# Federal Pacific Medium Voltage Transformer Catalog

FEDERAL PACIFIC™

## Federal Pacific History

In 1987, Electro-Mechanical Corporation acquired the dry-type transformer division of Federal Pacific Electric in Des Plaines, Illinois. It was moved to Bristol, Virginia and the name was changed to Federal Pacific (FP). A new 100,000 square foot facility was constructed where time-proven designs and modern technology were combined and deployed under new management. Expansion in early 1993 provided an additional 36,000 square feet of manufacturing space.

## Federal Pacific Today

Federal Pacific is a major manufacturer of dry-type transformers which serve the industrial, construction, commercial, mining, OEM and utility markets. The product scope is 50 VA through 10,000 kVA and 120 volts through 25,000 volts. The 600 volt class offering includes industrial control transformers, encapsulated/compound-filled general purpose and buck-boost transformers, ventilated designs for general purpose applications, electrostatically shielded transformers and a complete line of motor drive isolation transformers. The medium voltage offering includes core and coil transformers, general purpose designs, pad mount transformers, unit substation transformers, vacuum pressure impregnated transformers (VPI), and VPI/epoxy shielded transformers. K-Factor rated transformers are offered for the entire product scope.

## Distribution

Regional warehouse stocks have been implemented across the United States, ensuring quick delivery anywhere in the country.

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**Dimensions in this catalog not to be used for construction purposes.**

**Consult factory for detailed construction drawings.**

# Medium Voltage Dry-Type Transformers

## Overview

Federal Pacific is an industry leader in providing custom engineered dry-type transformers for low and medium voltage applications. Designs are available in a wide variety of types and ratings to provide reliable and versatile electrical distribution for lighting and power loads in industrial and commercial applications. Whether the application requires a dedicated use, engineered design or a commonly-used transformer with a simple voltage transformation for special equipment, Federal Pacific can design and build your transformer quickly and reliably.

Federal Pacific offers a full line of medium voltage transformers. Base styles and ratings are shown below. These transformers can be configured to meet most any application requirement. All medium voltage transformers are engineered-to-order to the requested specifications.

**High Voltage General Purpose Transformers**
2.4kV to 15kV, 15kVA through 1500kVA

**Unit Substation Transformers**
2.4kV through 25kV, 15kVA through 10MVA

**Pad-Mounted Transformers**
2.4kV through 25kV, 15kVA through 10MVA

The air-cooled, dry-type construction requires no special vault for installation. Units may be located in almost any indoor location convenient to the load being served. Most transformers are also available for outdoor installations. Maintenance requires only periodic inspection of cable connections and removal of any dust accumulation.

## Special Applications

Below are a few examples of the many variations of specialty transformers Federal Pacific has designed and manufactured.

Special sound levels
Reconnectables
Multiple primaries/secondaries
Special Impedance
Auto-Transformers
Special Paint
Test transformers
Mine Duty
ABS Marine Duty
Drive Isolation
Plus many others

## Insulation System

Federal Pacific 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

*Nomex® is a Registered Trademark of Dupont Co.*

## Industry Standards & Certifications

Federal Pacific dry-type transformers are UL® Listed and are designed, tested, and manufactured in accordance with applicable industry standards of ANSI, NEMA and IEEE.

## Industry-Leading Ship Times

Under the Lightning Fast Program Federal Pacific can deliver engineered-to-order low and medium voltage transformers with significantly reduced lead time (additional charges apply). Lightning Fast shipments should be requested at the time of quotation as some designs may be exempt from the service.

| Medium Voltage Typical Shipment Lead Times | | |
|---|---|---|
| kVA | Standard Lead Time | Lightning Fast Lead Time |
| ≤ 500 | 4-6 Weeks | ≤ 2 Weeks |
| 750 | 4-6 Weeks | ≤ 3 Weeks |
| ≥ 1000 | 4-6 Weeks | ≤ 4 Weeks |

## Standard Tested Performance

Federal Pacific performs a standard series of tests to ensure proper operation, adherence to applicable standards and product quality. Tests performed include:

**Ratio Testing** is performed on rated voltage connection and tap connections to assure the 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 Testing** determines the losses of a transformer which is excited at rated voltage and frequency, but which is not supplying a load. Transformer excitation losses consist mainly of losses in the core of the transformer.

**Impedance Voltage & Load Loss Test** determines the impedance voltage and the amount of losses (excluding no-load 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 Testing** determines the current necessary to maintain transformer excitation.

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

**Dielectric Tests** (applied and induced potential) check the insulation and workmanship to demonstrate that the transformer has been designed and manufactured to meet the insulation levels required by the standards and/or customer.

- **Applied Potential Testing** is performed by impressing a low frequency voltage between windings and between each winding and ground.
- **Induced Potential Tests** over-excite 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.

## Sound Levels

Federal Pacific transformers are designed, built, and comply with NEMA and IEEE maximum sound level requirements.

### Medium Voltage Sound Levels and Typical Impedance

*In accordance with IEEE C57.12.01*

| KVA | Percent Impedance - 3 Phase | | Audible Sound Levels (db) - 3 Phase | |
|---|---|---|---|---|
| | 5 kV Class (30 kV BIL) | 15kV Class (60 kV BIL) | Self Cooled (AA) Average | Forced Air Cooled (FA) Average |
| 112.5 | 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 | 68 |
| 1500 | 5.75 | 5.75 | 65 | 69 |
| 2000 | 5.75 | 5.75 | 66 | 71 |
| 2500 | 5.75 | 5.75 | 68 | 71 |
| 3000 | 5.75 | 5.75 | 68 | 73 |
| >3000 | Consult Factory | Consult Factory | Consult Factory | Consult Factory |

# Medium Voltage Dry-Type Transformers

The United States Department of Energy (DOE) establishes energy efficiency standards for all transformers under DOE Article 10 CFR 431. The latest updates to the standards went into effect on January 1, 2016. Federal Pacific's transformers meet the requirement set forth by the Department of Energy. The established standards and efficiency requirements have been defined below.

## *10 CFR 431 (DOE 2016)*
## *Energy Efficiency Requirements*

**Table 1**

| Nominal Efficiency Levels for Single-Phase Dry-Type Transformer | | | | |
|---|---|---|---|---|
| KVA | Low Voltage 35% Load | Medium Voltage — 50% Load | | |
| | | 20-45 kV BIL | 46-95 kV BIL | >= 96 kV BIL |
| 15 | 97.70 | 98.10 | 97.86 | — |
| 25 | 98.00 | 98.33 | 98.12 | — |
| 37.5 | 98.20 | 98.49 | 98.30 | — |
| 50 | 98.30 | 98.60 | 98.42 | — |
| 75 | 98.50 | 98.73 | 98.57 | 98.53 |
| 100 | 98.60 | 98.82 | 98.67 | 98.63 |
| 167 | 98.70 | 98.96 | 98.83 | 98.80 |
| 250 | 98.80 | 99.07 | 98.95 | 98.91 |
| 333 | 98.90 | 99.14 | 99.03 | 98.99 |
| 500 | — | 99.22 | 99.12 | 99.09 |
| 667 | — | 99.27 | 99.18 | 99.15 |
| 833 | — | 99.31 | 99.23 | 99.20 |

**Table 2**

| Nominal Efficiency Levels for Three-Phase Dry-Type Transformer | | | | |
|---|---|---|---|---|
| KVA | Low Voltage 35% Load | Medium Voltage — 50% Load | | |
| | | 20-45 kV BIL | 46-95 kV BIL | >= 96 kV BIL |
| 15 | 97.89 | 97.50 | 97.18 | — |
| 30 | 98.23 | 97.90 | 97.63 | — |
| 45 | 98.40 | 98.10 | 97.86 | — |
| 75 | 98.60 | 98.33 | 98.13 | — |
| 112.5 | 98.74 | 98.52 | 98.36 | — |
| 150 | 98.83 | 98.65 | 98.51 | — |
| 225 | 98.94 | 98.82 | 98.69 | 98.57 |
| 300 | 99.02 | 98.93 | 98.81 | 98.69 |
| 500 | 99.14 | 99.09 | 98.99 | 98.89 |
| 750 | 99.23 | 99.21 | 99.12 | 99.02 |
| 1000 | 99.28 | 99.28 | 99.20 | 99.11 |
| 1500 | — | 99.37 | 99.30 | 99.21 |
| 2000 | — | 99.43 | 99.36 | 99.28 |
| 2500 | — | 99.47 | 99.41 | 99.33 |

**Note** - Efficiencies are computed with the losses consumed at 35% load for low voltage transformers and 50% load for medium voltage transformers per 10 CFR 431 (DOE 2016). The losses are also corrected to 75°C.

Not all dry-type transformers must abide by the efficiency levels set forth by the Department of Energy (DOE). DOE defines a distribution transformer as having an input of 34.5 kV or less, an output voltage of 600 volts or less, 60 Hz and 15 KVA to 2500 kVA.

**Transformers Exempt from Efficiency Requirements**

- Transformers with output voltages greater than 600 volt
- Transformers outside the kVA range of 15 to 2500 or not defined in the tables above
- Autotransformers
- Drive isolation transformers
- Grounding transformers
- Machine tool transformers
- Non-ventilated transformers (including encapsulated transformers)
- Rectifier transformers
- Regulating transformers
- Sealed transformer
- Special impedance transformer
- Testing transformer
- Transformer of 20% or more tap range
- Uninterruptible power supply transformer
- Welding transformer
- Rebuilt or refurbished transformers
- 50 Hz transformers[1]

Formal definitions for each of these types of transformer are found in 10 CFR 431.192. Go to the "Electronic Code of Federal Regulations" website at ***http://www.ecfr.gov*** for complete regulations.

1. In the case of transformers designed for 50/60 Hz operation, the efficiency shall only be required for 60 Hz and shall be measured in accordance with its 60 Hz voltage and current ratings.

## Description

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

Medium voltage dry-type transformers for use in the United States must comply with the efficiency levels as set forth in the Code of Federal Regulations Title 10 Part 431.196 (10 CFR 431.196) as published by the US Department of Energy.

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 transformers an ideal choice for new or existing installations.

Transformers are available in three-phase ratings from 15 kVA to 10,000 kVA and single-phase from 15 kVA to 3,000 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 stand-alone transformers.

## Medium Voltage Industry Standards

Federal Pacific medium voltage 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.

Additionally, Federal Pacific can provide transformers meeting applicable CSA, IEC, and ABS standards.

## 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 precisely cut the steel laminations 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 core assembly is rigidly clamped with steel members to prevent movement and to provide support for the coils.

*Step-Lap Miter Core Construction*

## Coil Construction

Coils are precision wound in a circular or wound configuration (depending on design requirements) using aluminum conductor material as standard. Copper conductors can also be provided as an option.

Federal Pacific typically employs sheet-wound secondary windings. 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 an insulating barrier between the coils consisting of spacers and sheet insulation applied to the proper thickness. Primary windings may be layer-wound or disc-wound depending upon the design requirements. All coils are properly braced to withstand full short circuit forces.

## 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.

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 protect the unit from dust and moisture as well as provide 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.

## 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 nominal (FCAN) and two (2) 2-1/2% taps full capacity below nominal (FCBN).

The tap connections are located on the front side of each coil. Taps are accessible behind removable covers and can easily be changed by moving jumpers between connection points when the transformer is de-energized.

Federal Pacific can accommodate most customer-specified tap arrangements.

## Terminals

Wiring compartments located behind removable covers with terminals are arranged to accept cable connectors. A flexible grounding strap is provided to connect the core and coil assembly and enclosure to a ground stud or pad.

## Optional Testing

In addition to the standard testing summarized on page 5, Federal Pacific can complete the following testing on all medium voltage transformers. Additional charges may apply.

**Partial Discharge (PD)** - tests for harmful levels of PD that would destroy insulation over time. Refer to the Glossary for further definition.

**Impulse Testing** - tests the transformers ability to withstand overvoltage transients from lightning or switching. The impulse rating for a transformer is known as the basic lightning impulse level (BIL). This test exposes the transformer to simulated impulse waves in the laboratory similar to those experienced in the field.

- **Full Impulse Testing** - Consists of applying (4) impulse waves to the transformer, a reduced impulse, (2) chopped and a full wave test.
- **QC Impulse Testing** - Consists of applying (1) reduced and (1) full impulse wave to the transformer.

*Federal Pacific Medium Voltage Unit Substation Style transformer designed for close coupling on the primary (high voltage) side.*

*Completed Core and Coil assembly shown with optional fan cooling*

## General Information

Federal Pacific's High Voltage General Purpose (HVGP) transformers are freestanding indoor general purpose distribution transformers. HVGP style transformers can be necessary where there are special space requirements and equipment configurations. Primary voltage ratings are 2.4—15 kV and secondary voltages are less than 600 V. These transformers are highly efficient meeting U.S. DOE 10 CFR-431 (2016) minimum efficiency requirements. Standard efficiency models for export use only are also available. Since these transformers are made to order, optional 80°C and 115°C temperature rises are also available.

To indicate the HVGP transformer required replace "XX" with the primary and secondary voltages from the Voltage Codes table below.

For instance, catalog number GTM4112H is an HVGP style transformer rated 13800 Delta—208Y/120.

*Style A*

*Style B*

**Table I (2.4KV and 5KV Class)**

| KVA | Catalog Number | Enclosure |
|---|---|---|
| 15 | GT(XX) S15H | A |
| 30 | GT(XX) S30H | A |
| 45 | GT(XX) S45H | A |
| 75 | GT(XX) S75H | A |

**Table II (7.2 KV, 8.6KV, and 15 KV Class)**

| KVA | Catalog Number | Enclosure |
|---|---|---|
| 112.5 | GT(XX) S112.5H | B |
| 150 | GT(XX) S150H | B |
| 225 | GT(XX) S225H | B |
| 300 | GT(XX) S300H | B |
| 500 | GT(XX) S500H | B |
| 750 | GT(XX) S750H | B |
| 1000* | GT(XX) S1000H | B |
| 1500* | GT(XX) S1500H | B |

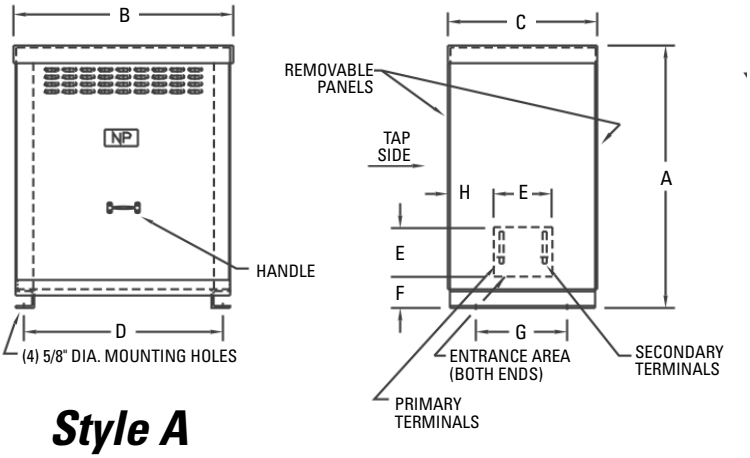
** Dimensions shown on page 12 are 480V secondary only.*

**Voltage Codes**

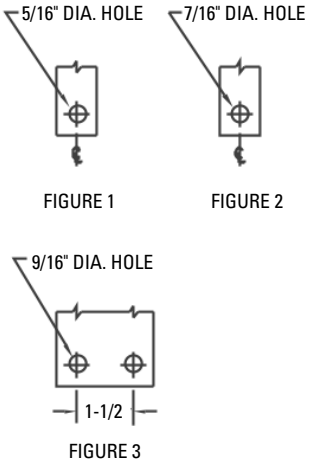
| Primary | | | |
|---|---|---|---|
| 2400 Delta | A | 4160 Delta | B |
| 4800 Delta | C | 7200 Delta | D |
| 8320 Delta | G | 12000 Delta | J |
| 12470 Delta | K | 13200 Delta | L |
| 13800 Delta | M | | |
| **Secondary** | | | |
| 240 Delta | 2 | 480 Delta | 3 |
| 208Y/120 | 4 | 480Y/277 | 5 |

# Dimensional Data

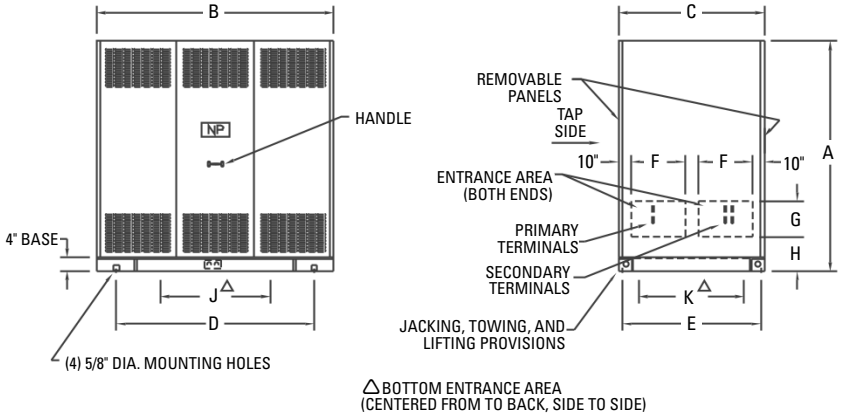
### HVGP Approximate Dimensions and Weights - Indoor Only (DOE 2016 Efficiency Compliant)
### Three Phase — 150° C Rise — 2.4 kV and 5 kV



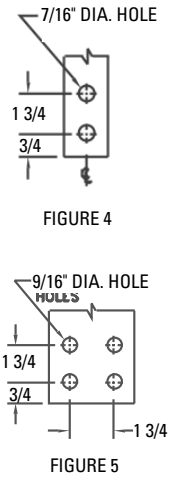

## Style A




| KVA | Net Wt. in Lbs. | A | B | C | D | E | F | G | H | Primary | Secondary |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 540 | 48 | 36 | 20 | 34.125 | 6 | 5.75 | 16.75 | 7 | Fig. 1 | Fig. 1 |
| 30 | 625 | 48 | 36 | 20 | 34.125 | 6 | 5.75 | 16.75 | 7 | Fig. 1 | Fig. 1 |
| 45 | 725 | 48 | 36 | 20 | 34.125 | 6 | 5.75 | 16.75 | 7 | Fig. 1 | Fig. 2 |
| 75 | 965 | 49 | 39 | 23 | 37.125 | 8 | 5.75 | 19.75 | 7.5 | Fig. 1 | Fig. 2 |




## Style B




| KVA | Net Wt. in Lbs. | A | B | C | D | E | F | G | H | J | K | Primary | Secondary |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 112.5 | 1650 | 80 | 48 | 48 | 30 | 44.75 | 12.5 | 12 | 4.25 | 30 | 39 | Fig. 4 | Fig. 5 |
| 150 | 1778 | 80 | 48 | 48 | 38 | 44.75 | 12.5 | 12 | 4.25 | 30 | 39 | Fig. 4 | Fig. 5 |
| 225 | 2250 | 80 | 53 | 48 | 43 | 44.75 | 12.5 | 12 | 4.25 | 30 | 39 | Fig. 4 | Fig. 5 |
| 300 | 2530 | 80 | 53 | 48 | 43 | 44.75 | 12.5 | 12 | 4.25 | 30 | 39 | Fig. 4 | Fig. 5 |
| 500 | 3428 | 80 | 64 | 48 | 54 | 44.75 | 12.5 | 12 | 4.25 | 30 | 39 | Fig. 4 | Fig. 5 |
| 750 | 5400 | 90 | 72 | 48 | 62 | 44.75 | 12.5 | 12 | 4.25 | 30 | 39 | Fig. 4 | Fig. 5 |
| 1000* | 6300 | 102 | 72 | 48 | 54 | 44.75 | 12.5 | 12 | 4.25 | 30 | 39 | Fig. 4 | Fig. 5 |
| 1500* | 8300 | 102 | 78 | 78 | 62 | 44.75 | 12.5 | 12 | 4.25 | 30 | 39 | Fig. 4 | Fig. 5 |

** Dimensions shown are for 480 secondary only. Consult factory for other voltages.*

# Dimensional Data

***HVGP Approximate Dimensions and Weights - Indoor Only (DOE 2016 Efficiency Compliant)***
***Three Phase — 150° C Rise — 7.2 kV, 8.6 kV & 15 kV***

**Notes:**

1. Covers and all panels are removable
2. Grounding block (welded to base)(2) 1/2 - 13 tapped holes
3. Lift eyes are a welded integral part of the base

**FIGURE 1**

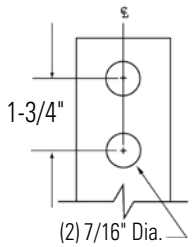
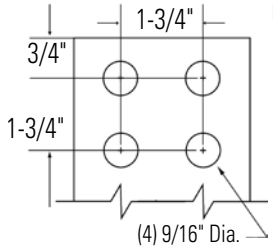



**FIGURE 2**

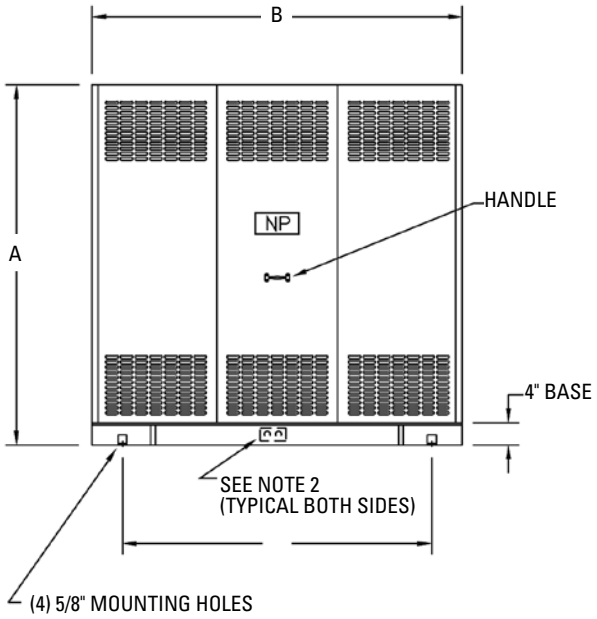


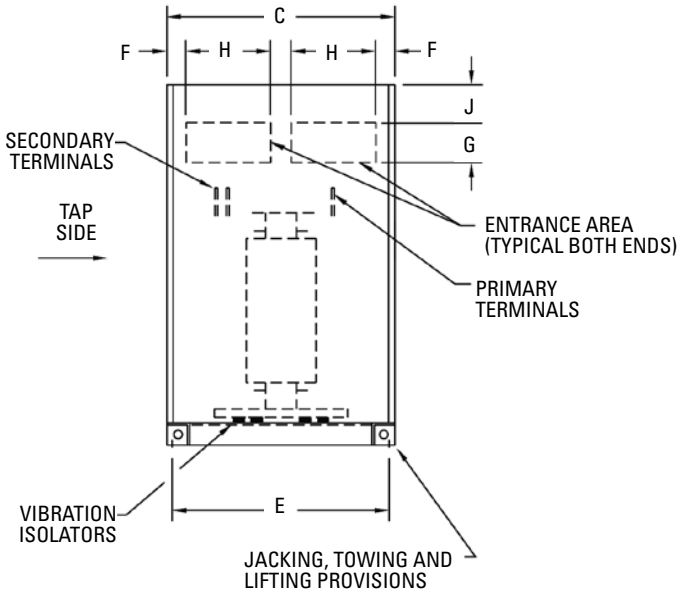

Terminal Material: Tin Plated Aluminum

Terminal Spade Figure

| KVA | 208V | 480V | 7.2kV, 8.6kV, 15kV |
|---|---|---|---|
| 75 | 1 | 1 | 1 |
| 112.5 | 1 | 1 | 1 |
| 150 | 1 | 1 | 1 |
| 225 | 2 | 1 | 1 |
| 300 | 2 | 1 | 1 |
| 500 | 2 | 1 | 1 |
| 750 | 2 | 2 | 1 |
| 1000 | — | 2 | 1 |
| 1500 | — | 2 | 1 |

## Style B




| KVA | Net Wt. in Lbs. | A | B | C | D | E | F | G | H | J |
|---|---|---|---|---|---|---|---|---|---|---|
| 112.5 | 3440 | 90 | 72 | 48 | 62 | 44.75 | 6 | 8 | 16.5 | 4 |
| 150 | 3360 | 90 | 72 | 48 | 62 | 44.75 | 6 | 8 | 16.5 | 4 |
| 225 | 3965 | 90 | 78 | 58 | 62 | 44.75 | 6 | 8 | 16.5 | 4 |
| 300 | 4350 | 102 | 78 | 58 | 68 | 44.75 | 6 | 8 | 16.5 | 4 |
| 500 | 5560 | 102 | 78 | 58 | 68 | 44.75 | 6 | 8 | 16.5 | 4 |
| 750 | 8820 | 102 | 90 | 58 | 76 | 50.75 | 6 | 8 | 16.5 | 4 |

** Refer to Unit Substation Style Transformers for larger KVA ratings.*

# Unit Substation Style (USST) Transformers

## Description

Federal Pacific specializes in the design and manufacture of medium voltage unit substation style transformers.

A unit substation consists of one or more transformers close-coupled to one or more switchgear or switchboard assemblies.

A unit substation is considered a secondary unit substation when the output voltage is less than 1000 volts.

Unit substations bring power closer to the load providing reduced power losses, better voltage regulation, improved service continuity, improved functional flexibility, lower installation cost and more efficient space utilization.

## Arrangements

Federal Pacific unit substation transformers meet a wide variety of application requirements with the highest degree of service reliability.

A Federal Pacific substation is a coordinated, engineered electrical center 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.

It typically provides 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

Federal Pacific's 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. Federal Pacific can also easily accommodate the bus arrangements of other high voltage switch vendors. The switch compartment is bolted directly to the high voltage side of the transformer.

## 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. Another incoming termination option is the "Non-Segregated Air Terminal Chamber" having no separating steel barrier and is utilized to minimize the over-all width of the unit substation by as much as 3 feet. It also eliminates the need for expensive flex bus.

## Low Voltage Distribution Sections

A complete selection of distribution and protective equipment is available to meet application requirements. Unit substation transformers from Federal Pacific can be 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. Non-segregated ATC's as described for the incoming compartment are likewise available for the low voltage outgoing section.

## Features of Typical USST Transformers

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 additional temporary overload capacity of 33-1/3% kVA capacity for units with self-cooled ratings of 300 kVA and above.

    Future Forced Air Cooling (FFA) provisions are also available and include 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.

## Options and Accessories

**Digital Temperature Monitors** are used for more intelligent interactive transformer temperature monitoring for safety relay schemes and SCADA options.

**Dust Filters** are placed over ventilation openings to provide a degree of protection from dust accumulation on the inside of the transformer enclosure.

**Electrostatic Shielding** is commonly used in areas where sensitive electronic equipment is being fed by the transformer. The electrostatic shield provides another level of isolation between the primary and secondary windings to reduce common mode noise and harmful transients.

**Flexible Connectors** are used to simplify the connections when close-coupling to equipment on the secondary side of the transformer.

**Hinged Doors** are an option for indoor transformers allowing easy access to the core and coil of the transformers. Standard enclosures are made up of bolted panels.

**IR Viewing Windows** are used to allow for monitoring the temperature of a transformer's internal parts without having to de-energize and remove transformer panels.

**RC Snubbers** protect dry-type transformers from high frequency, high voltage transients due to switching of nearby vacuum or SF6 breakers. These voltage transients cannot be prevented by traditional surge arresters. RC Snubbers have proven to provide reliable protection from these fast transients.

**Rodent Screening** is a fine metal mesh often installed over the ventilation openings of dry-type transformers to prevent damage from rodents or other small animals.

**Space Heaters** are used to keep transformer dry during long-term storage or for pre-drying the transformer before energizing.

**Surge/Lightning Arresters** serve to protect transformers from high transient voltages primarily caused by lightning or switching. Distribution, Intermediate and Station Class options are available. Distribution arresters are the most frequently used for dry-type transformers. Intermediate arresters for medium-duty applications provide improved protection and higher energy handling capability. Station class arresters for heavy duty applications have the highest degree of protection

**Thermostats** installed within the coils protect the transformer from overheating by triggering system alarms and actions to shut down the unit when necessary.

*A Federal Pacific unit substation transformer with a Federal Pacific close coupled line interrupting switch.*

## Options and Accessories

**Enclosure** - The standard configuration for Federal Pacific unit substation transformer enclosures is Category "C" indoor.

There are however many other enclosure options to meet design requirements. Drip-shields can be added to indoor enclosures to protect against falling debris. Enclosures for outdoor installations are also available.

Category C indoor or outdoor enclosures are intended:

1. for use in installations in secured areas generally inaccessible to unauthorized and untrained persons and
2. to provide a degree of protection against contact with the enclosed equipment.

| Enclosure Style | Classification per IEEE C57.12.55 |
|---|---|
| Indoor | Category C |
| Drip-Proof Indoor | Category C |
| Outdoor | Type 103R, Category C |

Federal Pacific outdoor enclosures use specially-designed back-to-back channel style grills to protect against 65 mph windblown rain.

Outdoor 103R type enclosures provide a degree of protection from incidental contact with the enclosed equipment and the ingress of rain, snow, and sleet.

Transformer enclosures can also be provided in stainless steel for corrosive environments.

## Triplex Designs

Triplex design is the housing of three single-phase transformers for a three-phase bank inside one enclosure. This type of design is sometimes necessary in cases such as elevator-accessible-only applications where the size of a three-phase transformer exceeds elevator capacity or where doorways are too small for a three-phase transformer.

## Forced Air Cooling

Unit substation transformers may be equipped with fans and controls to obtain additional kVA capacity during times of temporary unexpected heavy usage. Correctly-applied forced circulation of air permits the self-cooled kVA rating of the transformer to be temporarily increased by an additional 33-1/3%. (Class FA rating)

With forced air cooling, the winding transformer monitor is equipped with necessary controls for the operation of the fans:

1. Winding temperature indicator
2. Configurable fan exerciser
3. Temperature sensing device
4. Fuses
5. Green light (auxiliary power "On")
6. Amber light (fan operation)
7. Red light (excessive temperature)
8. MODBUS Communication via RS-485
9. Universal input power 80-380 VAC 50/60 HZ

The winding temperature indicator is furnished with three (5) sets of normally open and normally closed contacts. Each contact opens or closes as the average winding temperature reaches factory preset temperature values.

*Federal Pacific's preferred temperature monitoring device.*

## Options and Accessories

### Vacuum Pressure Impregnated (VPI)

Federal Pacific VPI transformers combine a performance proven dry-type transformer design with the environmental protection of a polyester coil encapsulation process. This combination ensures reliable transformer operation in environments containing moisture, dust, dirt, chemicals and other contaminants.

The VPI process fully penetrates and seals the coils into a high strength composite unit for complete environmental protection. Since the coil protection is created using vacuum pressure impregnation rather than molding, maximum design flexibility is achieved to allow conformance to the most stringent application requirements.

The vacuum impregnation of the polyester resin eliminates winding voids to reduce essentially to zero any corona generation due to insulation voids. Corona, particularly in conjunction with corrosive environments, accelerates the degradation of the insulation materials and will cause the transformer to fail prematurely.

The Federal Pacific VPI process can be applied to all transformer ratings.

Federal Pacific uses high performance 100% solid, precatalyzed, solventless varnish. This varnish, when applied, imparts a clear, tough, high bond strength coating to the coil assembly. It also adds high dielectric strength as well as mechanical bond strength and unparalleled thermal endurance.

### Epoxy Shield

In addition to VPI, Federal Pacific offers the Epoxy Shielded Transformer, a superior dry-type transformer.

The Epoxy Shielded Transformer is ideal for environments polluted with chlorides, acids, alkalies, salt water and high humidity.

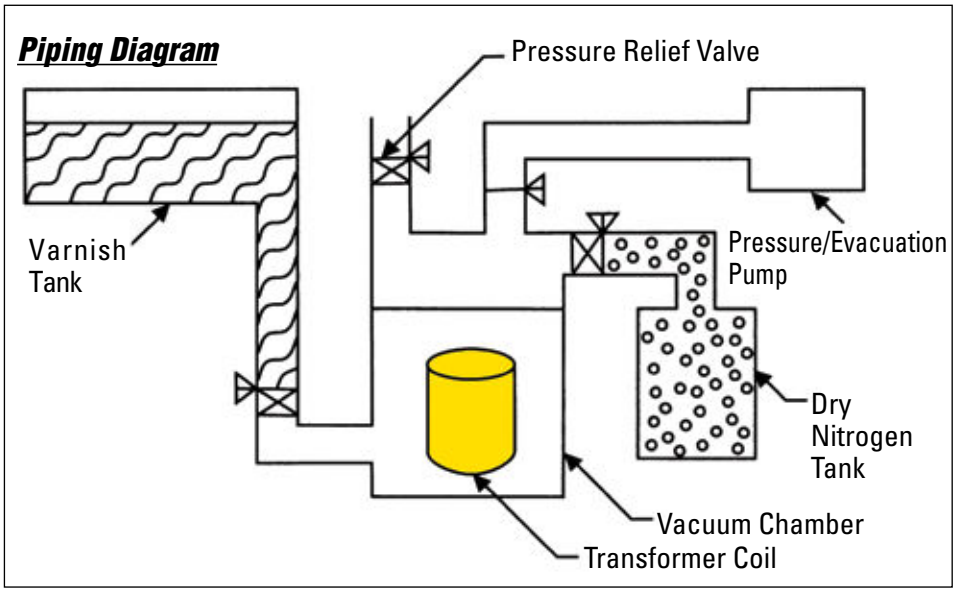
The Federal Pacific design begins with a quality VPI transformer. To this is added 2 mils minimum of modified epoxy varnish and the result is a premium transformer ready to handle the harshest environments.

Federal Pacific uses high viscosity formulated epoxy. This specially formulated epoxy is designed for greater film dry thickness than most epoxies in use today. The epoxy used has a high percentage of solids, yet has a relatively low cure weight. This unique combination allows high mechanical bond strength and a low overall unit weight.

Where your environmental concerns are the greatest, specify the best epoxy transformer on the market today - Federal Pacific's Epoxy Shielded transformer.

## Vacuum Pressure Impregnated Process

1. Transformer coils preheated for improved resin penetration into coils
2. Coils placed into special pressure vessel
3. Apply dry vacuum to remove trapped moisture from coils
4. Polyester resin is pumped into pressure vessel to completely submerge coils
5. Vacuum broken followed by application of high pressure forcing the resin to penetrate into the transformer coils thereby removing air voids
6. Resin evacuated from pressure vessel and returned to storage tank
7. Coils allowed to drain
8. Coils baked in oven to cure resin forming a barrier to airborne contaminants and enhancing the dielectric strength of the insulation system



# Unit Substation Style (USST) Transformers

## USS Approximate Dimensions and Weights - Indoor Only (DOE 2016 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 | 64 | 48 | 1643 |
| 150 | 90 | 64 | 48 | 1775 |
| 225 | 90 | 72 | 48 | 2312 |
| 300 | 90 | 72 | 48 | 2601 |
| 500 | 90 | 72 | 48 | 3264 |
| 750 | 90 | 90 | 48 | 5299 |
| 1000 | 90 | 90 | 48 | 6130 |
| 1500 | 90 | 90 | 48 | 8078 |
| 2000 | 102 | 102 | 48 | 12724 |
| 2500 | 102 | 102 | 58 | 15285 |

| KVA | 15kV- 60kV BIL | | | |
|---|---|---|---|---|
| | H (in.) | W (in.) | D (in.) | Wt. (lbs.) |
| 112.5 | 90 | 78 | 48 | 3258 |
| 150 | 90 | 78 | 48 | 3180 |
| 225 | 90 | 90 | 58 | 3843 |
| 300 | 90 | 90 | 58 | 4158 |
| 500 | 90 | 90 | 58 | 5363 |
| 750 | 90 | 102 | 58 | 8669 |
| 1000 | 90 | 102 | 58 | 8785 |
| 1500 | 102 | 102 | 58 | 11544 |
| 2000 | 102 | 112 | 58 | 14085 |
| 2500 | 110 | 120 | 58 | 16902 |

### 115° C Rise (Indoor Only)

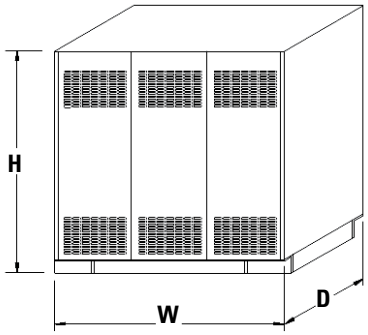
| KVA | 5kV - 30kV BIL | | | |
|---|---|---|---|---|
| | H (in.) | W (in.) | D (in.) | Wt. (lbs.) |
| 112.5 | 90 | 64 | 48 | 1643 |
| 150 | 90 | 64 | 48 | 1786 |
| 225 | 90 | 72 | 48 | 2312 |
| 300 | 90 | 72 | 48 | 2601 |
| 500 | 90 | 78 | 48 | 3764 |
| 750 | 90 | 90 | 48 | 5299 |
| 1000 | 90 | 90 | 48 | 6130 |
| 1500 | 90 | 90 | 48 | 8078 |
| 2000 | 102 | 102 | 48 | 12724 |
| 2500 | 102 | 112 | 58 | 15285 |

| KVA | 15kV- 60kV BIL | | | |
|---|---|---|---|---|
| | H (in.) | W (in.) | D (in.) | Wt. (lbs.) |
| 112.5 | 90 | 78 | 48 | 3258 |
| 150 | 90 | 78 | 48 | 3180 |
| 225 | 90 | 90 | 58 | 3843 |
| 300 | 90 | 90 | 58 | 4158 |
| 500 | 102 | 90 | 58 | 5363 |
| 750 | 102 | 102 | 58 | 8669 |
| 1000 | 102 | 102 | 58 | 8785 |
| 1500 | 102 | 102 | 58 | 11544 |
| 2000 | 102 | 112 | 58 | 14085 |
| 2500 | 110 | 120 | 58 | 16802 |

### 80° C Rise (Indoor Only)

| KVA | 5kV - 30kV BIL | | | |
|---|---|---|---|---|
| | H (in.) | W (in.) | D (in.) | Wt. (lbs.) |
| 112.5 | 90 | 64 | 48 | 1694 |
| 150 | 90 | 64 | 48 | 1775 |
| 225 | 90 | 72 | 48 | 2498 |
| 300 | 90 | 72 | 48 | 2764 |
| 500 | 90 | 78 | 48 | 3924 |
| 750 | 90 | 90 | 48 | 5727 |
| 1000 | 90 | 90 | 48 | 6116 |
| 1500 | 90 | 102 | 48 | 8608 |
| 2000 | 102 | 112 | 58 | 12725 |
| 2500 | 102 | 112 | 58 | 15351 |

| KVA | 15kV- 60kV BIL | | | |
|---|---|---|---|---|
| | H (in.) | W (in.) | D (in.) | Wt. (lbs.) |
| 112.5 | 90 | 78 | 48 | 3258 |
| 150 | 90 | 78 | 48 | 3180 |
| 225 | 90 | 90 | 58 | 3843 |
| 300 | 90 | 90 | 58 | 4193 |
| 500 | 90 | 90 | 58 | 5603 |
| 750 | 90 | 102 | 58 | 8669 |
| 1000 | 102 | 102 | 58 | 9250 |
| 1500 | 102 | 102 | 58 | 10849 |
| 2000 | 102 | 112 | 58 | 14515 |
| 2500 | 110 | 120 | 58 | 17977 |




## 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 |

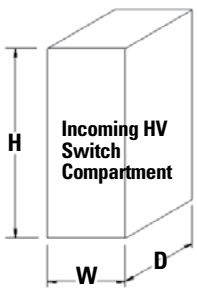
## III. Non-Segerated Cable Termination Area (Indoor - Cable Entrance: Top or Bottom, Outdoor - Cable Entrance: Bottom only)

- Non-Segregated Cable Termination Area is an alternate to Air Terminal Chamber.
- For the width dimension of a transformer with a Non-Segerated 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.*



# Pad-Mounted Transformers

## Description

Federal Pacific provides pad-mounted transformers serving commercial and industrial loads such as retail buildings, schools and hospitals from underground networks. Their tamper-resistant design allows installation in areas accessible to the public without the need for costly fences or barriers.

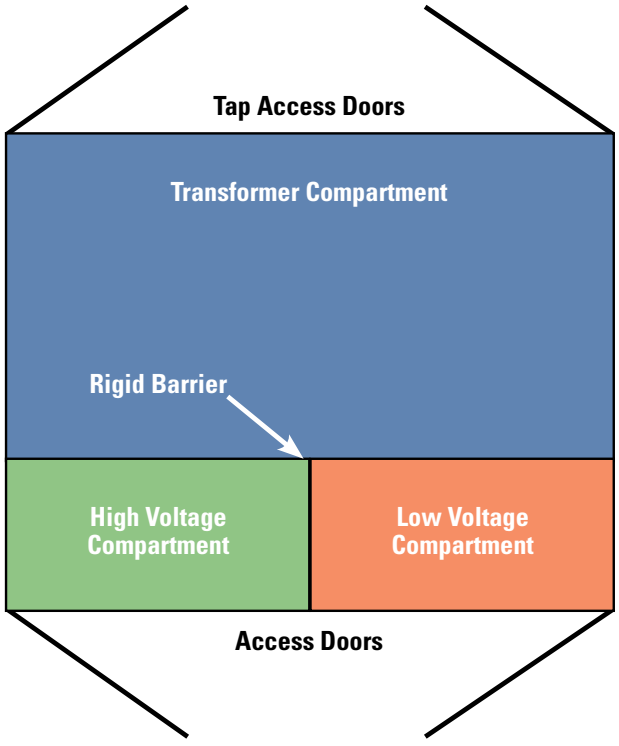
## Standard Features

- Separate high voltage and low voltage compartments with access doors.
- Pentahead screws must be removed to open low voltage doors, which are also mechanically interlocked so that low-voltage compartment must open first.
- Tamper resistant construction
- Bushing wells with parking stands or integral terminal spades as specified
- Cable accessory parking stands provided
- Low-voltage compartment door with three-point latching and handle for a locking device.
- Stainless steel hinges and handles
- Stainless steel channel grills provide superior protection from windblown rain or snow while permitting efficient air flow for cooling.
- May be lifted or skidded in any direction
- Jacking Facilities
- Lifting provisions for balanced vertical lift
- Sloped roof to direct water off sides away from access doors

## Benefits

- Configurable with custom components for various switching and protection options. Current limiting arcstrangler loadbreak type fuses are commonly specified.
- Deadfront construction available
- Safely installed in public areas / tamper-resistant
- Safe design for maintenance and operation
- May be coordinated with pad-mounted switchgear
- Dry-type construction when liquid-filled transformers are not a viable option.
- Radial or loop-feed
- Most accessories for Unit Substation also available

*Federal Pacific Pad-Mounted Transformer.*




*Overhead view of Federal Pacific's Pad-mounted Transformer.*

# High-Rise Building Transformers

Federal Pacific's high-rise transformer was developed as a response to demand for more efficient and lower overall costs in high-rise installations.

Many utilities presently offer vertical distribution circuits (typically 15 kV or 25 kV) to high-rise condominium developers that include single-phase, medium voltage, ventilated dry-type transformers manufactured by Federal Pacific.

Medium voltage vertical distribution circuits used in 20+ story buildings allow the local utility to offer more economical electrical service than a conventional 480 volt network. Medium voltage vertical distribution offers much better voltage regulation because of the voltage drops associated with long conventional low voltage circuit cable runs. Many of the same operating approaches used for residential underground power distribution in suburban locations can be used in vertical distribution circuits.

The electrical system for a high-rise building typically has a three-phase feeder entering the building in a main equipment vault containing over-current devices, vacuum interrupters, and over-voltage devices. Federal Pacific manufactures Wall-Mount Fuse Cabinets for these applications. As the medium voltage cables rise from floor-to-floor, they are split into single-phase circuits. A medium voltage open dry-type single-phase transformer rated from 100 kVA to 833 kVA with a 240/120 secondary is located as required to feed the customer's incoming panel. The reliability of this vertical distribution system is superb from an operational standpoint as any individual transformer replacement will affect only a small number of residents and any circuit outage will likely be only single-phase rather than three-phase.

High-rise Transformers are designed for extremely quiet operation with sound levels from 5 to 15 dB below standard levels in IEEE C57.12.01. Low sounds level are achieved through low magnetic induction levels and efficient step-lap mitered core construction.

The most significant deviation from a standard single-phase pad-mounted transformer is the application of a spring loaded flipper device to blow fuses, thus isolating the transformer from the circuit. The flipper, sometimes called a "mousetrap", is activated by a thermal fusible link triggered by the very unlikely event of dangerous heat levels inside the case of the transformer.

The high-rise transformer is a low loss, 80°C temperature rise, DOE 2016 energy efficient design using a 220°C insulation system capable of delivering a continuous load of 30% above its nameplate rating.

Having medium voltage distribution systems in high-rise buildings allows developers to promote a building having high power quality from the electric utility and a lower initial investment expense to the building owner because the high costs of providing extensive runs of low voltage cables, bus work, and junction boxes are avoided. The developer can also promote a "green power" distribution system having lower circuit losses because the amperes in a medium voltage system are roughly 5% of those in an equivalent low voltage circuit.

There are incentives for the utility to offer high power quality with minimal maintenance. The utility can include in its rate base structure the investment for the vertical distribution system. Most importantly, the utility will be utilizing dry type transformer technology containing no liquid that can leak or cause tank rupture while incorporating a premium 220°C insulation system that can support continuous overloading when required.

# Motor Drive Isolation Transformers

## General Information

Motor drive isolation transformers (DIT) are becoming increasingly common as more motor drives are installed in industrial applications. All motor drives powered from standard AC supplies perform AC to DC conversion (rectification). An unfortunate byproduct of the rectification process is the creation of harmonic currents and voltages, commonly referred to as harmonics, in the power system.

Federal Pacific drive-isolation transformers (DITs) serve to protect the power system from the harmful effects of harmonics produced in these drive systems by isolating the motor drive from the AC source. The isolation two-winding construction also aids in reducing some types of line transients that can cause misfiring of the silicon-controlled rectifiers (SCRs) commonly used in motor drives. DITs are specially designed to withstand the mechanical forces, harmonics and duty cycles associated with motor drives.

## Drive Isolation Transformer Types

**6 Pulse** - Traditional three-phase motor drives use a 6-pulse rectification system, meaning each rectified phase produces two pulses. These pulses are electronically added together by the rectifier and filtered to produce DC power.

**Multi-Pulse Drive Isolation** - Rectification systems using more than six pulses produce higher quality DC power with lower harmonics. Multi-pulse drive isolation transformers are designed with multiple secondaries having special phase-shifting characteristics to provide the necessary power for multi-pulse drives. Power becomes cleaner as the number of pulses generated in a system is increased. Multi-Pulse transformers are common in 12, 18, 24 and 36 pulse configurations. The number of secondary windings can be determined by dividing the pulse rating by 6. An 18 pulse Multi-Pulse Drive Isolation transformer is designed with 3 secondary windings to power the drive/rectifier. They may be used as drive isolation transformers or in DC rectifier applications like traction power.

Federal Pacific can design and manufacture specialty engineered 6 pulse, and Multi-Pulse Drive Isolation transformers to meet any customer need. Additionally we offer a full line of standard, build-to-order, aluminum wound 6 pulse Drive Isolation transformers in industry standard voltage configurations shown below.

# ABS Type Approved or Unit

## *Proudly Manufactured in the United States for Shipboard and Mobile Drilling Unit Applications*

To meet the harsh marine environments found onboard ships and offshore drilling platforms, Federal Pacific dry-type transformers comply with the American Bureau of Shipping ("ABS") standards for non-combatant installations. ABS has been a global leader in marine safety since 1862 and continually strives to improve the safety of marine equipment. Compliance with ABS standards means Federal Pacific can provide "ABS Type Approved" low and medium voltage transformers. Conforming to the ABS rules requires Federal Pacific's manufacturing processes be annually audited by ABS surveyors for ISO-9001 compliance.

ABS classifies low voltage to be below 1000 volts and high voltage from 1,000 up to 15,000 volts.

The link below can be used to search the ABS database for Federal Pacific's ABS credentials.

**http://ww2.eagle.org/en/rules-and-resources/type-approval-database.html**

### *Low Voltage Type FH Product – Up to 600 Volts*

(Design Certificate # 15-HS1404521-PDA)

- ABS low voltage products are "Type Approved" for marine applications.
- Marine and offshore applications
- Power Distribution and Motor Drive Isolation
- Ventilated dry-type transformers rated for 600 volts and below
- 1-Phase, 7.5 to 333 kVA, UL listed
- 3-Phase, 7.5 kVA to 3,000 kVA, UL Listed up to 1,500 kVA
- Non-Ventilated dry-type transformers up to 225 kVA
- Rectifier Transformer including 12 and 24 pulse applications.

### *High Voltage Type MV Product – 1,000 V to 15,000 V*

(Design Certificate # 15-HS1404522-PDA)

- ABS high voltage products are "Unit Certified" for marine applications.
- Power Distribution, Unit Substation and Rectifier Applications
- Ventilated dry-type transformers rated 1.2 kV to 15 kV
- UL Listed 1-Phase and 3-Phase 112.5 to 3,750 kVA
- 5 kV ratings up to 45 kV BIL
- 15 kV ratings up to 95 kV BIL
- General Purpose and Unit Substation designs

# Upgrade, Refurbish / KVA Upgrade, Voltage Upgrade

Federal Pacific can refurbish and/or repair and upgrade medium-voltage ventilated dry transformers from 15 kVA through 3750 kVA with HV ratings @ 5 kV, 15 kV, 25 kV having BIL ratings of 30 kV - 110 kV. A refurbished or upgraded transformer is not subject to the DOE transformer efficiency guidelines that went into effect on January 1, 2016.

Large kVA 600V transformers in the range of 300-1500kVA are also economical to refurbish/repair.

**When the transformer inside your facility:**

- Has failed
- Requires higher efficiency
- Requires an increased kVA output
- Requires new high voltage from 4160 to 13800 or similar
- Needs a back-up core and coil

**Federal Pacific has your answer.**

### *Transformer Refurbishment*

Transformers fail, in most instances due to inclement weather and/or voltage transients in one form or another. However, transformer failure does not necessarily mean a complete loss. Federal Pacific in many instances can repair a failed transformer at a fraction of the cost of a new unit and in less than typical lead times.

### *Upgrading a Transformer*

**Upgrade - Efficiency**
It may be possible to design replacement parts to refurbish a transformer to have lower core losses than the original transformer while keeping the original core, thereby reducing future operating costs.

**Upgrade - kVA**
Historically, one of the strong incentives for refurbishing a transformer is to increase the kVA power output of the unit. With today's high temperature, 220°C insulation materials, and better knowledge of duct spacing and coil construction, Federal Pacific can provide an increased kVA rating or a rewound transformer with a longer life expectancy than the original design. Sometimes this increased kVA output is achieved by increasing the average winding temperature rise or by substituting copper conductor for aluminum.

**Upgrade - Voltage (4160 - 13,800)**
In many cases, Federal Pacific can alter an existing transformer to increase voltage ratings and BIL without having to reduce the kVA output.

Examples of this need could include:

A utility plans to increase the service voltage to a facility, typically from 4160 volts to 13800 volts. In this situation the 4160 volt transformer has to be replaced or converted to the higher voltage; or perhaps the closing of a plant in another location has left the customer with an unusable transformer that has the wrong voltage.

Wherever possible and as needed, Federal Pacific will work toward providing increased kVA, increased efficiency, and upgraded voltage rating while refurbishing any transformer.

### *Levels of Refurbishment*

1. **Basic Repair.** Reburbish only the affected coil(s).
2. **Complete Coil Replacement.** Replacing all coils and new bus, if required, and repainting the enclosure. This level of refurbishing will restore the transformer back to "as new" condition with a standard repair warranty.
3. **Upgrading the Efficiency Voltages, and/or the Power kVA.** A standard repair warranty will be included with this level of refurbishing.

### *When a Transformer Needs Refurbished or Upgraded*

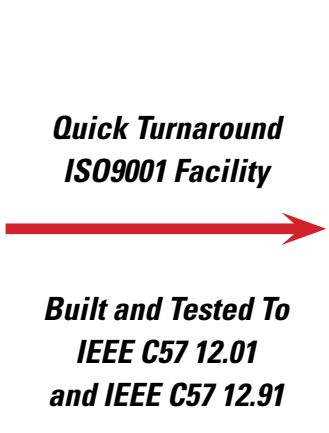
To repair, rebuild or upgrade your existing dry-type transformer, Federal Pacific will need the basic rating information contained on the transformer's nameplate. This information can be provided by going to http://www.federalpacific.com/rfq and following the "Refurbish" link.

Contact Federal Pacific to obtain an RMA, and provide the required characteristics for sending the transformer to the Bristol factory for refurbishing.

Federal Pacific will offer recommendations with estimated repair costs and turnaround times, usually within 24 hours from receiving your information.

*FROM THIS*

***Quick Turnaround***
***ISO9001 Facility***



***Built and Tested To***
***IEEE C57 12.01***
***and IEEE C57 12.91***

*TO THIS*

A transformer is a static, passive electrical device that converts alternating electrical voltage from one value to another without modifying the frequency or amount of electrical power. A transformer links together two or more electrical circuits through the process of electromagnetic induction. A simple transformer consists of two coils of electrical wire wrapped around a common closed magnetic iron circuit (or "core"). The coils are electrically isolated from one another but magnetically linked through the core, allowing electrical power to be transferred from one coil to the other.

Transformers are primarily used to increase ("step-up") or decrease ("step-down") voltage from their input ("primary") to their output ("secondary"). The amount of voltage change is determined by the construction of the transformer, effectively the ratio of the number of turns in the primary coil to the number of turns in the secondary coil. A secondary use of transformers is to electrically isolate the input from the output circuit while maintaining the same input and output voltage.

Electric power is always distributed over a wide area by means of alternating current. Direct current is not used for several reasons, the most important being that it cannot be changed from one voltage level to another without expensive conversion equipment. Alternating current however can be simply changed to any convenient voltage by the use of transformers

## Electrostatically Shielded Transformers

Electrostatically shielded transformers are designed to protect primary systems from unwanted high-frequency signals generated by loads connected to a transformer's secondary. While all transformers with separate primary and secondary windings provide some isolation from load circuits, transients and electrical noise can be transmitted through the internal capacitance of the transformer windings. These disturbances may have a detrimental effect on sensitive electronic equipment and can cause improper operation. Electrostatic shielding diverts these unwanted signals to ground and help prevent electrical disturbances from being transmitted to the load circuits.

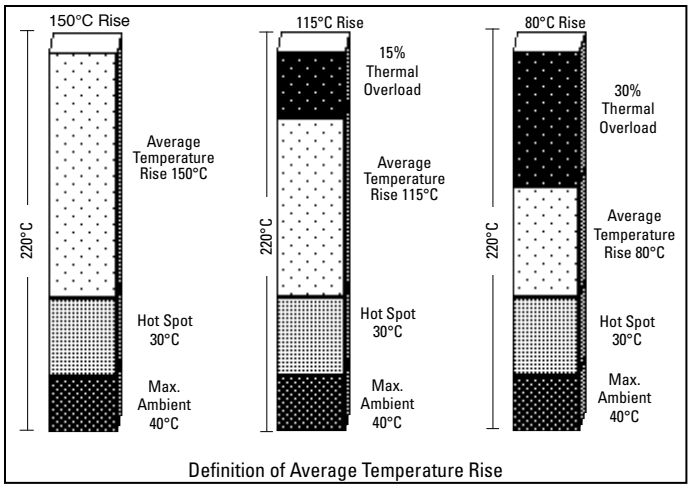
UL Listed electrostatically shielded transformers provide all the quality features of the transformer plus an electrostatic shield consisting of a single turn, full height, copper or aluminum strip placed between the primary and secondary windings with a lead connected to the transformer ground.

Typical applications for Electrostatically Shielded Transformers include:

- Hospital Operating Rooms
- X-Ray Equipment
- Computer Installations

## Optional Temperature Rise Transformers

Transformers are specifically designed for optimum performance on systems with a continuous high loading factor. Optional temperature rise transformers feature either 80°C or 115°C temperature rise (vs. 150°C typical) utilizing a 220°C insulation system which provides extended life and inherent overload capability (15% for 115°C and 30% for 80°C). (See chart below.) These transformers provide lower losses and can minimize operating costs, depending on loading factors and local energy costs.



Definition of Average Temperature Rise

## K-Factor Transformers

A K-Factor Transformer is designed to handle harmonic content in its load current created by modern electronic switching elements without exceeding its operating temperature limits.

## Harmonic Distortion, the need for K-Factor

**Harmonic**-As defined by ANSI/IEEE Std. 519 latest edition.

Harmonic components are represented by a periodic wave having a frequency that is an integral multiple of the fundamental frequency.

In other words, harmonics are voltages or currents at frequencies that are integer multiples of the fundamental (60 Hz) frequency, e.g.120 Hz, 180 Hz, 240 Hz, 300 Hz, etc.

Harmonics superimpose themselves on the fundamental waveform, distorting it and changing its magnitude. For instance, when a sine wave voltage source is applied to a non-linear load connected from phase-to-neutral on a 3-phase, 4-wire wye circuit, the load itself will draw a current wave made up of the 60 Hz fundamental frequency of the voltage source plus 3rd and higher order odd harmonic (multiples of the 60 Hz fundamental frequency), which are all generated by the non-linear load.

# Transformer Selection Considerations

## Selection Steps

- Determine the system supply voltage available (Primary voltage).
- Determine the required load voltage rating (Secondary voltage).
- Determine the KVA rating of the load. (If the load rating is given only in amperes, the proper KVA size of the transformer can be selected from the Full Load Current Rating Tables below. The KVA capacity of the transformer must equal or be greater than the load rating.

## Full Load Current Ratings Quick Reference (Low-Voltage)

| Single Phase Transformers | | | | |
|---|---|---|---|---|
| KVA Rating | Full Load Current (Amperes) | | | |
| | 120 V | 240 V | 480 V | 600 V |
| .050 | 0.42 | 0.21 | 0.1 | 0.08 |
| .075 | 0.63 | 0.31 | 0.16 | 0.13 |
| .100 | 0.83 | 0.42 | 0.21 | 0.17 |
| .150 | 1.25 | 0.63 | 0.31 | 0.25 |
| .250 | 2.08 | 1.04 | 0.52 | 0.42 |
| .500 | 4.17 | 2.08 | 1.04 | 0.83 |
| .750 | 6.25 | 3.13 | 1.56 | 1.25 |
| 1 | 8.33 | 4.17 | 2.08 | 1.67 |
| 1.5 | 12.5 | 6.25 | 3.13 | 2.5 |
| 2 | 16.7 | 8.33 | 4.17 | 3.33 |
| 3 | 25 | 12.5 | 6.25 | 5 |
| 5 | 41.7 | 20.8 | 10.4 | 8.33 |
| 7.5 | 62.5 | 31.3 | 15.6 | 12.5 |
| 10 | 83.3 | 41.7 | 20.8 | 16.7 |
| 15 | 125 | 62.5 | 31.2 | 25 |
| 25 | 208 | 104 | 52 | 41.7 |
| 37.5 | 312 | 156 | 78.1 | 62.5 |
| 50 | 417 | 208 | 104 | 83.3 |
| 75 | 625 | 312 | 156 | 125 |
| 100 | 833 | 417 | 208 | 167 |
| 167 | 1392 | 696 | 348 | 278 |
| 333 | 2775 | 1387 | 694 | 555 |

| Three Phase Transformers | | | | |
|---|---|---|---|---|
| KVA Rating | Full Load Current (Amperes) | | | |
| | 208 V | 240 V | 480 V | 600 V |
| 3 | 8.33 | 7.22 | 3.61 | 2.89 |
| 6 | 16.6 | 14.4 | 7.22 | 5.77 |
| 9 | 25 | 21.6 | 10.8 | 8.66 |
| 15 | 41.6 | 36.1 | 18 | 14.4 |
| 25 | 69.4 | 60.1 | 30.1 | 24.1 |
| 30 | 83.3 | 72.2 | 36.1 | 28.9 |
| 37.5 | 104 | 90.2 | 45.1 | 36.1 |
| 45 | 125 | 108 | 54.1 | 43.3 |
| 50 | 139 | 120 | 60.1 | 48.1 |
| 60 | 166 | 144 | 72.2 | 57.7 |
| 75 | 208 | 180 | 90.2 | 72.2 |
| 100 | 278 | 241 | 120 | 96.2 |
| 112.5 | 312 | 271 | 135 | 108 |
| 150 | 416 | 361 | 180 | 144 |
| 225 | 625 | 541 | 271 | 217 |
| 300 | 833 | 722 | 361 | 289 |
| 400 | 1110 | 962 | 481 | 385 |
| 500 | 1388 | 1203 | 601 | 481 |
| 750 | 2082 | 1804 | 902 | 722 |
| 1000 | 2776 | 2406 | 1203 | 962 |

## Full Load Current Formulas for Calculation

$I_{Line}$ *Line Current (Amps)*

$V_{Line}$ *Line-to-Line Voltage (Volts)*

*KVA Power in kilovoltamperes*

### Three Phase

$$I_{Line} = \frac{KVA \bullet 1000}{\sqrt{3} \bullet V_{Line}}$$

$$KVA = \frac{\sqrt{3} \bullet V_{Line} \bullet I_{Line}}{1000}$$

### Single Phase

$$I_{Line} = \frac{KVA \bullet 1000}{V_{Line}}$$

$$KVA = \frac{V_{Line} \bullet I_{Line}}{1000}$$

## Three-Phase Full Load Current Ratings Quick Reference (Medium-Voltage)

| 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 | 18.0 | 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 |

## Connections

Many single-phase transformers are manufactured with series multiple winding construction and a dual voltage primary or secondary designation (e.g. 240x480V to 120/240V). These transformers will have two windings on the primary or secondary that can be connected either in series for the higher voltage or in parallel for the lower voltage. Transformers with primary voltage ratings containing an "x" can only be connected for one or the other of the two voltages. Transformers with secondary voltage ratings separated by a forward slash "/", can be connected to provide either or both voltages (three wire operation). Three-phase transformers are provided with a Delta primary for three wire input and either a Wye secondary for four wire output or a Delta secondary for three wire output.

## Delta Secondary with 120v LT

Transformers with a 240 volt Delta secondary may have a 120 volt single-phase lighting tap as a standard feature. Maximum single-phase 120 V load should not exceed 10% of the 3-phase KVA rating. The load should also be balanced at 5% maximum between terminals X1 to X4 and 5% between terminals X2 to X4. The 3-phase KVA must also be reduced by 30% of the nameplate rating.

For example, a 45 KVA transformer can have a 4.5 KVA maximum 1-phase 120V load. Of that 4.5 KVA, 2.25 KVA must be loaded between X1-X4 and 2.25 KVA must be loaded between X2-X4. The 3-phase KVA rating must be reduced to 31.5 KVA.

## Altitude

Standard self-cooled dry-type transformers are designed for operation with normal temperature rise at altitudes up to 3300 feet above sea level (ASL). The transformer rated KVA should be reduced by 0.3% for each 330 feet the transformer is installed above 3300 feet when the average ambient temperature is no greater than 30°C. Medium voltage transformers must be designed with increased air clearance requirements for high altitude applications over 3,300 feet ASL.

## Angular Displacement

The angular displacement of a three-phase transformer is the time angle expressed in degrees between the line-to-neutral voltage of a specified high voltage terminal and the line-to-neutral voltage of a specified low voltage terminal.

The angular displacement for three-phase transformers with Delta-Wye connections is 30 degrees with the low voltage lagging the high voltage.

## Balanced Loading

Single-phase loads connected to the secondary of a transformer must be distributed so as not to overload any one winding of the transformer.

Single-phase transformers generally have two secondary windings that can be connected for 120/240 volt three wire operation. When so arranged, care must be taken when connecting 120 volt loads to assure that the total connected load on each secondary winding does not exceed one-half the nameplate KVA rating.

When connecting single-phase loads on a three-phase transformer, each phase must be considered as a single-phase transformer. The single-phase loading on each phase of a three-phase transformer must not exceed one-third of the nameplate KVA rating. For example, a 45 KVA three-phase transformer with a 208Y/120 Volt secondary should not have any 120 volt single-phase loads distributed such that more than 15 KVA of single-phase load is applied to any one phase.

## Banking

Three single-phase transformers can be properly connected to supply a three-phase load. The single-phase units can be used in a three-phase bank with Delta connected primary and Wye or Delta connected secondary. The equivalent three-phase capacity would be three times the nameplate rating of each single-phase transformer. For example, three 15 KVA single-phase transformers will yield 45 KVA three-phase load when properly banked.

## Basic Impulse Level (BIL)

Basic impulse level is a specific insulation level expressed in kilovolts of the crest value of a standard lightning impulse. 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 | Optional Levels |
|---|---|---|
| <2.5 KV | 10 KV | |
| 2.5 KV | 20 KV | 30 KV |
| 5 KV | 30 KV | 45 KV |
| 7.2 KV | 45 KV | 95 KV |
| 15 KV | 60 KV | 95 KV |
| 25 KV | 110 KV | 125 KV |

## Enclosure Types

The type of enclosure specified for a transformer will depend on several different factors.

- Is the installation indoors or outdoors?
- Are corrosive agents or excessive dirt and dust present?
- Are there seismic/earthquake requirements?
- Will there be public access to the transformer?

Federal Pacific standard indoor and outdoor enclosures are suitable for most installations.

**Enclosure Designations**

| Location | Low Voltage | Medium Voltage |
|---|---|---|
| Indoor | NEMA 1<br>NEMA 2 (Drip-proof) | Indoor Category C |
| Outdoor | NEMA 3R | Outdoor Category C |
| Special Outdoor | NEMA 12 (non-ventilated)<br>NEMA 4 (dust-tight)<br>NEMA 4X<br>(dust-tight, corrosion resistant) | Pad-mount Category A (for use in areas accessible to the public) May also be installed indoors. |

## Overcurrent Protection

*(Reference N.E.C. Article 450)*

## Primary & Secondary Protection

If the transformer secondary is protected by an overcurrent protective device rated no more than 125% of the transformer rated secondary current (or the next higher standard rating device), an individual primary protective device is not required provided the primary feeder circuit overcurrent device is rated no more than 250% of the transformer rated primary current.

## Primary Protection Only

If secondary protection is not provided, a transformer must be protected by an individual overcurrent device on the primary side. The primary overcurrent device must be rated: No more than 125% of the rated primary current or the next higher standard device rating (for primary currents of 9 amperes or more); no more than 167% of the rated primary current (for 2 amperes to 9 amperes); and no more than 300 % of the rated primary current (for ratings less than 2 amperes). An individual transformer primary protective device is not necessary where the primary circuit overcurrent protective device provides the required protection.

## Parallel Operation

Transformers with the same KVA ratings can be connected in parallel if required conditions are met. Single-phase transformers must have the same voltage rating, tap settings and frequency rating. Plus, the impedance values of the transformers must be within 7.5% of each other. When paralleling three-phase transformers, the same conditions would apply and, in addition, the angular displacement of the transformers must be the same.

## Polarity

Transformer polarity is an indication of the direction of current flow through the high voltage terminals with respect to the direction of current flow through the low voltage terminals at any given instant in the alternating cycle. Primary and secondary terminals are said to have the same (or additive) polarity when, at a given instant, the current enters the primary terminal in question and leaves the secondary terminal in question in the same direction as though the two terminals formed a continuous circuit.

Single-phase transformers rated 600 volts and below normally have additive polarity.

The polarity of a three-phase transformer is fixed by the internal connections between phases. It is usually designated by means of a vector diagram showing the angular displacement of the windings and a sketch showing the markings of the terminals.

## Sound Levels

A humming sound is an inherent characteristic of transformers due to the vibration caused by alternating flux in the magnetic core. Sound levels will vary according to transformer size. Attention to installation methods can help reduce any objectionable noise. When possible, locate the transformer in an area where the ambient sound will be equal to or greater than the transformer sound level. Avoid locating units in corners. Make connections with flexible conduits and couplings to prevent transmitting vibration to other equipment. Larger units should be installed on flexible mountings to isolate the transformer from the building structure. For more detail on transformer sound refer to Federal Pacific's Understanding Transformer Noise white paper.

## Primary Taps

Taps where provided are generally in the primary windings and are used to compensate for input voltage variations so that output voltage is maintained. The taps will provide a range of voltage adjustment above and/or below the nominal voltage rating of the transformer. Tap connections are shown on the nameplate. Refer to the instruction manual for proper methods of adjusting taps.

# Advantages of Ventilated Dry-Type Over Liquid-Filled Transformers

Federal Pacific medium voltage ventilated dry-type transformers include the voltage class range of 2.4 kV through 25 kV, BIL ratings of 20 kV through 125 kV, self-cooled, with power ratings below 5000 kVA. They can be installed outdoors or indoors in any suitable room that complies with the National Electrical Code spacing and ventilation.

Transformers having higher voltage classes and BIL ratings than mentioned are typically core and coils immersed in a suitable non-PCB mineral oil or other well-known high temperature "less flammable" fluids.

As the EPA imposed its authority over industrial chemicals several regulations came into existence. Foremost is the CFR 40-112 regulation that covers the handling of all oil substances, which include not only mineral oil in transformers but also chemicals like FR3™.

## Insulation Advantages

Dry-type transformers use a 220° C insulation system compared to a 135° C system used in liquid-filled. Regardless of the loading on the transformer, a higher temperature rated system is better. Liquid-filled systems use a lot of cellulosic paper material that will deteriorate at higher temperatures and that will absorb moisture contained in the liquid surrounding the coils. For this reason insulation power factor tests (like Doble Tests) are needed periodically to verify the integrity of the insulation system in liquid-filled transformers. Also combustible gas analyses are needed periodically on liquid-filled transformers to assure that identifiable insulation components are performing properly. Neither the insulation power factor nor the combustible gas analyses tests are needed on dry-types.

## Coil Advantages

Federal Pacific transformers have coils built in a circular shape for maximum short circuit strength. Liquid filled transformers in the small power range at distribution voltages have windings in a rectangular form to save core steel.

## Summary

- The first cost (price) of medium voltage ventilated dry-type transformers is comparable to transformers using bio-based fluids like FR3™.
- Nomex® is better than cellulosic material and film wire insulation.
- Dry-type transformers do not leak.
- Dry-type transformers do not require pressure relief devices and are not subject to tank rupture that can injure personnel.
- Dry-type transformers do not require periodic testing of dielectric, combustible gas, and liquid samples.
- Dry-type transformers can be moved without draining liquid or worrying about punctures in protruding radiators.
- Repairs, especially coil replacement, for a dry-type transformer are much faster and easier than repairs for liquid-filled transformers.
- The manufacture of dry-type transformers is much faster than for liquid-filled.
- Federal Pacific dry-type transformers do not require a Spill Prevention, Control, Countermeasure (SPCC).

| Installation and Maintenance Requirements | Dry-Type Outdoor | Dry-Type Indoor | Liquid-Filled Outdoor | Liquid-Filled Indoor |
|---|---|---|---|---|
| Is a bund or curbing required for the mineral oil? | N/A | N/A | No | N/A |
| Is a bund or retainer required for FR3? | N/A | N/A | No | Yes |
| Is a vault required for mineral filled transformers? | N/A | N/A | No | Yes |
| Is a SPCC required for transformers? | No | No | Yes | Yes |
| Requires a licensed professional engineer to certity the SPCC. | No | No | Yes | Yes |
| Does EPA 40 CFR 112 apply? | No | No | Yes | Yes |
| Requires periodioc testing of liquid samples. | No | No | Yes | Yes |
| Periodic testing of gas samples is required. | No | No | Yes | Yes |
| Lifting equipment is required to inspect the core and coil of the transformer. | No | No | Yes | Yes |
| Requires pressure relief devices or sudden pressure relays. | No | No | Yes | Yes |

# *Advantages of VPI With Epoxy Shield Compared to Cast Coil*

Federal Pacific Transformer offers a Vacuum Pressure Impregnation (VPI) process on ventilated dry-type transformers to provide very reliable performance when installed in harsh outdoor and indoor environments. The impregnation of the transformer coils is a three stage activity as described on page 17 of this catalog.

The vacuum impregnation of the varnish eliminates winding voids to reduce essentially to zero any corona generation, due to insulation voids. Corona, particularly in conjunction with corrosive environments, accelerates the degradation of the insulation materials and can cause the transformer to fail prematurely.

When there is a requirement to provide a barrier against corrosive chemicals, the coils are dipped in an epoxy resin which protects the structure from corrosive compounds like "black and white liquor" compounds present in pulp processing, for instance.

The materials used by Federal Pacific were developed for transformers which are subjected to severe thermal cycling due to changing electrical loads. Thermal activity causes uneven movement within the transformer, because of the difference in the thermal expansion coefficients of the several winding and insulation materials. When these thermally induced mechanical movements occur, the VPI varnishes will expand and contract reliably in such a manner that they will not crack or otherwise become dislodged.

As a transformer ages under load, a rigid insulation subject to movement eventually becomes fatigued. Historically, one of the hardest problems to solve with rigid or cast coil construction is the elimination of the cracking of the epoxy mass from thermally induced stresses, particularly as the transformer undergoes a lifetime of loading cycles.

Ventilated dry-type transformers offer the same performance relative to the cast coil technology in the areas of power ratings, continuous voltage ratings and resistance to chemicals. The basic advantages of ventilated, dry-type transformer are:

- Lower initial cost
- Flexibility of design
- Elimination of cracking epoxy
- Higher thermal overload: VPI = 30% @ 80/150°C rise
- Less weight for easier handling and installation
- Smaller dimensions to save valuable floor space
- Outstanding environmental protection

## Ventilated Dry-Type vs. Cast Coil

| Feature | VPI Polyester/Epoxy | VPI/Polyester | Cast Coil | Conventional Varnish Dip/Bake |
|---|---|---|---|---|
| Typical Maximum Power Rating (KVA) | 10,000 | 10,000 | 10,000 | 10,000 |
| Maximum Operating Voltage | 36KV | 36KV | 72KV | 36KV |
| Maximum Temperature Rise | 150° C | 150° C | 115° C | 150° C |
| Insulation Temperature Rise Rating | 220° C | 220° C | 185° C | 220° C |
| Maximum Overload Capability Over 80° C Base w/o Fans | 30% | 30% | 15% | 30% |
| Resistance to Dust, Fumes and Moisture | Superior | Excellent | Superior | Good |
| Resistance to Severe Acid or Caustic Fumes | Excellent | Good | Excellent | Fair |
| Resistance to Cracking Due to Thermal Cycling | Superior | Superior | Good | Superior |
| Resistance to Shock and/or Vibration | Excellent | Excellent | Superior | Good |
| ANSI Short-Circuit Withstand | Excellent | Excellent | Superior | Good |
| Capability for Energization Without Pre-Drying | Excellent | Excellent | Superior | Fair |
| Design Flexibility for Low Losses and Special Dimensions | Superior | Superior | Limited | Superior |
| Relative First Cost | Medium 105% | Low 103% | High 150% | Lowest 100% |
| Average Shipment Cycle and Time | 4-6 Weeks | 4-6 Weeks | Longer | 4-6 Weeks |
| Coil Repairability | Good | Good | Poor | Good |

This guide can be used as a reference to develop USST transformer requirements during the project planning stages.

## 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 electrostatically applied powder coat 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 ISO 9001 registered.

## Basic Rating

This section should be filled with the general requirements and ratings of the transformer being specified.

Refer to the Medium Voltage Transformer Specification Checklist at *http://www.federalpacific.com/rfq/mvspeclist* 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 R).

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 cut step-lap mitered as needed for efficiency requirements. Core laminations shall be 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.

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.

Transformers used in harsh environments exposed to moisture, dust, dirt, chemicals and other contaminants shall be vacuum pressure impregnated (VPI) for protection. All outdoor applications shall have VPI. An additional Epoxy over-coat (Epoxy Shield) shall be used for maximum environmental protection.

## Encapsulating Technologies

## Vacuum Pressure Impregnation (VPI)

The coil assembly shall be encapsulated using a VPI process. This process shall utilize heat, vacuum and pressure to completely seal and bind the windings. The VPI encapsulating material shall be solventless polyester, equivalent to the PD George 70 VT varnish.

## VPI with Epoxy Shield

The coil assembly shall also be treated with an additional high viscosity insulating epoxy (Epoxy Shield) after the VPI process for protection against corrosive agents.

## Final Dip and Bake

After undergoing the VPI process the coils will be assembled on the core, the core top yokes shall be 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 shall be dipped into a 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 shall then be 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 IEEE standards. The cabinet metal must be at least 14 gauge thickness. Whenever the cabinet must be outdoors (103R) the ventilation openings must be constructed as "back-to-back" channels as shown in the 103R Unit Substation of the Federal Pacific Transformer Catalog. (Lip Slot ventilation is not acceptable for outdoor 103R).

Paint for the transformer enclosure shall be an ANSI-61 light grey color of a polyurethane powder coating that is electro-statically applied conforming to UL 1332 specifications. For installation areas within highly corrosive environments stainless steel enclosures may be furnished as an option.

When primary or secondary switchgear is to be close-coupled to the unit substation transformer, manufacturer shall be responsible for all the drawings and mechanical provisions for proper coordination.

*Special attention needs to be given to the "Transformer Construction" section of the "Basic Medium Voltage Open Dry Transformer Rating Information" specification sheet for primary and secondary connection details.*

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 four 2.5% taps: two above and two 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 or NEMA ST-20.

## Forced-Air Cooling

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% for temporary overload requirements. The system shall contain 120 VAC single-phase fans and a control panel with indicating lights, temperature indicator, and configurable fan exerciser.

## Efficiency

Transformers shall meet the efficiency levels as defined by the U.S. Department of Energy in 10 CFR 431 (DOE 2016) unless it qualifies for an exemption. Refer to 10 CFR 431.192 for transformers exempted from these regulations.

## Accessories as specified

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

Winding Temperature Monitor 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 shall be furnished for each unit upon request, documenting the successful passing of all required testing.

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

# Glossary

## A

**Air-Cooled -** A transformer cooled by the natural circulation of air over and/or through the core and coils or forced air by using fans.

**Ambient Noise Level -** The sound level of the surrounding area of a transformer as measured in decibels on the "A" weighted scale (dBA).

**Ambient Temperature -** Temperature of the surrounding air which comes in contact with the transformer.

**Ampere -** Unit of current flow.

**ANSI -** American National Standards Institute.

**ANSI-61 -** A light gray paint used on dry-type transformers.

**Applied Voltage (Hi-Pot)** - A standard test on dry-type transformers consisting of extra-high potentials (high voltage) impressed on the windings.

**ASTM** - American Society for Testing Materials.

**Autotransformer -** A transformer in which at least two windings have a common section.

## B

**Banked Transformers** - When two or more single-phase transformers are connected together to supply a three-phase load.

**BIL** -Acronym for basic impulse insulation levels, a specific insulation level expressed in kilovolts of the crest value of a standard lightning impulse.

**Buck-Boost Transformers** -An insulating transformer which has two primary windings and two secondary windings. These windings can be interconnected so that the transformer will be changed from an insulating transformer to a "bucking" or "boosting" autotransformer.

## C

**C°** - Temperature in degrees Centigrade (Celsius).

**Cast-coil Transformer** - A transformer with coils cast in an epoxy resin.

**Center Tap** - A reduced-capacity tap at the mid-point in a winding.

**Coil** - A number of turns of wire wound on a form.

**Conductor Losses** - Losses caused by the resistance of a transformer winding, measured at 25, 50, 75, and 100 per cent of load.

**Continuous Duty** - A requirement of service that demands operation at a constant load for an indefinite period.

**Continuous Rating** - The load that a transformer can handle indefinitely without exceeding the specified temperature rise.

**Control Transformer** - A transformer which is designed for good voltage regulation characteristics when low power factor, large inrush currents are drawn.

**Core** - The steel which carries the magnetic flow.

**Core Loss** - Losses caused by a magnetization of the core and its resistance to magnetic flux.

**Current Transformer -** A transformer designed to have its primary winding connected in series with the circuit and used for transforming current into a value suitable for measurement of control.

## D

**Decibel** - (dB) The standard unit for the measurement of sound intensity.

**Delta** - (Δ) A standard three-phase connection with the ends of each phase winding connected in series to form a closed loop, 120 degrees from the other.

**Delta-Wye** - (Δ-Y) A term used indicating the method of connection for both primary (Δ) and secondary (Y) windings of a three-phase transformer bank.

**Dielectric Test** - A test conducted at higher than rated nameplate voltage to determine the effectiveness of insulating materials and electrical clearances.

**Distribution Transformer** - A transformer for transferring electrical energy from a primary distribution circuit to a consumer service circuit.

**Dry-Type Transformer** - A transformer that is cooled by air as opposed to a transformer that is immersed in oil.

**Dual Winding** - A winding that consists of two separate windings connected in series to handle a specific voltage and KVA, or in parallel to handle the same KVA at one half the series connected voltage.

## E

**Eddy-Current Loss** - losses in conductors or conductive materials resulting from eddy currents caused by voltages induced within the material through electromagnetic induction. Unit of measure is the watt.

**Electrostatic Shield** - A grounded conductor sheet placed between the primary and secondary winding to reduce or eliminate line-to-line or line-to-ground noise.

**Exciting Current** - (No-Load Current) Current which flows in any winding used to excite the transformer when all other windings are open-circuited, expressed in per cent of the rated current of a winding.

## F

**FCAN** - Full capacity above normal taps.

**FCBN** - Full capacity below normal taps.

**Fan Cooled** - A mechanical means of accelerating heat dissipation to lower the temperature rise of the transformer.

**Frequency** - The number of times an AC voltage will alternate from positive to negative and back again within a specified period of time, expressed in cycles per second and identified as Hz.

**Full Capacity Tap** - A tap designed to deliver the rated capacity of the transformer.

## G

**Ground** - Connected to earth or to some conducting body that serves in place of earth.

**Grounding Transformer** - A special three-phase autotransformer for establishing a neutral on a three-wire delta secondary. (Also referred to as a "zig-zag transformer").

## H

**Hertz** - A term meaning cycles per second, abbreviated Hz.

**High Voltage Windings** - A term applied to two winding transformers, designates the winding with greater voltage, identified by H1, H2, etc.

**Hi Pot** - Refer to "Applied Voltage" definition.

## I

**I2R Loss** - losses resulting from current flowing through the resistance of the transformer windings. The I2R Loss in a transformer winding is computed by multiplying its measured DC resistance (in ohms) by the square of the RMS value of the AC current flowing in the winding. These losses must be corrected to the proper reference temperature. I2R Losses are also referred to as DC watts, DC losses or copper losses.

**IEEE** - Institute of Electrical and Electronic Engineers.

**Impulse Tests** - Dielectric tests consisting of the application of a high-frequency steep-wave-front voltage between windings and between windings and ground. (Used to determine BIL.)

**Impedance** - The vector sum of resistance and reactance which limits the current flow in an AC circuit. Impedance is identified in percentage and is used to determine the interrupting capacity of circuit breakers which protect the primary circuit. (Symbol Z)

**Induced Potential Test** - A standard dielectric test which verifies the integrity of insulating materials and electrical clearances between turns and layers of a transformer winding.

**Insulating Materials** - Those materials used to electrically insulate the transformer windings from each other and ground. (Rated 80° C rise, 115° C rise and 150° C rise.)

**Insulating Transformer** - A transformer that insulates the primary from the secondary winding. (Also called an isolating transformer.)

## K

**kVA** - Kilovolt Ampere rating designates the output which a transformer can deliver at rated voltage and frequency without exceeding a specified temperature rise.

## L

**Line Conditioner** - Portable or hard wire devices that will stabilize voltage, suppress electrical noise and act as surge suppressors against lightning discharges.

**Liquid Transformer** - A transformer with core and coils immersed in liquid (as opposed to a dry-type transformer).

**Load** - The kVA or VA requirement which the transformer must supply.

**Load Loss** - losses resulting from current flowing to the load on the transformer output. These losses are independent of the core loss or no-load loss.

**Loss** - the real electrical power consumed within the transformer and dissipated as useless heat. The term "loss" is used because this power is lost due to the inefficiency of the transformer. The unit of measure is the watt (W).

## M

**Mid-tap** - A reduced-capacity tap midway in a winding, usually the secondary.

**Multiple Winding** - A winding which consists of two or more sections that can be paralleled for a specific mode of operation.

## N

**NEC**- National Electric Code.

**NEMA** - National Electrical Manufacturers Association.

**Noise Isolation Transformer** - A transformer that is designed to provide both common and transverse mode noise attenuation.

**Noise Level** - The relative intensity of sound, measured in dBA.

**No-Load Losses** - The losses incurred when a transformer is excited but without a load connected to the secondary. These include core loss, dielectric loss, and exciting current $I^2R$ loss.

## O

**OSHA** - Occupational Safety and Health Act. Federal regulation setting minimum safety standards for compliance in industrial and commercial installations.

## P

**Parallel Operation** - Transformers may be connected in parallel, provided that the electrical characteristics are suitable for such operation.

**Partial Discharge (PD)** - A localized electrical discharge or spark that bridges a small portion of the insulation between two electrodes. "PD" most often occurs in air voids within the winding insulation due to dielectric breakdown of the air. The unit of measure for "PD" is the picocoulomb (pC).

**Percent IR** - (%IR) Percent Resistance. The voltage drop due to conductor resistance at rated current expressed in percent of rated voltage.

**Percent IX** - (%IX) Percent Reactance. The voltage drop due to reactance at rated current expressed in percent of rated voltage.

**Percent IZ** - (%IZ) Percent Impedance. The voltage drop due to impedance at rated current expressed in percent of rated voltage.

**Phase** - Classification of an AC circuit. Usually, circuits are rated single-phase two wire or three wire or three-phase three wire or four wire. Single-phase transformers can be used on a three-phase source when two wires of the three-phase system are connected to the primary of the transformer. The secondary will be single-phase.

**Polarity Tests** - A standard test on transformers to determine instantaneous direction of the voltages in the primary compared to the secondary.

**Potential Transformer** - A transformer that is designed to have its primary winding connected parallel with a circuit and used for transforming voltage to a value suitable for measurement or control.

**Power Conditioning** - The means to correct voltage fluctuations and electrical noise problems common to incoming power sources.

**Power Factor** - The ratio of watts to volt amperes in a circuit. (% watts/VA)

**Primary Voltage** - The input circuit voltage for which the primary winding is designed.

## R

**Rating** - The characteristics such as volt-ampere capacity, voltages, frequency and temperature rise that a transformer is designed to.

**Ratio Test** - A standard test of transformers to determine the ratio of the primary to the secondary voltage.

**Reactance** - A component of impedance produced by either inductance or capacitance in an AC circuit.

**Reactor** - A device for introducing inductive reactance into a circuit for motor starting, operating transformers in parallel and controlling current.

**Regulation** - The per cent change in output voltage from full load to no-load.

## S

**Scott - T Connection** - A transformer connection usually used to get a two-phase output from the secondary of a transformer with a three-phase input to the primary or vice versa. It can also be used to provide three-phase to three-phase transformation.

**Secondary Voltage Rating** - Designates the load-circuit voltage for which the secondary winding is designated.

**Series/multiple** - A winding of two similar coils that can be connected for series operation or multiple (parallel) operation.

**Star Connection** - Same as WYE connection.

**Step Down Transformer** - High voltage winding is connected to the power source input and the low voltage winding to the output load.

**Step Up Transformer** - Low voltage winding is connected to the power source (input) and the high voltage winding is connected to the output load.

**Stray Loss** - losses in the transformer resulting from electromagnetic flux in the windings, core, terminals, bus and all conductive metal structures within the transformer. Unit of measure is the watt.

## T

**T-Connection** - A Scott connected three-phase transformer utilizing two primary and two secondary coils.

**Tap** - A connection in a transformer winding which has the effect of changing the nominal voltage ratio of the transformer. (Taps are usually placed on the high voltage winding to correct for high or low voltage conditions found on the low voltage output side.)

**Temperature Rise** - The increase over ambient temperature of the winding due to energizing and loading.

**Total Losses** - Losses represented by the sum of the no-load and the load losses.

**Transformer** - A transformer is a static electrical device, which by electro-magnetic induction, transfers electrical energy from one circuit to another circuit, usually with changed values of voltage and current.

## U

**UL** - Underwriters' Laboratories. Establishes standards for transformers.

**Universal Taps** - A combination of six primary voltage taps consisting of 4-2 1/2% FCBN and 2-2 1/2% FCAN.

## V

**Volt Amperes** - The current flowing in a circuit multiplied by the voltage of that circuit. (The output rating of a transformer.)

## W

**Winding Eddy-Current Loss** - stray losses composed of eddy-current losses within the winding conductors and losses due to circulating currents between conductor strands and/or parallel winding circuits. These losses must be corrected to the proper reference temperature. Unit of measure is the watt.

**WYE Connection (Y)** - A three-phase connection in which similar ends of each phase winding are connected together at a common point which forms the electrical neutral and is often grounded.

## Z

**Zig-Zag Transformer** - Commonly used term for a grounding transformer.

# Electro-Mechanical Corporation Overview

Federal Pacific is a division of Electro-Mechanical Corporation, a privately held, American-owned company founded in 1958. It is headquartered in Bristol, Virginia (USA) and for more than 60 years has manufactured a wide variety of products used in the generation, transmission, distribution and control of electricity. These products, along with various electrical equipment repair and maintenance services, are used by a diverse mix of Energy (coal, oil and gas), Electric Utility and Industrial customers worldwide.

Electro-Mechanical Corporation has earned a "customer oriented" reputation by keeping its focus on providing the best value to its customers through quality products and services. With six manufacturing companies and two repair and service companies, Electro-Mechanical Corporation has over 650,000 square feet of modern manufacturing facilities, located in Virginia, Tennessee and Mexico.

The Electro-Mechanical Corporation consists of:

**Federal Pacific** - Dry-type transformers from .050 KVA through 10,000 KVA single and three phase, up to 25 kV, 110 kV BIL with UL® approval through 15 kV; Vacuum pressure impregnation and vacuum pressure encapsulation. Medium voltage switchgear including air-insulated live-front, dead-front, SCADA-controlled, automatic transfer, primary metering and wall-mounted pad-mounted and metal-enclosed switchgear. ISO9001:2015 Registered.

**Line Power Manufacturing Corporation** - Custom engineered electrical distribution and control apparatus including low and medium voltage metal-enclosed switchgear, power control centers, motor controls, and substations. Electrical power distribution systems and components used in mining. ISO 9001:2015 Registered.

**MAFESA** - Electro-Mechanical Corporation's manufacturing facility in Mexico for stock low-voltage transformers.

**Engineered Solutions** -The Engineered Solutions Group specializes in the innovative design and creation of custom medium voltage switchgear for Data Center, Solar Energy and other alternative energy, mission-critical projects worldwide.

**Machinery Components Division** - Manufactures prototype and machined component products.

**Electric Motor Repair & Sales Company** - Electric motor and apparatus repair and new equipment sales. Equipment for the Electric Motor Repair and Transformer Manufacturing Industries including winding machines, coil spreaders, dynamometers and transformer core cutting machines.

**Line Power Parts & Rebuild** - Complete electrical equipment remanufacturing and onsite electrical equipment service. The parts service department provides replacement components manufactured by Electrical Group companies as well as commonly used OEM parts.

Federal Pacific

Line Power Manufacturing Corporation

# Federal Pacific Dry-Type Transformer Products

**Industrial Control - 50 through 750 VA**

**Encapsulated 600 Volt Class**

Three-Phase 3 through 15 kVA • Buck-Boost 50 VA through 5 kVA • Single-Phase 50 VA through 25 kVA

**Ventilated 600 Volt Class**

Single-Phase 15 through 167 kVA • Specialty through 1000 kVA • K-Factor Rated
Three-Phase 15 through 500 kVA • Specialty through 3000 kVA •Motor Drive Isolation Three-Phase 7.5 through 750 kVA

**High Voltage General Purpose**

Three-Phase 2.4 and 5 kV Class, 15 through 1500 kVA • Three-Phase 8.6 and 15 kV Class, 112.5 through 1500 kVA

**Pad-Mounted**

Single- and Three-Phase 2.4, 5 and 15 kV Class, 112.5 through 2500 kVA

**Unit Substation and High Voltage Power**

Three-Phase 2.4 through 25 kV Class, 112.5 through 10000 kVA High Voltage General Purpose
Three-Phase 2.4 and 5 kV Class, 15 through 1500 kVA • Three-Phase 8.6 and 15 kV Class, 112.5 through 1500 kVA

**Vacuum Pressure Impregnated (VPI) and VPI/Epoxy Shielded**

600 Volt Class through 25 kV Class, 112.5 through 10000 kVA

**Specialty Transformers**

600 Volt Class through 25 kV Class, 50 VA through 10000 kVA

**ABS Certified Marine Duty Transformers for Marine, Petro-Chem and Offshore Applications**

# Federal Pacific Switchgear Products

**Live-Front Pad-Mounted Switchgear - 15 kV • 27 kV**

Manual, Automatic Transfer, Remote Supervisory Controlled Models

**Live-Front/Dead-Front Pad-Mounted Switchgear - 15 kV • 27 kV**

Manual, Automatic Transfer, Remote Supervisory Controlled Models

**Dead-Front Pad-Mounted Switchgear - 15 kV • 27 kV**

Manual, Automatic Transfer, Remote Supervisory Controlled Models

**Pad-Mounted Capacitor Banks**

**Primary Metering Dead-Front Pad-Mounts - 15 kV • 27 kV • 38 kV**

**Fused Sectionalizer Dead-Front Pad-Mounts - 15 kV • 27 kV**

**Metal-Enclosed Switchgear - 5 to 38 kV**

Manual, Automatic Source Transfer, Remote-Supervisory Control, Shunt Trip

**Wall-Mounted Equipment - 15 kV • 27 kV**

Wall-Mounted Switch Cabinets, Wall-Mounted Fuse Cabinets

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**Vacuum Reclosers - 15 kV**

**Custom-Engineered Products - 5 to 121 kV**

Portable Substations - Trailer, Skid and Track Mounted

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FP-MVC-10/18

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