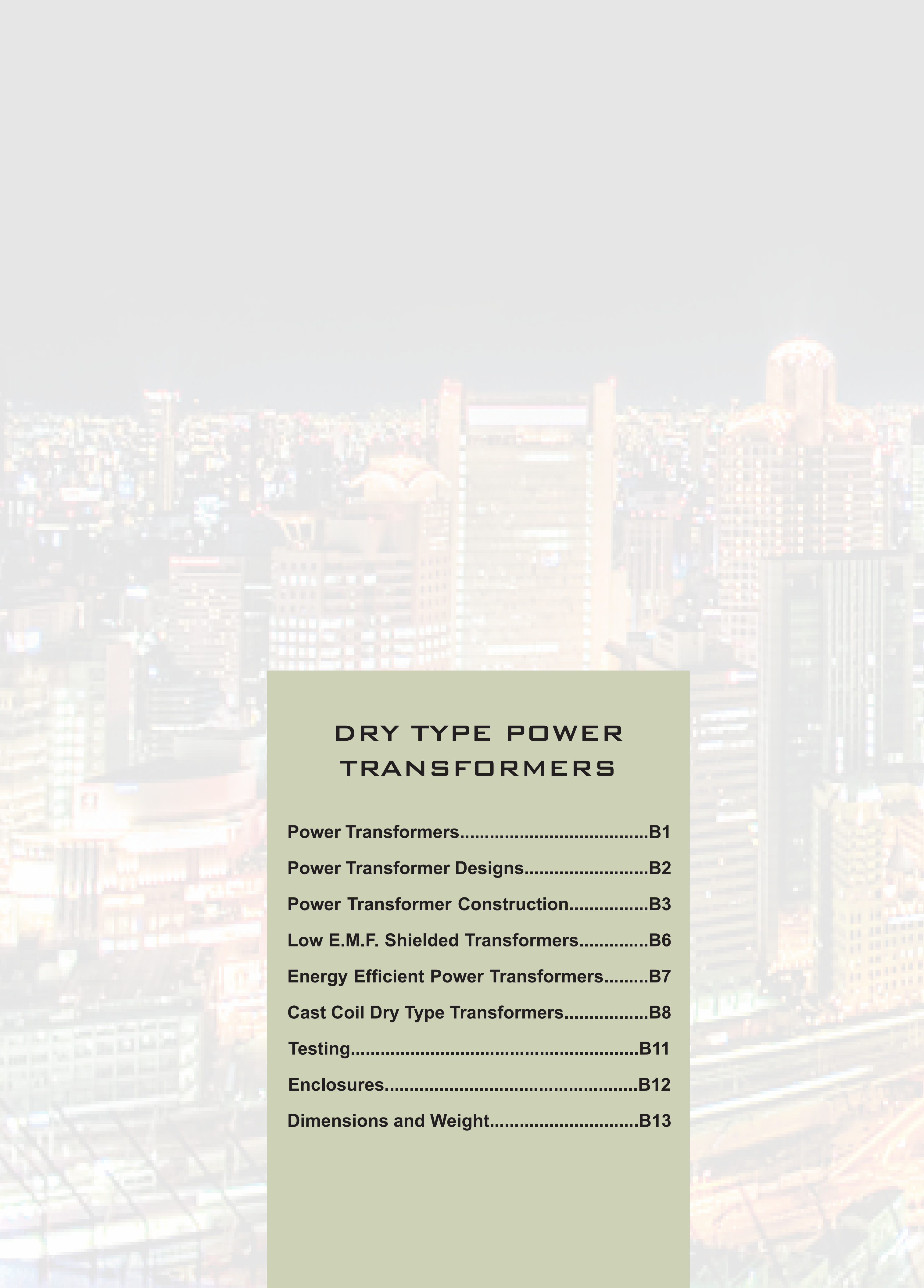
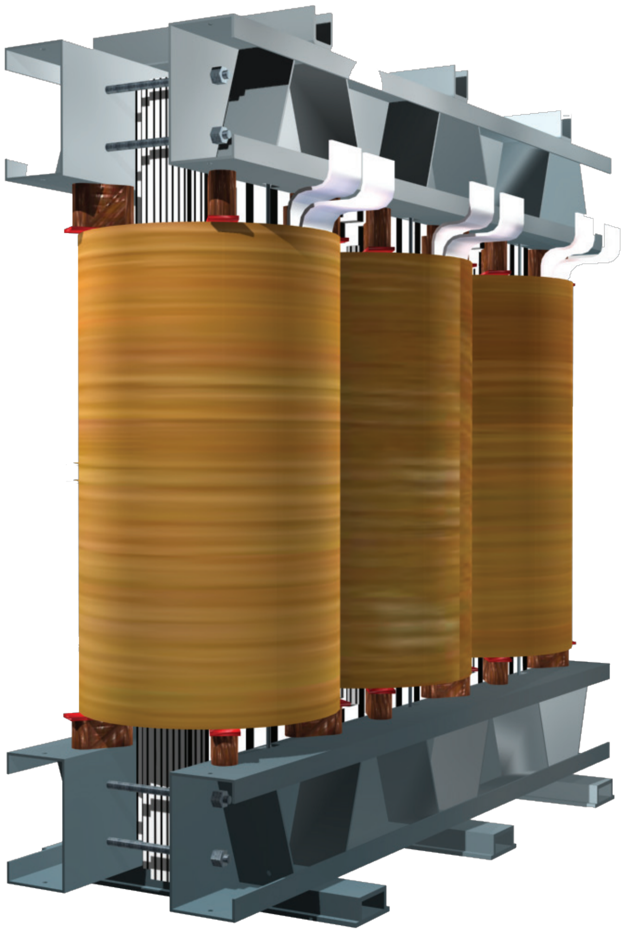


DRY TYPE POWER TRANSFORMERS

High Voltage Dry Type Power Transformers

Applications

Pioneer Electric dry type power transformers are primarily designed for stepping down high voltages from transmission and distribution systems to utilization voltages and commercial, industrial, institutional, or utility applications. They are ideally suited for both indoor and outdoor applications.



Dry type power transformers require minimum maintenance to provide many years of reliable trouble-free service. Unlike liquid-filled transformers which are cooled with oil or a fire-resistant liquid dielectric, dry type units utilize only environmentally safe, CSA and UL recognized high temperature insulation systems. Every dry type design provides a safe and reliable power source which does not require fire-proof vaults, catch-basins, or the venting of toxic gases. These important safety factors allow the installation of dry type transformers inside buildings close to the load, which improves overall system regulation and reduces costly secondary lines losses.

Pioneer Electric provides quality dry type power transformers up to 15MVA at 35kV and 150kV BIL. A sampling of their applications are:

- Power distribution
- Indoor or outdoor primary and secondary substations
- Grounding transformers
- Mining, pulp, and paper application transformers
- Corrosion-resistant transformers for marine distribution and power
- Low electromagnetic field emission transformers for hospital and institutional use
- Traction power rectifier transformers for transit systems
- Motor starting and drive applications
- High harmonic and intermittent load applications
- Many other applications

Pioneer Electric Technical Capability

Pioneer Electric has the engineering capability to design, manufacture, and test all standard and specialty dry type transformers, related magnetic products, and power transformers rated up to 15MVA and 150kV BIL. All Pioneer Electric products are CSA certified and UL listed including power transformers.

The Pioneer Electric engineering and design team consists of highly competent and qualified individuals with many years of transformer design experience.

Pioneer Electric Power Transformer Designs

Standard Designs

Cast Coil Transformers: the ultimate dry type transformer for use in harsh environments.

Drive Isolation Transformers: specifically designed to meet the requirements of AC and DC variable speed drives or rectifier units. Available in 6-pulse, 12-pulse, and 18-pulse.

Electrostatically Shielded Transformers: Protect systems from high-frequency transients that occur due to switching and loading on distribution lines.

Energy Efficient Transformers (e-Rated™): Designed to perform with lower than standard conductor and total losses which result in greater life expectancy, lower operating costs, and significant overload capabilities. Pioneer Electric e-Rated™ transformers are built to meet and exceed CSA C802 and NEMA TP-1 standards.

Non-Linear Load (K-factor Rated): Power transformers for use where harmonic currents are present. Available in all ratings, for example K4, K9, K13, K20, K30, etc.

Low E.M.F. Emission Transformers: Designed to allow very low electromagnetic field emission outside of the enclosure.

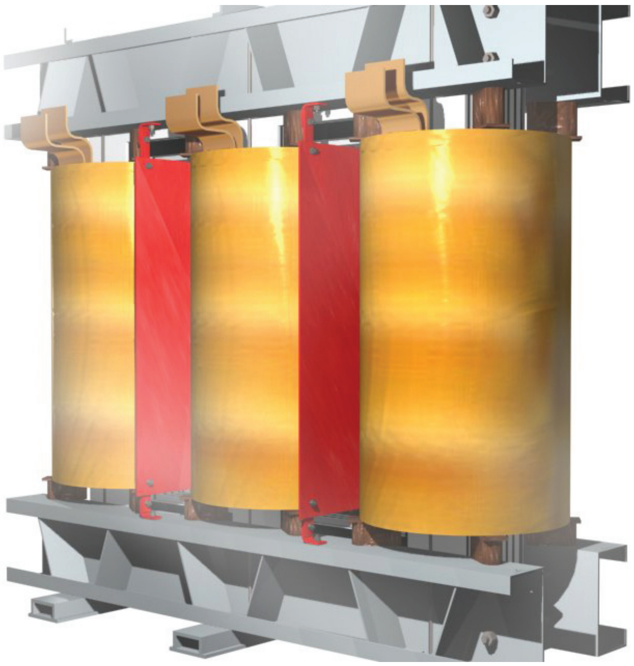
Low Sound Level Transformers: Designed to emit lower than normal audible hum.

Special Frequency Designs: To operate at frequencies other than 60Hz.

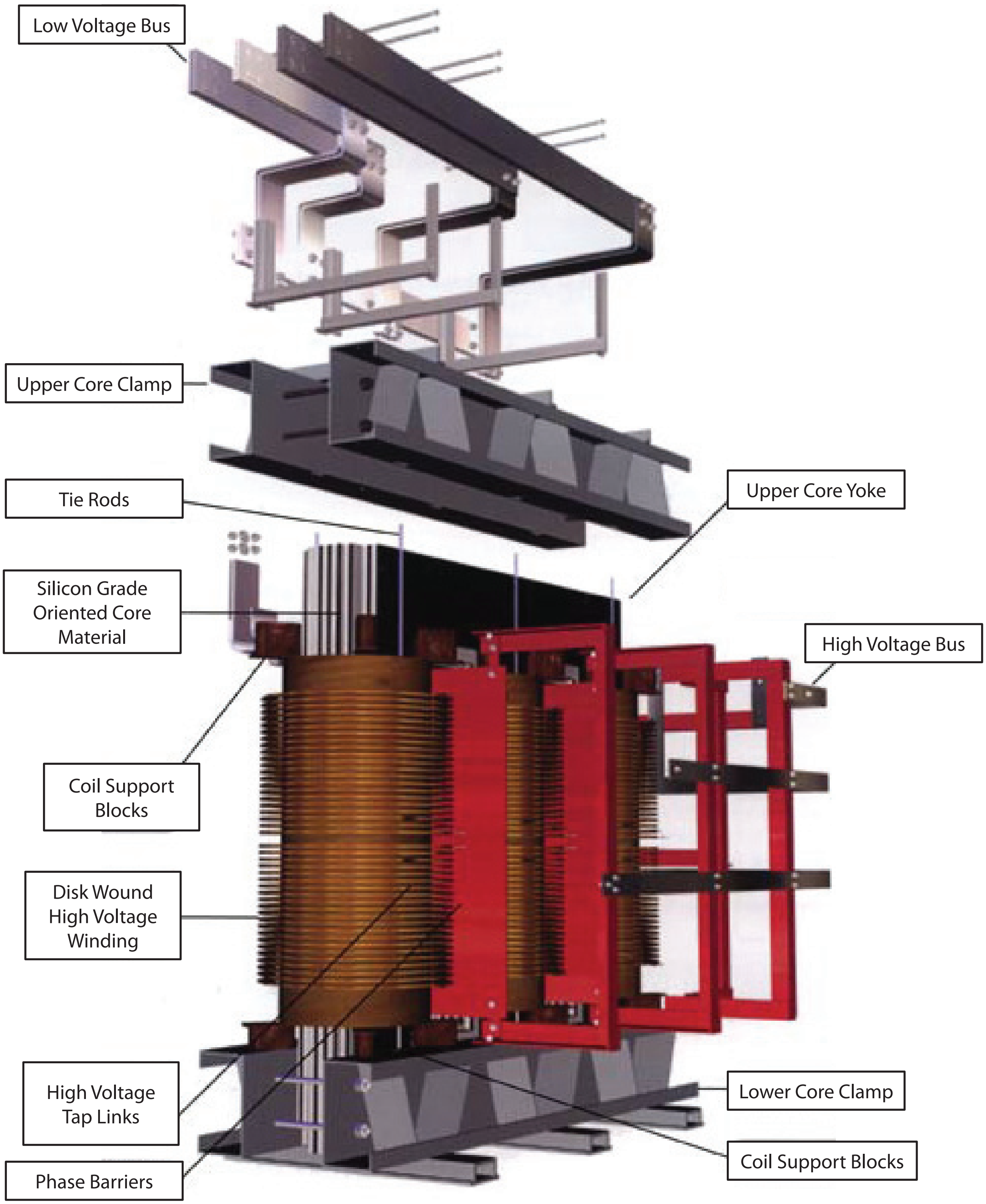
VPI and Epoxy Dipped Windings: All Pioneer Electric transformers windings are vacuum pressure impregnated and polyester resin. For applications with harsh operating conditions or where airborne contaminants are present an epoxy resin coating can be added to the polyester impregnated coils.

Optional Accessories

- Provisions for future fans or fan packages completely installed with or without control power.
- Bus coordination with primary and secondary switchgear
- Dial type or digital thermometers to monitor winding temperatures.
- Neutral grounding resistors and monitors
- Strip heaters to avoid condensation when the transformer is not energized
- Ground fault relays
- Anti-vibration mountings to reduce transformer hum.
- Provision for seismic mounting or seismic snubbers and restraints.
- Lighting arrestors: distribution, intermediate, or station class.
- Provisions for rolling, skidding, and lifting.
- Provisions for bus duct entry
- Mimic bus
- Key interlock systems
- Fully insulated bus
- Special enclosures, NEMA 1, NEMA 3R (with or without filters), NEMA 4, NEMA 12.



Typical Construction of a Disc Wound Transformer



Power Transformer Construction

Coil Construction

Pioneer Electric power transformers utilize either barrel or disc wound coil constructions. Windings type selection is determined by the design which will provide the optimum combination of short circuit strength, impulse distribution, and dielectric withstand characteristics. All windings are insulated to withstand surge voltages and basic impulse level. Primary windings are manufactured of high quality Nomex wrapped copper or aluminum conductor.

Low voltage windings may be stripped or foil wound and are constructed to be electrically balanced to reduce axial short circuit forces.

Barrel Windings

This winding is constructed by progressively winding turns of magnet wire from one end of the coil to the other. Layers are electrically insulated by solid sheet insulation and cooling ducts.

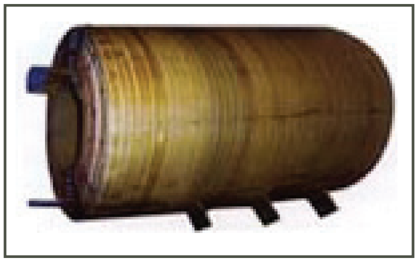
Disc Windings

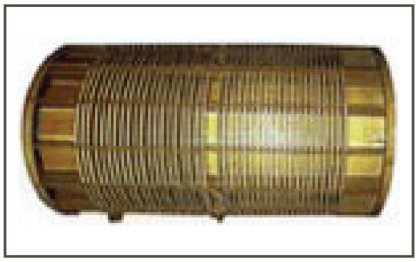
This winding construction is achieved by winding the conductor into slotted spacers (combs) that are arranged around the circumference of the coil. The continuous series connected disc winding provides a high capacitance which improves the distribution of the impulse wave through the winding. Cooling efficiency is also maximized by exposing a large surface area of the conductor to the air.

Insulation

The life span of the insulation is the main detriment in the life span of the transformer. The working temperature of the transformer affects the life of the insulation. This working temperature is a combination of the unit's temperature rise, the ambient temperature, and the hot spot temperature.

Pioneer Electric transformers are manufactured with class 220°C. insulation material. Only high temperature resistant material of the best quality are used including nomex aramid papers, silicon, or polyester coated fiberglass, nomex sleeving, glass tapes, and polyester/glass duct sticks.





Vacuum Pressure Impregnation

Subjecting coil windings to the VPI treatment ensures that Pioneer Electric transformers have outstanding electrical, thermal, and mechanical properties.

At the conclusion of the winding process, the completed transformer coil is prepared for impregnation by preheating to reduce moisture. The drying process is completed when the coil is subjected to full vacuum in a vacuum chamber removing all the moisture absorbed by the insulation from the atmosphere.

A clear, low viscosity, high temperature resin (class 220°C) is introduced into the tank under vacuum eliminating any air bubbles in the resin. When the winding is completely submerged pressure is applied forcing the resin into all winding spaces and voids in the turn to turn and layer to layer insulation.

The vacuum/pressurization cycle is repeated four times to achieve full resin penetration the coil is then removed from the chamber and placed in a baking oven to cure the resin. The entire vacuum impregnation process is repeated twice, to ensure a uniform protective, hard, and impermeable coating is formed on all exposed surfaces of the winding.

As an option and for greater protection the coil can be coated with high viscosity epoxy resin and heat cured.

Power Transformer Construction

Core Construction

Every Pioneer Electric transformer core is constructed from electrical grade, cold rolled oriented silicon steel of M5 grade or better. Grain oriented steel is utilized for its superior magnetic permeability, low hysteresis, and eddy current losses. Steel is cut into individual laminations on automated cutting machines to ensure precise and consistent dimensions.

Core laminations are meticulously stacked on specially designed jig tables. The individual laminations of the core are then clamped together by structural grade steel core clamps.

Once the core is complete an epoxy coating is applied to guard against corrosion.

Pioneer Electric constructs cores with either a rectangular or cruciform configuration. The core configuration is chosen to provide the most efficient with the best weight and dimension factors. Both configurations may utilize either the butt and lap stacking method or the full miter stacking method.

Rectangular Core
This configuration is used mainly for smaller units constructed with layer wound coils.

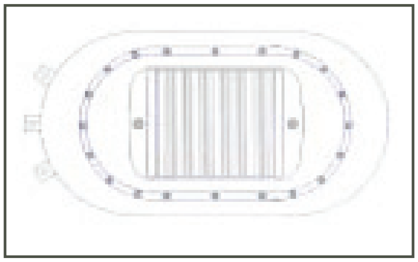
Cruciform Core
This configuration is utilized mainly for large round windings. The core shape is steeped to give as close as possible coupling with the round coils. This type of design inherently has higher short circuit capability.

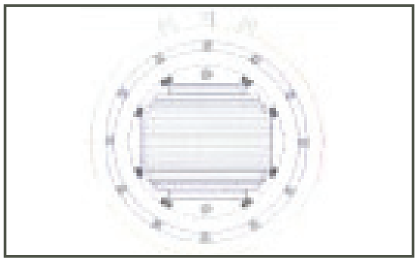
Power Transformer Losses

Losses of transformer consist mainly of:

1. Conductor losses which are proportional to the load and vary with loading.
2. Core losses which are constant and are present as long as the transformer is energized.

Since most transformers are energized at all times regardless of the loading it is therefore evident that reducing the core losses will results in significant energy and cost savings.

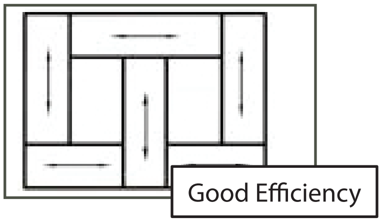




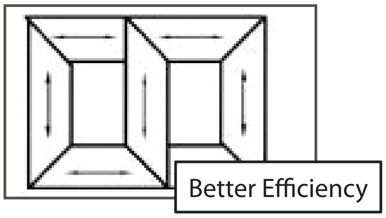
Core Stacking Methods

The following illustrates the various core cutting and stacking arrangements in order of efficiency provided:

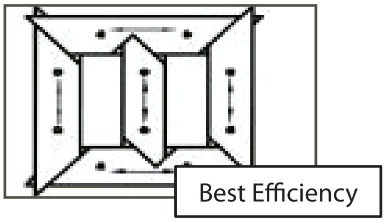
Butt Lap Cut:
Consists of rectangular pieces of core steel arranged in such a way so that the grain orientation of the steel is along the flux path except in the corners where the flux path changes direction from the legs to the yolk members.



Scrap-Less Mitre Cut:
Scrap-Less mitering where the steel is cut at 45 degree angles and arranged such that the grain orientation is maintained in line with the flux path, even in the corners of the transformer core thus reducing the core losses.



Full and Step Lap Mitre:
This type of core cutting and stacking ensures that the overlapping of the joints in the corners are mitred and staggered so that the best possible grain orientation and flux transition is achieved. By avoiding crowding of the flux lines the least core losses are achieved and therefore the best efficiencies.



Low E.M.F. Shielded Transformers

Application

Power frequency electromagnetic fields from electrical distribution systems are virtually omnipresent. The closer to a source the higher the field intensity, be it a transformer, feeder run, or switch gear.

To prevent interference with sensitive electronic equipment as well as to satisfy possible health concerns major magnetic "polluters" can be located in remote areas of a building. However, this is not always possible or practical and may add additional costs and limit the useful space.

Low E.M.F. Shielded Transformers

Pioneer Electric has a complete line of low emission power and distribution transformers that have the external stray flux attenuated by 95% or better than the standard transformer field emission.

Unshielded transformers 300 - 3000 KVA produce electromagnetic fields in the order of 100 - 500 milligauss in the immediate vicinity of the unit. Pioneer Electric specially designed transformers can lower these emissions by a factor of 10 or better depending on the specifications.

This allows for the transformers to be located at practically any location in a building without any restrictions due to intrusive magnetic fields.

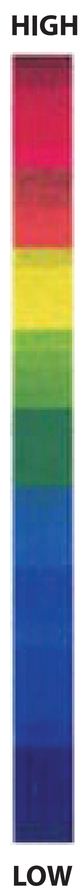


Image 1: Shows a graphical representation of the intensity level of the electromagnetic fields outside of the enclosure of a typical non-shielded transformer.

Image 2: Shows a graphical representation of the intensity level of the electromagnetic fields outside of the enclosure of a shielded transformer. Due to magnetic shielding of the enclosure most of the field emission is contained within the transformer enclosure.

Energy Efficient Power Transformers

Application

As energy prices continue to rise, it is imperative to reduce the operating costs of electrical systems. The losses of a transformer are a very small percentage of the total power that flows through it. However, all transformers have losses that appear in the form of heat. Transformers designed for temperature rises of 80°C or 115°C and with the special grade core materials and assemblies, are designed with lower than normal losses, and therefore, have greater life expectancy, lower operating costs, and significantly enhanced overload capabilities.

How are NEMA TP-1 and CSA C802 Qualified Transformers More Efficient?

Transformers lose energy in two components the steel core and the surrounding copper, or aluminum windings. Energized 24 hours a day, the core loses energy at a fixed rate that is independent of the transformer load. Winding energy loss varies with transformer load. To comply with NEMA TP-1 and CSA C802 transformer efficiency standards, transformer cores are made with higher grade silicon steel and constructed with special miter cut arrangements which produce lower losses than conventional cores.

What is Core Loss?

Core loss is the electrical loss in a transformer caused by magnetization of the core. These sometimes are referred to as no load losses because they exist whenever the primary side of the transformer is energized, regardless of whether there is a load on a transformer.

What is Load Loss?

Winding loss is the loss associated with the flow of electricity through the windings of the transformer. It is directly proportional to the amount of energy flowing in the winding, which in turn is dependent on load.

What has a greater effect on the total loss?

Winding loss is the loss associated with the flow of electricity through the windings of the transformer. It is directly proportional to the amount of energy flowing in the winding, which in turn is dependent on load.

Total Losses = Core Loss + (%Load^2 X Winding Loss)

Energy Efficient Transformers

Pioneer Electric energy efficient transformers utilize M5 or better high grade silicon steel of grain oriented core steel and mitre cut core assembly, see page B5, that result in significantly lower core losses. Winding losses are also reduced by designing the transformers with lower temperature rises.

Pioneer Electric energy efficient power transformers meet or exceed the guidelines set out in the CSA C802 and NEMA TP-1 standards.

Efficiency Recommendation

KVA	Recommended Level
750	98.8%
1000	98.9%
1500	99.0%
2000	99.0%
2500	99.1%

Transformer Cost-Effectiveness Example: 1500 KVA Three Phase Medium Voltage

Performance	Base Model	*e-Rated*™
Efficiency	98.6%	99.0%
Annual Energy Loss	91,380 kWh	66,360 kWh
Annual Energy Loss Cost	$10,050*	$7,300*
Lifetime Energy Loss Cost	$251,250*	$182,500*
Lifetime Energy Loss Cost Savings	-	$68,750*

*Annual energy loss is based on 50% of nameplate load. Lifetime cost savings is based on average usage and an assumed transformer life of 25 years. The assumed electricity price is 11 cents per kWh.

Using the cost-effectiveness table: In the example shown above, a 1500kVA, three phase medium voltage transformer at the recommended efficiency level of 99% is cost-effective if its purchase price is no more than $68,750 above the price of the base model. Contact Pioneer Electric for help in calculating cost savings and payback period.

Cast Coil Dry Type Transformers

Description

The unique design and manufacturing process of cast coil dry type transformers offers several key advantages over liquid filled or conventional dry type transformers. Specifically, cast coil type transformers are environmentally safe and provide long uninterrupted service in the most demanding applications and under the most severe operating conditions.

The most important distinguishing feature of the transformer design is that the primary (and optionally) the secondary coils are solidly vacuum cast in epoxy resin. The casting process effectively locks the windings in a very strong, high dielectric resin which protects the transformers from extremely severe environments and electrical demands. During the casting process, the coil windings which are layered with absorbent fiberglass are fully and completely impregnated with the epoxy resin. The result is a coil construction which provides the following key features:

Suitability for installation in harsh environments
Cast coil type transformers offer the greatest degree of protection against the presence of moisture and atmosphere pollutants affecting the performance and life expectancy of dry type transformers.

High short circuit strength
The fiberglass reinforced solid cast construction provides superior mechanical strength with the highest short circuit withstand capability of all transformer types including that of liquid filled units.

High overload capability
Due to the long thermal time-constant of cast coils in comparison with conventional ventilated dry type transformers, higher short time overload capabilities are possible.

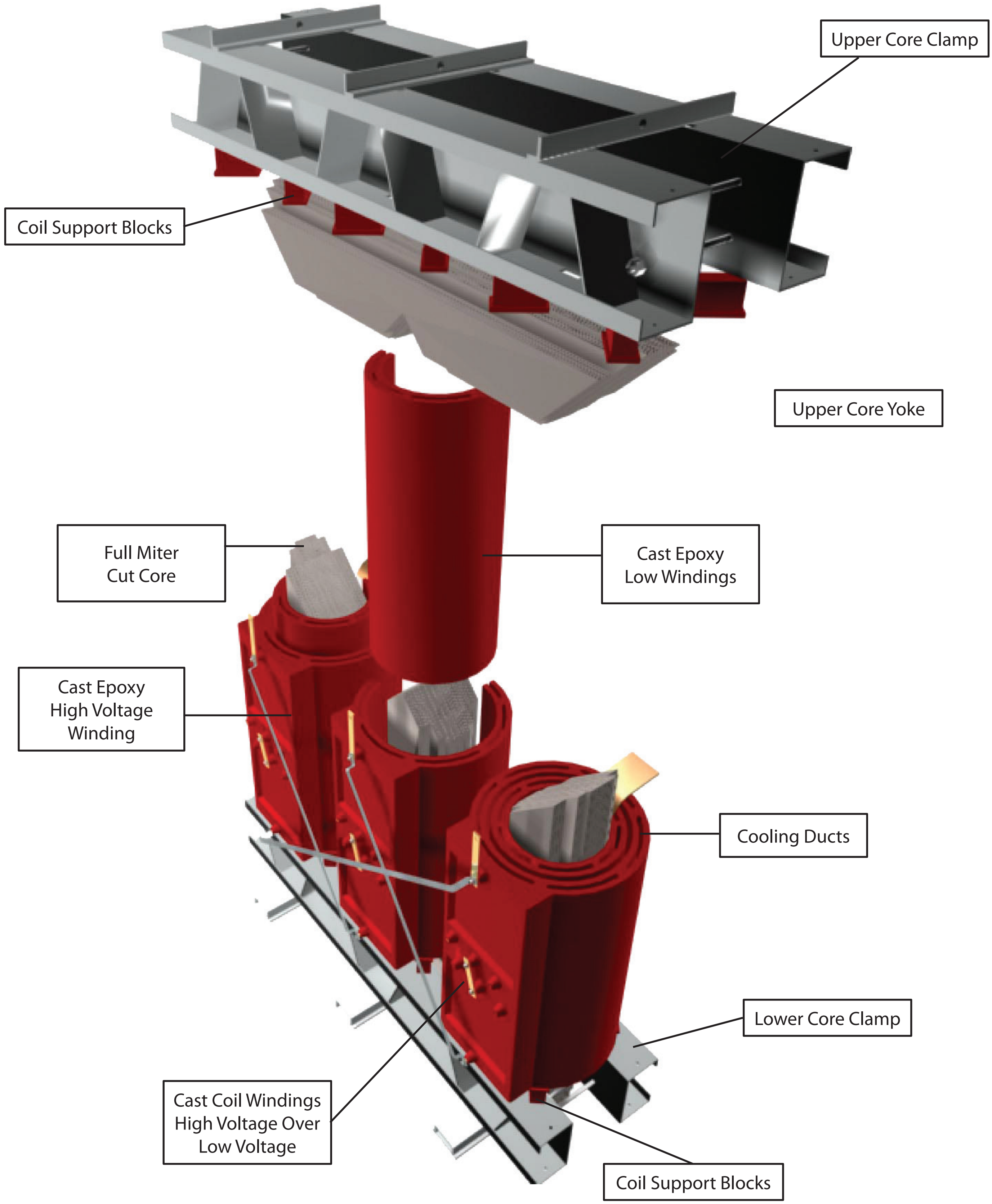
Safety
Cast coil type transformers are self-extinguishing which virtually eliminates the possibility for fire or explosion. Installations do not require special fire protection systems.

High Impulse Voltage Strength
The impulse voltage withstand capability of cast coil transformers is higher than conventional dry type transformers and comparable to liquid filled units.

Maintenance
Cast coil type transformers are virtually maintenance free due to smooth crevice free construction of the coils. With proper precaution cast coil units can be installed at ambient temperatures as low as -50°C and can be energized from cold start at full rating.

Environmentally Friendly
Cast coil transformers contain only chemical non-hazardous material.

Typical Construction of a Cast Coil Transformer



Cast Coil Dry Type Power Transformers

Design and Construction Features

- The primary and secondary windings are magnetically and electrically balanced to minimize mechanical stresses due to short circuits and momentary overloads, especially those due to axial forces.
- Unique coil construction techniques are used to reduce the dielectric stresses due to uneven distribution during impulse. The dielectric stresses are such that partial discharges are virtually non-existent at 120% overvoltage. The basic construction of the cast resin has high permittivity material in the series capacitance paths. The result is a more linear distribution of transient voltages.
- The epoxy used in casting the coils is a two part very low viscosity resin with excellent penetration capabilities and superior thermal shock performance. Extensive use of fiberglass reinforcement wraps during coil construction enhances the strength and crack resistance of the finished coils.
- Conductor and inter-layer insulation used during coil construction are aramid paper (Nomex) and the casting epoxy resin is approved for use in 180°C systems.
- Each coil is preheated in its casting mold which must be specifically designed to withstand vacuum. The pre-heated mixed epoxy is then introduced under high vacuum into the mold. The procedure of pulling vacuum directly into the mold ensures the great penetration and most void free casting possible. The filled mold is then subjected to a program pre-bake, bake, and post-bake cycles which can last from 16 to 30 hours to relieve the casting of all residual stresses before removing the finished coil from the mold.
- The primary and secondary coils are cast separately and assembled on the core. Special axial clamping techniques are used to give uniform pressure while allowing for thermal expansion and ensuring maximum creepage distance between the coils. This type of assembly also provides better isolation between the coils by reducing the number of creepage paths and increasing the lengths of these paths where they exist.

Comparison with Other Transformers

- Cast coil transformers are ideal for use in installations where environmental restrictions discourage the use of liquid filled units.
- Cast coil units require very little maintenance in comparison to liquid filled transformers which require regular maintenance to check gauge levels and periodical sampling and testing of cooling fluids. Low maintenance type transformers are preferable for installation in harsh environments where regular maintenance routines are difficult or inconvenient to perform.
- The initial cost of cast coil type transformers is comparable to silicon filled units and is higher than the cost of conventional ventilated dry types. Although the equipment cost is marginally higher, the installation cost of cast coil transformers are similar to that of conventional dry type units and significantly lower than liquid filled transformers.
- Cast coil transformers are as adaptable as conventional ventilated dry type transformers allowing for easier coordination with other equipment compared to liquid filled units.
- Cast coil transformers are designed with a long thermal time-constant. This results in a transformer with superior short term overload capabilities.
- The solid epoxy, fiberglass reinforced cast construction produces coils that have outstanding mechanical strength which results in unparalleled short circuit withstand capabilities. This high short circuit withstand and the short term overload capabilities of cast coil transformers make them ideal for heavy industrial installations such as automotive manufacturing and rapid transit, traction power applications.
- When specifying transformers there are many different types and many different options to consider. All types of transformers when installed and maintained properly will provide many years of satisfactory service. However, cast coil type transformers offer a long life with practically maintenance free operation in nearly any environment.

Testing

Standard Tests

Every power transformer supplied by Pioneer Electric receives the following standard production tests:

- **Resistance Measurement:** Measures the DC resistance of the windings to ensure integrity.
- **Ratio Test:** Determines that the ratio of the turns in the primary winding to the turns in the secondary windings is correct.
- **Polarity and Phase Relation Test:** Compares the instantaneous direction of the current and voltage in the primary relative to the secondary to determine the angular displacement and phase sequence. Determining the polarity is particularly important when paralleling or banking two or more transformers.
- **No-Load Loss and Excitation Current Test:** Measures the losses in a transformer operating at rated voltage and frequency under no load conditions. These losses include core loss, dielectric losses, and I^2R losses from no-load current flow in the primary winding.
- **Load Loss Test:** Measures losses in the windings resulting from full load current flow and stray losses due to magnetic leakage to the core clamps and other structural members.
- **Impedance Test:** Measures the voltage required to circulate rated current through the windings.
- **Applied Potential Test:** Determines the dielectric strength of the insulation between windings and between the windings and ground.
- **Induced Potential Test:** Checks the dielectric strength and integrity of the turn to turn and layer to layer insulation.

Average Audible Sound Level (Ventilated Self-Cooled)

KVA Rating	Line to Line Voltage Class up to 15KV BIL (dB)	Above 15KV Voltage Class up to 125KV BIL (dB)
300 - 500	60	62
501 - 750	62	64
751 - 1000	64	66
1001 - 1500	65	67
1501 - 2000	66	68
2001 - 3000	68	70
3001 - 4000	70	72
4001 - 5000	72	74

Optional Tests

- **Basic Impulse Insulation Level (BIL):** A dielectric test consisting of a high frequency instantaneous impulse voltage applied to the windings to determine the ability of the unit to withstand overvoltage surges.
- **Temperature Rise Test:** The transformers are tested under loading conditions that give losses as near as possible to the nameplate rating to ensure its ability to operate within its designed temperature limit.
- **Partial Discharge Test (Corona):** An induced voltage is applied to the transformer to determine corona. Corona is a type of localized discharge resulting from transient gaseous ionization in the insulation system under voltage stress.
- **Sound Level Test:** Measures the level of sound (transformer hum) emitted by the transformer.

Standard Impedance Range

Voltage Class (KV)	Up To 2000KVA	Over 2000KVA
5.0	4.0% - 6.0%	6.0% - 7.0%
8.7	4.5% - 6.5%	6.0% - 8.0%
15.0	5.5% - 7.0%	6.5% - 8.0%
25.0	6.5% - 7.5%	7.0% - 8.5%

Basic Impulse Level (BIL) (BIL Full and Chopped Wave KV Crest)

Voltage Class (KV)	CSA Standard	Pioneer Electric Standard
2.5	20	30
5.0	30	30
8.7	45	60
15.0	60	95
18.0	95	110 or 125
25.0	125	125
35.0	150	150

Enclosures

Pioneer Electric Standard Enclosures

Pioneer Electric transformer enclosures are designed and quality constructed to protect against accidental contact with the transformer enclosed within them and to protect the transformer core and coil from a variety of different operating conditions.

NEMA 1

A general purpose indoor ventilated enclosure designed to provide a limited degree of protection against falling dirt particles. It is commonly utilized indoors for commercial and industrial applications.

NEMA 2

A general purpose indoor ventilated enclosure designed to provide a degree of protection against dripping and light splashing of noncorrosive liquids and falling dirt particles.

NEMA 3R

A general purpose ventilated enclosure for either indoor or outdoor use, designed to provide a degree of protection against rain, sprinklered water, and snow. Ideal for sprinklered commercial applications, severe industrial environments, and outdoor applications.

Note: For outdoor applications, Pioneer Electric recommends the installation of optional ventilation filters.

NEMA 4

A non-ventilated enclosure for either indoor or outdoor use, constructed to provide a degree of protection against windblown rain, snow, dust, and splashing water. Hose-directed water, and to be undamaged by the formation of ice externally. Ideal for industrial and commercial applications in harsh environments or where severe weather conditions are likely.

NEMA 4X

A non-ventilated enclosure the same as NEMA 4, but it is corrosion resistant. Ideal for industrial applications such as food processing, refineries, and mines.

NEMA 12

An indoor non-ventilated enclosure constructed to provide a degree of protection against circulating dust, lint, fibers, and flings. It also provides protection against dripping and light splashing of noncorrosive liquids. Ideal for industrial applications such as mills, refineries, or mines.

NEMA 1

NEMA 3R with Filters

Sprinkler Proof

Dimensions and Weight

5 KV (30 KV B.I.L.)

KVA Rating	Dimensions for Core and Coil Assembly 220°C Insulation (150°C Rise)				Enclosure Dimensions Stubs-Up Pads Arrangement				Total Weight (lbs.)
	Width (in.)	Depth (in.)	Height (in.)	Weight (lbs.)	Width (in.)	Depth (in.)	Height (in.)	Weight (lbs.)	
300	41	30	39	1900	46	40	60	500	2400
500	51	30	46	2800	60	45	70	700	3500
750	60	35	60	3200	72	45	80	850	4050
1000	62	35	62	4000	72	45	80	850	4850
1500	66	45	66	7000	80	48	91.5	1050	8050
2000	70	45	70	8400	90	60	91.5	1250	9650

8.5 KV (45 KV B.I.L.)

500	60	36	54	3300	72	45	80	850	4150
750	62	42	62	4500	72	45	80	850	5350
1000	66	42	64	5000	80	48	91.5	1050	6050
1500	70	44	66	6000	80	48	91.5	1050	7050
2000	72	44	68	8900	90	60	91.5	1250	10150
2500	76	50	74	9700	90	60	91.5	1250	10950
3000	80	50	78	11000	90	60	100	1300	12300

15 KV (60 KV B.I.L.)

750	66	42	62	5000	80	48	91.5	1050	6050
1000	68	42	64	6200	80	48	91.5	1050	7250
1500	72	44	68	8000	90	60	91.5	1250	9250
2000	75	44	72	9500	90	60	91.5	1250	10750
2500	78	50	77	10500	100	60	110	1450	11950
3000	84	50	80	12100	100	60	110	1450	13550
3750	90	55	84	17000	110	72	110	1600	18600
5000	100	55	96	19500	120	72	120	1900	21400

18 KV (95 KV B.I.L.)

750	72	45	64	6200	90	60	91.5	1250	7450
1000	78	45	70	6800	100	60	91.5	1300	8100
1500	80	45	76	8200	100	60	110	1450	9650
2000	80	45	80	9600	100	60	110	1450	11050
2500	87	50	82	10800	110	60	110	1550	12350
3000	95	50	86	13000	110	60	110	1550	14550
3750	98	60	88	17700	120	72	120	1900	19600
5000	100	60	92	20500	120	72	120	1900	22400

25 KV (125 KV B.I.L.)

1000	80	48	80	7200	100	60	110	1450	8650
1500	84	48	82	8500	110	60	110	1550	10050
2000	90	50	85	9800	110	60	110	1550	11350
2500	92	50	90	11000	110	60	120	1600	12600
3000	95	50	95	14000	120	60	120	1900	15900
3750	98	55	108	18500	120	72	132	2100	20600
5000	100	60	118	21000	130	72	130	2500	23500

Note: Dimensions may change if co-ordinated with switchgear. Dimensions are estimates. For firm dimensions contact factory.