.
4. High dielectric interphase barriers assure positive phase to phase insulating characteristics.
5. High voltage tap connections are easily accessible by removal of front panels. The centrally located taps are changed by moving jumpers between connection points when the transformer is de-energized.
6. Rugged enclosure base with provisions for lifting, jacking, towing, skidding or rolling for installation.
7. Rigidly braced low voltage bus bars arranged for proper electrical connections to the transformer. The low voltage bus is equipped with flexible connectors to the core and coil assembly to reduce transmission of vibration to the connected equipment.
8. Diagrammatic nameplate provides complete rating and connection information.
9. Vibration isolation pads isolate core and coil assembly from the base structure to reduce sound levels.
10. Optional fan cooling equipment to provide an additional 33-1/3% KVA capacity for units with self-cooled ratings of 300 KVA and above. (Provisions for future forced air cooling are provided as standard — including sufficient current-carrying capacity on internal bus bars.) Fans and controls can be installed at the factory or can be shipped for installation at the jobsite.

Core and Coil Assembly

Core Construction

The transformer cores are made of high grade silicon electrical steel laminations with high magnetic permeability. Precision steel cutting machines are used to cut the steel laminations with precise squareness and miter and to be free of burrs.

Laminations are hand stacked to computer generated specifications to assure correct positioning for close fitting joints to minimize noise and core loss. Each lamination has an insulating coating bonded to both sides to minimize eddy-current losses.

The core legs are arranged in a "stepped" configuration to accommodate the coils and to provide maximum cooling and strength. The completed three-leg core assembly is rigidly clamped with steel members to prevent movement and to provide support for the coils.

Coil Construction

Coils are precision wound in a **circular** configuration using aluminum conductor material as standard. Copper conductors can also be provided as an option.

On low voltage where possible, sheet-wound secondary windings are used. The windings are separated by insulation layers and spacers. These sheet windings offer the advantage of virtually eliminating axial short circuit stresses.

Nomex® insulated wire-wound primary windings are placed directly over the secondary windings with a suitable insulating barrier between the coils consisting of spacers and sheet insulation applied to the proper thickness. Primary windings may be random-wound or disc-wound depending upon the design requirements. All coils are adequately braced for full short circuit capability.

Assembly

The completed coil units are placed on the core legs. Top core yokes are put into place and securely clamped. Electrical connections are made using welded aluminum or brazed copper, to ensure reliable service.

Coils may be vacuum pressure impregnated, when specified. After installation of the mounting hardware, the complete core and coil assembly is submersed and impregnated with an insulating varnish. The assembly is completely coated to provide moisture and dirt resistance as well as high dielectric strength. After dipping, the varnish is fully cured in a drying oven.

Completed core and coil assemblies receive a final inspection and testing prior to installation in the enclosure. When installed, vibration isolation pads are provided to isolate the core and coil assembly from the base structure. All structural parts are grounded to prevent induced voltage buildup.

Construction

FP transformers utilize a 220° C insulation system that combines inorganic materials and resins to provide a fire resistant, high dielectric capability. All materials have been thoroughly tested and proven with respect to their stability at required operating temperatures.

The major components of the 220° C system include Nomex® paper for conductor insulation plus resin-glass laminates, silicon rubber and polyester varnish. The combination of materials is specifically chosen to assure long operating life and quiet operations

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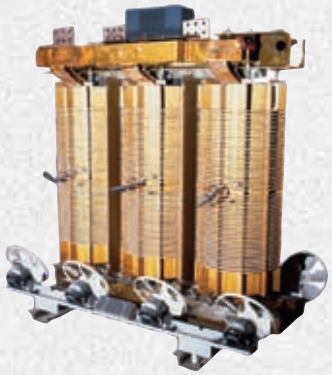
Taps

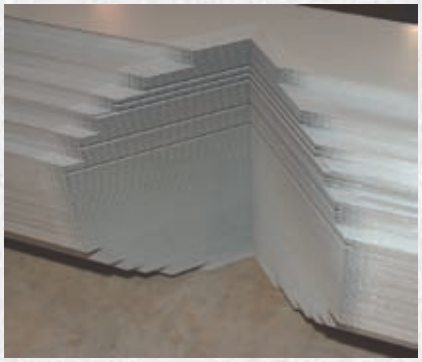
Primary windings are furnished with full capacity tap connections to provide adjustment to accommodate variations in the incoming high voltage. All units include, as standard, two (2) 2-1/2% taps full capacity above normal (FCAN) and two (2) 2-1/2% taps full capacity below normal (FCBN).

The tap connections are located in a vertical arrangement on the side of each coil. Accessible behind removable covers, the taps can easily be changed by moving jumpers between connection points when the transformer is de-energized.



Complete Core and Coil Assembly

Step-Lap Mitre Core Construction



Step-Lap Mitre Core Construction

Forced Air Cooled System

Forced-Air Cooled System Operation

Unit substation transformers with self-cooled ratings of 300 KVA and above can be supplied with fans and controls to obtain additional KVA capacity. Forced circulation of air correctly applied permits the self-cooled KVA rating of the transformer to be increased by an additional 33-1/3%. (Class FA rating)

The winding temperature control panel is equipped with necessary controls for the operation of the fans:

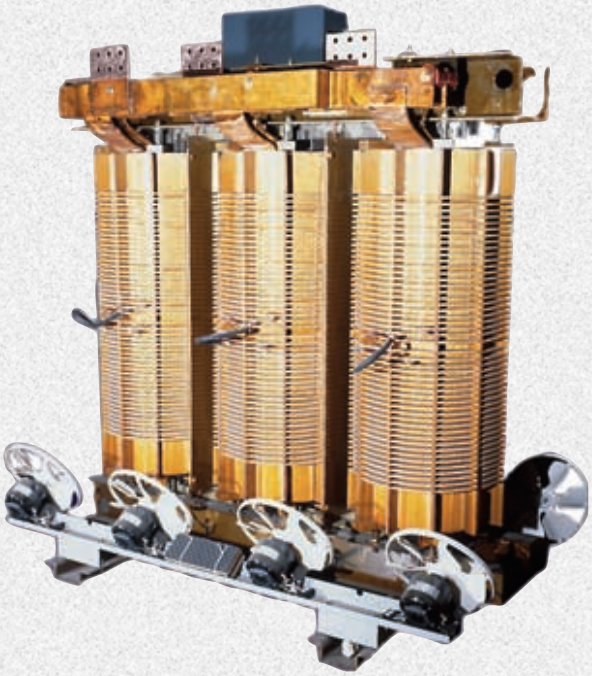
1. Winding temperature indicator
2. Fan position test switch
3. Temperature sensing device
4. Fuses
5. Green light (auxiliary power "On")
6. Amber light (fan operation)
7. Red light (excessive temperature)

The winding temperature indicator is furnished with three (3) sets of normally open contacts. Each contact closes as the average winding temperature reaches factory preset temperature values.

Sequence of operation is as follows:

1. When the winding indicator reaches 190° C (based on 150° C average winding rise temperature in a maximum 40° C ambient), the fan relay is energized which closes the fan-relay contact. The fans operate resulting in 33-1/3% additional KVA capacity.
2. Should the temperature increase to 200° C, the red light and remote alarm (if connected) operate.
3. A further increase in winding temperature to 210° C will operate contacts that can be used to trip the primary or secondary main breaker.

Temperature Gauge



Core and Coil Assembly 15 KV Class, Fan Cooled

Rating Information

Three Phase Transformer Standard Ratings

High Voltage Ratings	High Voltage Taps (Volts at Rated KVA)			
(Delta) 60 Hz	+5%	+2-1/2%	-2-1/2%	-5%
2400	2520	2460	2340	2280
4160	4360	4260	4055	3950
4800	5040	4920	4680	4560
6900	7245	7070	6730	6555
7200	7560	7380	7020	6840
12000	12600	12300	11700	11400
12470	13095	12780	12160	11845
13200	13860	13530	12870	12540
13800	14400	14100	13500	13200

Low Voltage Ratings 60 Hz			
208Y/120 240		480Y/277 480\600\	
KVA Ratings			
Self Cooled (AA)	Forced Air Cooled (FA)	Self Cooled (AA)	Forced Air Cooled (FA)
112-1/2	—	112-1/2	—
150	—	150	—
225	—	225	—
300	300/400	300	300/400
500	500/667	500	500/667
750	750/1000	750	750/1000
1000	1000/1333	1000	1000/1333
		1500	1500/2000
		2000	2000/2667
		2500	2500/3333
		3000	3000/4000

BIL (Basic Insulation Level

Designs can be furnished to meet individual system requirements. Federal Pacific construction incorporates high short-circuit capabilities with the following BIL ratings:

Primary Voltage Class	IEEE Standard BIL	FP Standard BIL	FP Hi-Pulse BIL
2.5 KV	20 KV	20 KV	30
5.0 KV	30 KV	30 KV	45
7.2 KV	45 KV	45 KV	95
15 KV	60 KV	60 KV	95

The standard rating for 15 KV class dry-type transformers is 60 KV BIL.

Federal Pacific designed and developed the Hi-Pulse Ventilated Dry-Type Transformer which has a basic insulation level of 95 KV BIL. The application of a Hi-Pulse Transformer in a 15 KV installation eliminates the potential weak-link and provides 58% additional surge protection over the conventional 60 KV BIL dry-type transformer. The 95 KV BIL ventilated dry-type transformer provides a fully rated, air insulated 15 KV installation

Transformer Nominal Impedance and Sound Levels

KVA	Percent Impedance - 3 Phase		Audible Sound Levels (db)	
	5 KV Class (30 kV BIL)	15KV Class (60 kV BIL)	Self Cooled (AA) Average	Forced Air Cooled (FA) Average
112-1/2	Consult Factory	Consult Factory	50	—
150	Consult Factory	Consult Factory	50	—
225	Consult Factory	Consult Factory	55	—
300	5.00	5.00	55	67
500	5.75	5.75	60	67
750	5.75	5.75	64	67
1000	5.75	5.75	64	67
1500	5.75	5.75	65	68
2000	5.75	5.75	66	69
2500	5.75	5.75	68	71
3000	5.75	5.75	68	71

Temperature Rise

The rated KVA of a transformer is the output based on average winding temperature rise above an average 30° C ambient not to esceed 40° C during a one (1) hour period. Standard transformers are designed to operate with a 150° C temperature rise.

Designs are optionally available with either 80° C or 115° C rise that can provide long life performance per IEEE C57.96 with lower losses and minimize operating costs on systems with a continuous high loading operation.

Full Load Current Ratings

Three Phase Self-Cooled Transformers

KVA Rating	Primary Full Load Current (Amperes)								
	2400V	4160V	4800V	7200V	12000V	12470V	13200V	13800V	14400V
112.5	27.1	15.6	13.5	9.0	5.4	5.2	4.9	4.7	4.5
150	36.1	20.8	18.0	12.0	7.2	6.9	6.6	6.3	6.0
225	54.1	31.2	27.1	18.1	10.8	10.4	9.8	9.4	9.0
300	72.2	41.6	36.1	24.1	14.4	13.9	13.1	12.6	12.0
500	120	69.4	60.1	40.1	24.1	23.1	21.9	20.9	20.0
750	180	104	90.2	60.1	36.1	34.7	32.8	31.4	30.1
1000	241	139	120	80.2	48.1	46.3	43.7	41.8	40.1
1500	361	208	180	120	72.2	69.4	65.6	62.8	60.1
2000	481	278	241	160	96.2	92.6	87.5	83.7	80.2
2500	601	347	301	200	120	116	109	105	100
3000	722	416	361	241	144	139	131	126	120

KVA Rating	Secondary Full Load Current (Amperes)			
	208V	240V	480V	600V
112.5	312	271	135	108
150	416	361	180	144
225	625	541	271	217
300	833	722	361	289
500	1388	1203	601	481
750	2082	1804	902	722
1000	2776	2406	1203	962
1500	4164	3608	1804	1443
2000	5551	4811	2406	1925
2500	6939	6014	3007	2406
3000	8327	7217	3608	2887

$$\text{Three-Phase KVA} = \frac{\text{Volts x Load Amperes x 1.7321}}{1000}$$

Primary Switch Ratings

Type Auto-jet II® Load Interrupter Switch Ratings

Voltage Ratings			Current Ratings				
Maximum Design KV	Withstand		Continuous Amps	Interrupting Amps	Fault Closing Asym. Amps	Momentary Asym. Amps	3-Second Short-Time Sym. Amps
	60 Hz KV	BIL KV					
5.0	19	60	600	600	40,000 61,000	40,000 61,000	25,000 38,000
15.0	36	95	600	600	40,000 61,000	40,000 61,000	25,000 38,000

Suggested Minimum Current Limiting Fuse Ratings for Three Phase Self-Cooled Dry-Type Transformers*

KVA	4160 V		7200 V		12470 V		13200 V		13800 V	
	G.E.	Cutler Hammer	G.E.	Cutler Hammer	G.E.	Cutler Hammer	G.E.	Cutler Hammer	G.E.	Cutler Hammer
112-1/2	40E	25E	30E	15E	20E	8E	20E	8E	20E	8E
150	40E	30E	40E	18E	20E	10E	20E	10E	20E	10E
225	65E	45E	50E	25E	30E	15E	30E	15E	30E	15E
300	80E	60E	65E	35E	40E	25E	40E	20E	40E	18E
500	125E	100E	100E	60E	65E	40E	65E	30E	65E	30E
750	150E	150E	125E	100E	80E	60E	80E	45E	80E	45E
1000	200E	200E	150E	125E	100E	75E	100E	65E	100E	60E
1500	300E	300E	200E	200E	125E	100E	125E	100E	125E	100E
2000	375	400X	—	250E	150E	150E	150E	150E	125E	125X
2500	400	600E	—	—	175E	175E	175E	175E	150E	175E

*Fuse selections are based on recommendations of the listed fuse manufacturers and are minimum sizes suggested to allow for transformer magnetizing current inrush. Ratings are shown for the following types:

General Electric Co. — Type EJ-1 and EJO-1

Cutler-Hammer — Type CLE

Application Guide - Nominal System Suggested Arrester Rating†

Line-to-Line Voltage	4 Wire Multi-Grounded Neutral System	3 Wire Delta or WYE[1]	
		Low Impedance Ground	High Impedance or Ungrounded
4160	3	6	6
4800	6	6	6
6640	6	6	9
7200	6	9	9
7620	6	9	9
8320	6	9	10
9960	9	9	12
11000	9	10	12
11500	9	10	15
12000	9	12	15
12470	9	12	15
13200	10	12	15
13800	10	12	18
14400	12	15	18
17250	15	15	21
19750	15	18	21
20780	15	18	24
22860	18	21	27
24940	18	24	30
26400	21	24	30
27700	21	27	30
34500	27	30	36
36200	27	36	—

[1]Application of specified rating may be permissible for ungrounded or resistance grounded systems where a single phase ground may be tolerated for a period of time not to exceed the arrester's power frequency overvoltage capability.

† Source: GE Buylog®, January 2008. Used by permission.

Approximate Dimensions and Weights - Indoor Only

USS Approximate Dimensions and Weights - Indoor Only (DOE 2010 Efficiency Compliant)

Data based on standard aluminum wound indoor transformer, having 480 volts low voltage. Contact factory for dimensions on NEMA 3R outdoor units. Contact factory for depth dimensions on transformers having 208 volts low voltage.

150° C Rise (Indoor Only)

KVA	5KV - 30KV BIL			
	H (in.)	W (in.)	D (in.)	Wt. (lbs.)
112.5	90	72	48	2190
150	90	72	48	2375
225	90	72	48	2500
300	90	72	48	2875
500	90	78	48	3325
750	90	78	48	5000
1000	90	78	48	6125
1500	90	90	48	7550
2000	90	102	58	9940
2500	90	102	58	10430
3000	102	112	58	13750

KVA	15KV- 60KV BIL			
	H (in.)	W (in.)	D (in.)	Wt. (lbs.)
112.5	90	78	48	2450
150	90	78	48	2500
225	90	78	48	2925
300	90	78	48	3700
500	90	90	58	5040
750	90	90	58	6290
1000	90	90	58	7540
1500	90	102	58	8810
2000	102	112	58	11400
2500	102	112	58	12000
3000	110	120	58	14950

115° C Rise (Indoor Only)

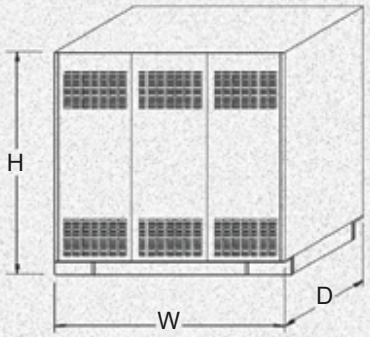
KVA	5KV - 30KV BIL			
	H (in.)	W (in.)	D (in.)	Wt. (lbs.)
112.5	90	72	48	2245
150	90	72	48	2425
225	90	72	48	2550
300	90	78	48	2950
500	90	78	48	3450
750	90	78	48	5050
1000	90	78	48	6150
1500	90	90	48	7615
2000	90	102	58	10000
2500	102	102	58	11275
3000	102	112	58	13900

KVA	15KV- 60KV BIL			
	H (in.)	W (in.)	D (in.)	Wt. (lbs.)
112.5	90	78	48	2690
150	90	78	48	2750
225	90	78	48	3125
300	90	78	48	3950
500	90	90	58	5200
750	90	90	58	6450
1000	90	90	58	7700
1500	90	102	58	8920
2000	102	112	58	11700
2500	110	112	58	13580
3000	110	120	58	16250

80° C Rise (Indoor Only)

KVA	5KV - 30KV BIL			
	H (in.)	W (in.)	D (in.)	Wt. (lbs.)
112.5	90	72	48	2275
150	90	72	48	2450
225	90	72	48	2575
300	90	78	48	3000
500	90	78	48	3500
750	90	78	48	5100
1000	90	78	48	6175
1500	90	90	48	8420
2000	102	102	58	10025
2500	102	112	58	12125
3000	102	112	58	14125

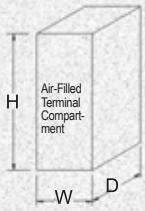
KVA	15KV- 60KV BIL			
	H (in.)	W (in.)	D (in.)	Wt. (lbs.)
112.5	90	78	48	2950
150	90	78	48	3000
225	90	78	48	3375
300	90	78	48	4190
500	90	90	58	5400
750	90	90	58	6900
1000	90	90	58	8400
1500	102	112	58	9940
2000	102	112	58	12900
2500	110	112	58	14170
3000	110	120	58	17650



I. Air-Filled Terminal Compartment - Low Voltage Outgoing Line Section

The depth and height of the air-filled cable terminal compartment will match the corresponding ventilated dry-type transformer dimensions.

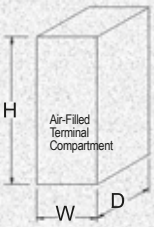
Voltage Class	Cable Termination	Width (Inches)	Weight (lbs.)		
			H = 90"	H = 102"	H = 110"
600V	Clamp-type	18	350	440	470



II. Air-Filled Terminal Compartment - High-Voltage Incoming Line Section (HV Switch Not Required)

The depth and height of the air-filled terminal compartment will match the transformer.

Voltage Class	Cable Termination	Width (Inches)	Weight (lbs.)		
			H = 90"	H = 102"	H = 110"
5 kV 30 kV BIL	Clamp-type	18	360	400	425
	Clamp-type with Lightning Arresters	18	360	400	425
	Pothead (3/1/C or 3/C)	18	360	400	425
15 kV 60 kV BIL	Clamp-type	18	360	400	425
	Clamp-type with Lightning Arresters	18	360	400	425
	Pothead (3/1/C or 3/C)	18	360	400	425



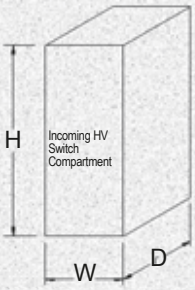
III. Non-Segregated Cable Termination Area (Indoor - Cable Entrance: Top or Bottom Outdoor - Cable Entrance: Bottom Only)

- Non-Segregated Cable Termination Area is an alternate to Air Terminal Chamber.
- For the width dimension of a transformer with a Non-Segregated Cable Termination Area (HV only, LV only, both HV & LV), use the width dimension of the next KVA size up.

IV. The Auto-jet® Switch Compartment (HV Air Filled Terminal Compartment Not Required)

Voltage Class	Cable Termination	Height (Inches)	Width[1] (Inches)	Depth[2] (Inches)	Weight (lbs.)
5 kV 60 kV BIL	Two position switch and CL fuse	90	36	46	1200
	Two position switch,expulsion fuse, arresters	90	41	46	1000
	Two position switch, CL fuses and arresters	90	36	46	1300
15 kV 95 kV BIL	Two position switch and CL fuse	90	36	46	1300
	Two position switch,expulsion fuse, arresters	90	41	46	1200
	Two position switch, CL fuses ad arresters	90	36	46	1400

[1]For a side entry termination cabinet add 20 inches to the width.
[2]For a rear entry termination cabinet add 16 inches to the depth.



Specification Guide

General Specification Guide

The transformer shall be ventilated, open,dry-type construction cooled by the circulation of air through the windings.
The unit shall be mounted in an indoor or outdoor enclosure finished in the manufacturer's standard ANSI 61 light gray paint with provisions for direct connection to the primary and secondary equipment as specified.
The transformer shall be designed, manufactured, and tested in accordance with the applicable NEMA, ANSI, and IEEE standards
The facility in which the transformers are manufactured shall be an ISO 9001:2000 registered facility.

Basic Rating

(Refer to the Transformer Specification Checklist Page, Items 1-12, for specifying basic ratings).

Insulation Materials

All insulation materials for the primary and secondary coil assembly shall be rated for continuous 220° C total temperature (Class H).
Insulation on the rectangular wire conductor shall be Nomex® or equivalent, which has a UL Listed 220°C insulation system having suitable overlapping to keep dielectric volts/mil stress within limits recommended by the insulation supplier.
Layer insulation for LV strip windings shall be Nomex® or equivalent, which is in a UL Listed 220°C insulation system having a thickness to keep volts/mil stress values no higher than values recommended by the insulation supplier.

Core and Coil Assembly

The core shall be constructed of non-aging, cold-rolled, high permeability silicon steel. All core laminations shall be step-lap mitred cut, free of burrs and stacked without gaps. The core framing structure shall be of rigid construction to provide full clamping pressure upon the core and provide the support points for the coils. Butt lap construction shall not be acceptable for power ratings above 1000 KVA.
The HV and LV coils shall be cylindrically wound (not rectangular) as an assembly with the HV coil wound directly over the LV coil. Coils shall be adequately braced for full short circuit capability to pass short circuit tests in accordance with IEEE C57.12.91.

VPI Process for transformer coils:
The coil assembly is baked for 2 hours at 190° C to remove moisture. Preheated coils are placed in a sealed VPI pressure/vacuum tank and impregnated with a 100% solids varnish in accordance with the process described on page 99 of the Federal Pacific Transformer Catalog.

Final Dip and Bake

Upon completion of the VPI process of the coils and their assembly on the core, the core top yokes are stacked, the core is clamped and all necessary leads are welded (if aluminum) or brazed (if copper) to the LV and MV bus components. At this time the complete core and coil assembly is dipped into a soft solvent based varnish of Isonel® 51 or equivalent to provide a protective coating from oxidation for all bare metal parts like core laminations and core clamping hardware. The varnish used for this process must not be a hard varnish like a 100% solids material. This core and coil assembly is then baked at the proper time and temperature (usually 4-8 hours @ 175°C) to cure all of the varnish.

Transformer Enclosure and Base

The transformer base shall be welded construction and shall be constructed to permit 4 point lifting using 1-1/2" diameter and 1" thick lifting eyes along the base of the transformer. The enclosure shall include provisions for rolling, skidding, lifting, and jacking for installation.
Removable panels shall not exceed 70 pounds in weight and shall contain suitably strong handles for lifting and placing. If installation space is adequate, hinged doors may be provided, when specified.
The enclosure shall be constructed of heavy gauge sheet steel equipped with removable parts for access to the core and coils on the front and rear. Ventilated openings shall be furnished to meet NEMA standards. The cabinet metal must be at least 14 gauge thickness. Whenever the cabinet must be outdoors (NEMA 3R) the ventilation openings must be constructed as "back-to-back" channels as shown in the NEMA 3R Unit Substation Photograph on page 83 of the Federal Pacific Transformer Catalog. (For NEMA 3R Lip Slots for ventilation are not acceptable).
Paint for the transformer enclosure shall be an ANSI-61 light grey color of a polyurethane powder coating that is electrostatically applied conforming to UL 1332 specifications. For installation areas within highly corrosive environments stainless steel enclosures may be furnished as an option as shown in Item 13(a) of the Transformer Specification Checklist Page.

The manufacturer of the Unit Substation Transformer shall be responsible for all the drawings and mechanical provisions for the proper coordination and attachment of the closely coupled switchgear on both the HV and LV ends of the transformer. Special attention needs to be given to item 14 in the Transformer Specification Checklist page for this requirement.
Vibration dampening pads shall be provided to isolate the core/coil assembly from the base structure.

High Voltage Taps

Each coil shall have taps at nominally rated voltage and an additional 4 taps: 2-2-1/2 % above and below rated nominal voltage.
Tap leads shall be terminated at the coils and equipped with provisions for changing taps under de- energized conditions.

Sound Level

The transformer shall be designed to meet the sound level standards for dry-type transformers as defined in IEEE C57.12.01 -1998 or NEMA ST-20.

Forced-Air Cooling

(Refer to the Transformer Specification Checklist Page, Item 3)

When forced-air cooling is specified, the forced-air cooling package (fans and controller shall be provided for automatically increasing the self-cooled rating by 33-1/3%. The system shall contain 120 VAC single phase fans and a control panel with indicating lights, temperature indicator, fan position test switch, and alarm mode selector switch.

Accessories as specified

(Refer to Basic Medium Voltage Open Dry Transformer Rating Information.)

Winding Temperature Controllers and Monitors shall be Qualitrol or equivalent.
Provisions for grounding shall be provided to be welded Ground Pads or special termination hardware.

Final Tests

Final Test Reports in the proper IEEE format can be furnished for each unit upon request, documenting the successful passing of all required testing.

Optional Testing may be specified in the Basic Medium Voltage Open Dry Transformer Rating Information.

Basic Medium Voltage Open Dry Transformer Rating Information

Ship To Destination:
City _____ **State** _____

Power Rating Self-Cooled (AA) _____ **KVA** ❑ **Three Phase**

Power Rating Self-Cooled (AA/FA) _____ **KVA** ❑ **Single Phase**
(If fans are required)

Frequency: ❑ 60 Hz
❑ 50 Hz

❑ UL Listing is Required
❑ UL Listing is **NOT** Required

Enclosure:
❑ **Indoor (NEMA 1)**
❑ **Outdoor (NEMA 3R)**

Fans or Provisions for Fans Required: ❑ **Yes** ❑ **No**
❑ Furnish 1ø CPT (480 OR 208V) **with Fans**
❑ No CPT Power for Fans and controller by others
❑ Provisions for fans (**no** wiring, **no** controller)
❑ Provisions for fans (**with** wiring, **no** controller)
❑ Provisions for fans (**with** wiring, **with** controller)

Sound Level: ❑ STD ❑ Special Sound in db:

NEMA TP-1 Energy Efficient ❑ Yes ❑ No
DOE TSL2 Energy Efficient ❑ Yes ❑ No

Primary Voltage: _____ **Volts** ❑ **Delta** ❑ **Wye** **BIL in KV:** _____

Secondary Voltage: _____ **Volts** ❑ **Delta** ❑ **Wye** **BIL in KV:** _____

Average Winding Tamperature Rise °C: ❑ 150 ❑ 115 ❑ 80

HV Taps: ❑ Standard Full Capacity: 2 2-1/2% Above and 2 2-1/2% Below Rated Primary Voltage
❑ Other Taps

Impedance: ❑ **Standard** ❑ **Other** **Specify:** _____

Windings: ❑ Aluminum ❑ Copper

Electrostatic Shield Between Primary and Secondary Windings: ❑ Yes ❑ No

Transformer Construction

❑ **High Voltage General Purpose, HVGP** ("Cable In" and "Cable Out' without segmented Air Terminal Compartments)

❑ **Unit Substation**

Unit Substation Primary Side
❑ Close Coupled to Switchgear (Flange)
❑ Full Height Terminal Chamber
❑ Non-Segregated Cable Terminal Area
❑ Throat
❑ Bolted Panel Only

Unit Substation Secondary Side
❑ Close Coupled to Switchgear (Flange)
❑ Full Height Terminal Chamber
❑ Non-Segregated Cable Terminal Area
❑ Throat
❑ Bolted Panel Only

❑ **Pad-Mount** Tamper Resistant Low Profile per IEEE C57.12.28 (Typical configuration shown on page 94)

Basic Medium Voltage Open Dry Transformer Rating Information

TESTING:

Standard (IEEE C57.12.91) ❑ Yes ❑ No

Optional Special Tests ❑ Yes ❑ No

QC Impulse	❑ Yes	❑ No	
IEEE C57.12.91 Impulse	❑ Yes	❑ No	
Audible Sound	❑ Yes	❑ No	
Heat Run (Temperature)	❑ Yes	❑ No	
Partial Discharge	❑ Yes	❑ No	
Other	❑ Yes	❑ No	If Yes Please Specify _____

FEATURES & ACCESSORIES:

Primary Arresters

❑ Distribution kV _____
❑ Intermediate kV _____
❑ Station kV _____

Secondary Arresters

❑ Distribution kV _____
❑ Intermediate kV _____
❑ Station kV _____

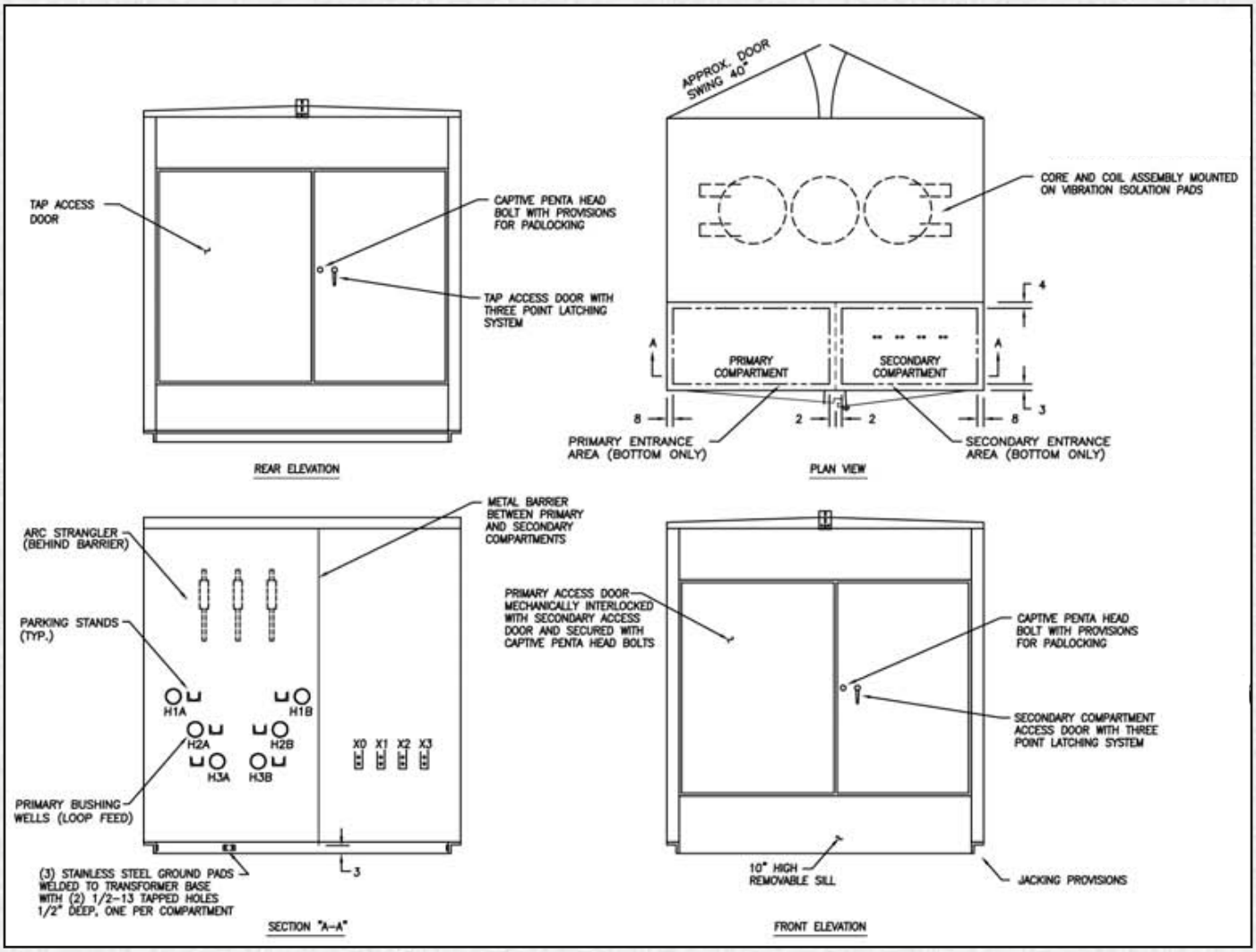
Other Features

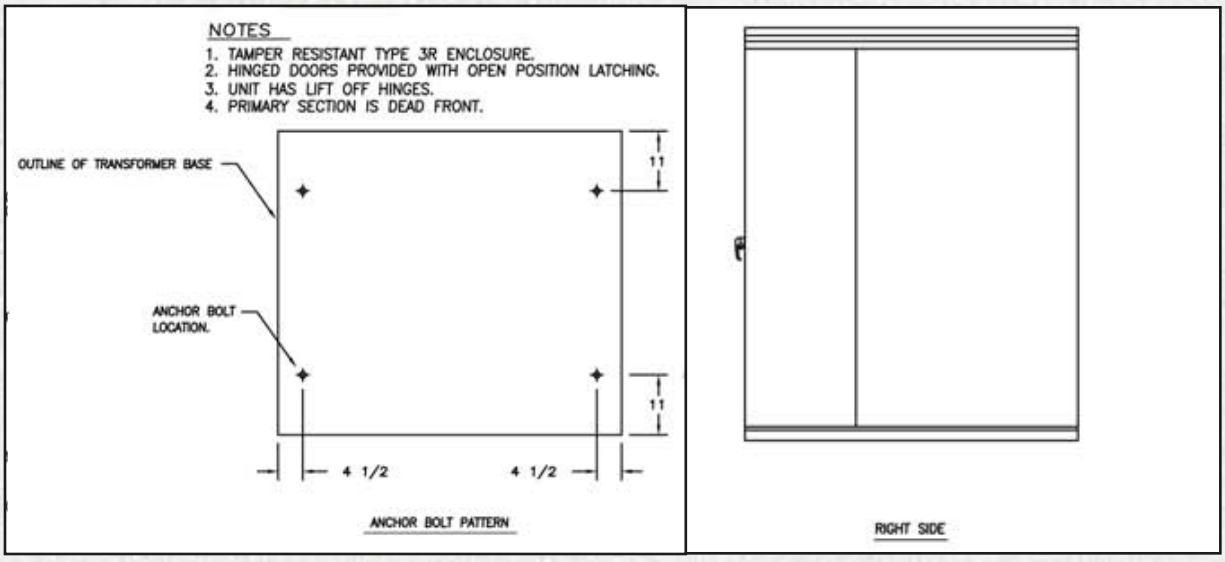
VPI Coils	❑ Yes	❑ No	
VPI Coils with Epoxy Shield	❑ Yes	❑ No	
Copper Ground Bus	❑ Yes	❑ No	
Altitude Above 3300 Feet	❑ Yes	❑ No	Altitude in _____ Feet
Digital Temperature Monitor	❑ Yes	❑ No	
Space Heaters With Thermostat	❑ Yes	❑ No	
Dust Filters	❑ Yes	❑ No	
Rodent Proofing	❑ Yes	❑ No	

Losses Needed With Quotation ❑ Yes ❑ No ❑ Typical ❑ Guaranteed

Dimensions Needed With Quote ❑ Yes ❑ No

Weight Needed With Quote ❑ Yes ❑ No





Typical Pad-Mount Transformer Configuration