Make the Best Choice

Rethinking Transformers For Safety, Performance, and Value

Transformer Selection Guide

COOPER Power Systems

Transformer Selection — How to Make the Best Choice

Distribution transformer selection, whether for residential, commercial, industrial, or utility application, has long-term ramifications. Transformers can have lives of 15, 30, and even 50 years or more, depending on their design, loading, application, protection, and maintenance. So it's important to evaluate all of the transformer attributes that affect the final purchase decision.

This guide provides the information needed to choose the best transformer for your application. Your transformer choices include:

Liquid-Filled:
- Mineral Oil
- Fire-Resistant Fluids (Less-Flammable)
  - High Molecular Weight Hydrocarbon (HMWH) (R-Temp®)
  - Silicone Oil (Polydimethylsiloxane)
  - Synthetic Ester (Envirotemp® 200™)
  - Natural Seed Oil Ester (Envirotemp® FR3™)

Dry-Type:
- Standard Vented Dry
- Vacuum Pressure Impregnated (VPI) Dry
- Cast Resin

In order to make a fair comparison, equivalent transformer attributes should be compared. Installation flexibility, performance, accessory integration, environmental impact, and cost are all examples of attributes that should be considered. Each of the following attributes are addressed in this guide, so that all choices can be properly evaluated.

Installation:
- Outdoor
- Indoor
- Public Access
- Code Requirements

Performance:
- Efficiency
- Overload Capacity
- Operating Temperature
- Sound Level

Capabilities:
- Electrical Withstand
- Partial Discharge
- Harmonic Withstand

Transformer Accessories:
- Accessory Integration

Total Life Cycle Cost:
- First Cost
- Installation Costs
- Maintenance Costs
- Reliability
- Environmental Impact
  - Repairability
  - Recycling and Disposal
  - Environmentally Friendlier Fluids
- Energy Costs
- Total Life Cycle Cost Summary

When all of the transformer attributes are factored into your purchase decision, some will be more important than others. Page eleven of this guide includes a table that summarizes these attributes. This table will enable you to easily compare different transformer alternatives, and help you make the best choice for safety, performance, and value.

Installation

Although it is possible to use just about any transformer type for a particular application by incorporating the appropriate safeguards, some choices are better than others. The location where a transformer will be installed is a key determining factor and, in some cases, a limiting factor in the type of transformer that can be selected. The following are additional criteria that should be considered: ***environmental conditions, public access, and applicable local, state, and national codes.***

Outdoor Locations

The effects of dirt, moisture, and corrosive contaminants must be considered when specifying a transformer for outdoor locations. Standard dry-type transformers typically are not considered suitable for outdoor applications because of this. For these applications, a NEMA 3R enclosure for the transformer can be used to locate a dry-type transformer outdoors. This enclosure substantially limits air flow and, thus, may require derating. These measures add substantial cost to the transformer installation. In contrast, a liquid-filled transformer's standard sealed tank and insulation system protect the core and coil from harsh environments, helping to ensure reliable, long-term performance in even the worst environmental conditions.

Indoor Locations

The evaluation criteria become a little more complicated for indoor installations. Dry-type transformers can be used in indoor locations, but may require added protective measures for installation in addition to those required by code. In dirty environments, a separate "clean room" is normally required to house a dry-type transformer. Cast resin type transformers mitigate the problem to a degree because their coils are encased in resin, but they, too, still require periodic cleaning. Liquid-filled transformers are routinely used in indoor locations and typically do not require these additional measures.

Public Access

Transformers that are installed in areas exposed to the public (indoor or outdoor) must comply with industry standards as defined by ANSI/IEEE, in addition to local, state, and national codes. Per ANSI C57.12.28, pad-mounted liquid-filled transformers can be installed in most public areas without requiring access barriers. Since there is no equivalent standard for dry-types, they typically require a secure location that is isolated from the public.

Code Requirements

Code requirements for indoor transformer applications can be easily met with either a less-flammable liquid-filled or dry-type transformer. Both can be specified as *Nationally Recognized Testing Laboratory (NRTL) Listed and Labeled,* which minimizes the additional installation requirements mandated by the NEC Sections 450-23 and 450-21. In most cases, this means maintaining minimum distances from building materials. For example, per FMRC Approval Standard Class 3990, an FM Approved liquid-filled transformer can be installed indoors as close as 3 feet to a wall and 5 feet from a ceiling. Containment, when required, can be as simple as a sill in the electrical room doorway, or a curb or metal pan around the transformer. Requirements for indoor conventional mineral oil-filled transformers are more stringent and typically require a three-hour rated vault per Article 450-C.

Code requirements for outdoor transformer installations can be met by using either a liquid-filled or dry-type transformer. Dry-type transformers installed outdoors shall have a weatherproof enclosure per NEC 450-22. In contrast, liquid-filled transformers do not have this requirement. And when filled with a listed less-flammable fluid, they can be installed per NEC 450-23 attached to, adjacent to, or on the rooftops of Type I and Type II buildings. Similar to indoor installations, the requirements for conventional mineral oil-filled transformers are more stringent.

Performance

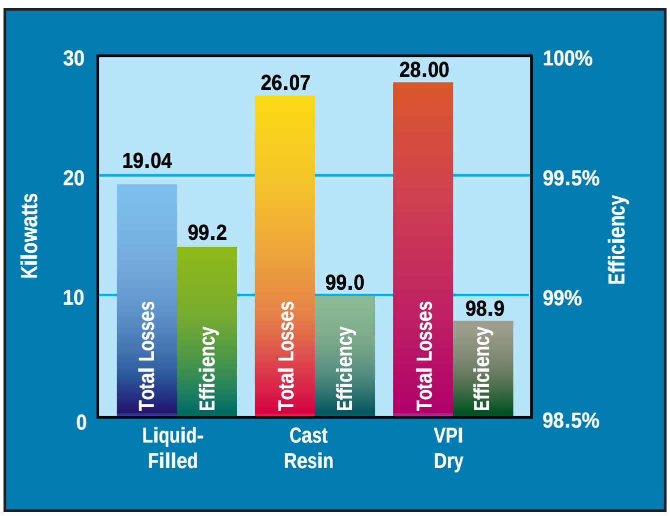
Determining the overall performance of a transformer requires more than simply evaluating its efficiency. Although efficiency is a key component in the evaluation process, other factors are also important. These factors include: ***overload capacity, heat generation, life expectancy, and sound levels.***

Efficiency

A transformer's energy efficiency is determined by dividing its nameplate rating by the sum of its nameplate rating plus its total losses. A small difference in energy efficiency can be significant when valued over the life of the transformer. A differential of just one-half percent efficiency can easily add energy costs that exceed the original purchase price.

Liquid-filled transformers have the flexibility in design to provide a wide range of transformer efficiencies or loss profiles when compared to both dry and cast resin type transformers. Liquid-filled transformers can provide the lowest total losses and highest efficiencies because their design is inherently more compact. In addition, they are typically designed to optimize winding and core configurations. It is the wide range of winding and core materials available for core and coil construction, along with flexible winding and core tooling, that makes this possible.

Transformer Losses and Energy Efficiency



2500 kVA transformer.

Conversely, dry and cast resin type transformers have fewer winding and core material configurations available. Coupled with fixed winding and core tooling, they provide a limited range of available efficiencies.

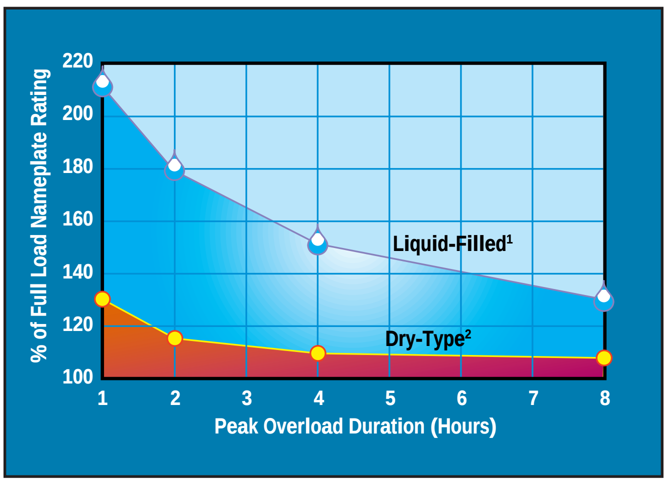
Standard designs for liquid-filled transformers are typically more efficient. Dry and cast resin type transformers can be designed with the same losses or efficiencies as liquid-filled, but at a significant cost premium.

Dry-type transformers typically have losses which are 1.5 to 2 times greater than liquid-filled units and, in turn, generate significantly more heat. These losses are converted to heat in the core and coil, which causes the transformer to heat up. Although dry-type transformers are designed to operate at higher temperatures, this negatively impacts their energy efficiency.

Overload Capacity

Liquid-filled transformers have superior ability to withstand overloading compared to dry-type transformers. The cooling system of liquid-filled transformers provides better protection from severe overloads that can lead to significant loss of life, sometimes failure, in dry-type transformers. Under the same ambient and continuous loading conditions, liquid-filled transformers can tolerate greater overloads for longer periods of time without abnormal loss of insulation life.

Loading Capability for Normal Loss of Transformer Insulation Life



[1]Data taken from ANSI/IEEE C57.91-1981, Table 5. Assumes 65°C rise transformer with 30°C ambient temperature and 50% continuous equivalent load exclusive of peak.

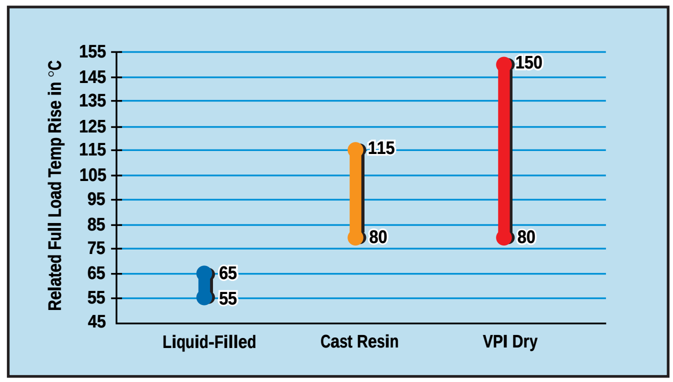
[2]Data taken from ANSI/IEEE C57.96-1989, Table 6. Assumes 150°C rise transformer with 30°C ambient temperature and 50% continuous equivalent load exclusive of peak.

For example, a liquid-filled transformer with a 50% continuous equivalent base load at 30°C ambient temperature could be loaded to 128% of full load nameplate rating for eight hours without excessive loss of insulation life. Under identical base loading and ambient conditions, a dry-type transformer could only provide one hour of 128% overload without excessive loss of life. For a peak load duration of four hours, dry-type transformers could not exceed 110% load, while liquid-filled transformers could take as much as 150% load without excessive loss of insulation life.

Operating Temperature

The liquid-filled transformer design has additional benefits: because it runs cooler, it is safer for operating personnel and the people it serves. And it doesn't put as great a burden on the building HVAC system if the transformer is located indoors. Liquid-filled transformers have a standard temperature rise of 65°C above ambient. Dry-type transformers have a standard temperature rise of 80°C, 115°C, or 150°C at nominal ratings.

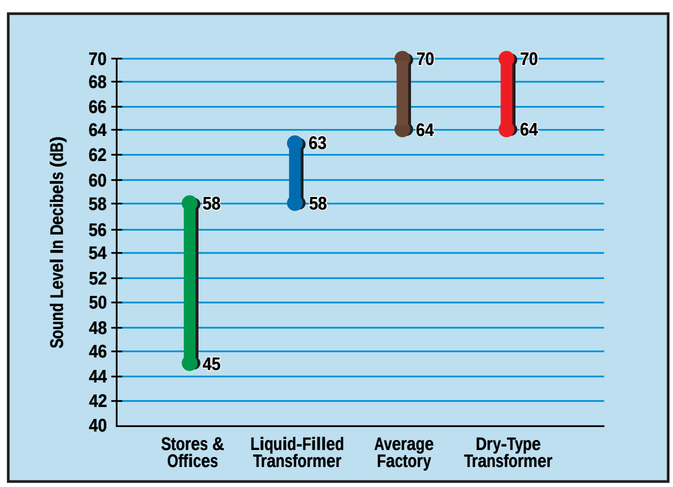
Typical Transformer Operating Temperature Ranges



Sound Level

Standard liquid-filled transformers run quieter than standard dry or cast resin type transformers. This lower noise level makes them more suitable for areas where ambient noise reduction is desired or in sound-sensitive locations.

Typical Transformer Sound Level Ranges



Capabilities

The capabilities of a transformer can be compared by looking at the following different transformer characteristics: ***electrical withstand, partial discharge, and harmonic withstand.***

Electrical Withstand

Many electrical faults are caused by voltage surges from lightning, switching operations, or other voltage transients. The standard impulse withstand ratings (BIL ratings) are used to determine the level at or below which an impulse voltage surge should not cause the insulation system to break down. The ANSI/IEEE standard impulse withstand ratings are higher for liquid-filled than dry-type transformers.

Standard Transformer Insulation Levels

High Voltage Rating (Volts)	Basic Impulse Level (BIL) in kV			
	Liquid-Filled Transformer		Dry-Type Transformer	
	HV Side	LV Side*	HV Side	LV Side*
2400	45	30	20	10
4160	60	30	30	10
4800	60	30	30	10
6900	75	30	45	10
7200	75	30	45	10
12,000	95	30	60	10
12,470	95	30	60	10
13,200	95	30	60	10
13,800	95	30	60	10
14,400	95	30	60	10
25,000	150	30	110	10
35,000	200	30	150	10

Source: Liquid-Filled Standard ANSI/IEEE C57.12.00 and Dry-Type Standard C57.12.01. *LV at 480V.

Dry-type transformers can be specified with higher than standard BIL levels to match the standard levels of liquid-filled transformers. However, the design and construction costs increase for this added protection.

Partial Discharge

Partial discharge is an electrical discharge that partially bridges the insulation between two potentials. Even at low energy levels it can cause radio interference. At higher levels, it can lead to transformer failure. Partial discharge occurs at lower voltages in dry-type transformers than liquid-filled. In liquid-filled transformers, the effects of partial discharges are minimized because the liquid insulation system has a higher dielectric strength than air. Unlike fixed dry insulation, any small area of liquid insulation that is degraded by temporary discharges and other electrical stress migrates and becomes diluted by the unaffected liquid coolant. This is known as a "self restoring" property in the Industry, and is another reason liquid-filled transformers typically last longer than dry-type transformers.

Harmonic Withstand

Because of their non-linear power demand, solid-state electronics and controls cause harmonic loading on the distribution system. As their usage grows within a low voltage distribution system, the frequency and magnitude of the harmonic loading also increases. The resulting non-sinusoidal load currents can lead to excessive localized heating within both the core and coil of the transformer serving the circuit.

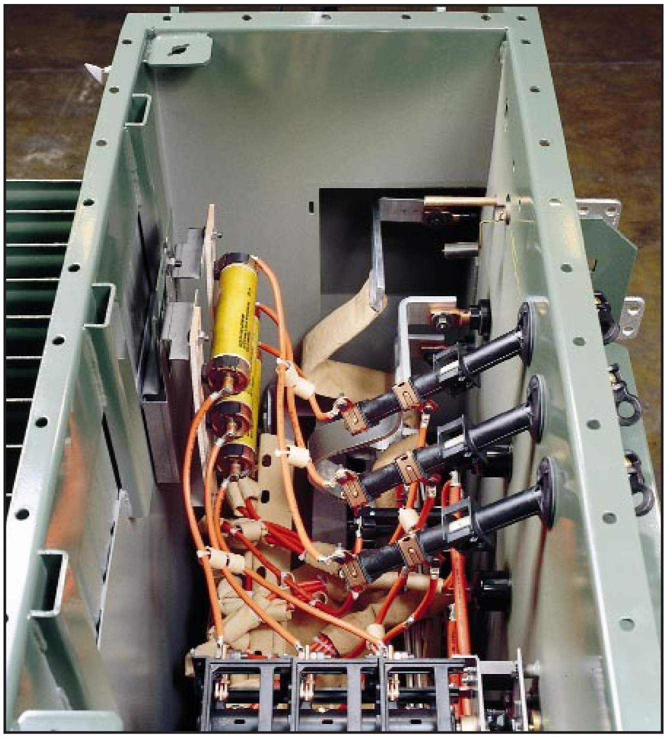
If the levels of the non-sinusoidal load currents cannot be attenuated from the circuit, K-rated transformer designs should be specified.

Service history shows that standard dry-type transformers appear more challenged by harmonic loads. Liquid-filled transformers, due to their inherently superior overload capacity and localized heat dissipation, can better handle non-sinusoidal load currents. In fact, they typically withstand short-term harmonic levels that exceed their specified range without resulting in insulation life reduction.

Transformer Accessories

Accessory Integration

The ability to protect the transformer, its source line, and the load it serves is paramount to proper transformer application. Transformer accessories like loadbreak switches, overcurrent and overvoltage protection, and deadfront loadbreak connectors are often specified to meet application requirements. Liquid-filled transformers can incorporate all of these accessories where they provide the highest degree of safety, flexibility, and economy – inside the transformer. In contrast, dry-type transformers typically require a separate switchgear cabinet for these accessories. The ability to integrate additional functionality into the transformer or transformer cabinet not only costs less, but also reduces the space requirements for the installation.



Integrated Accessories for Liquid-Filled Transformers

Options	Benefits
Bay-O-Net Fuse	Economical and convenient under-oil overcurrent protection with loadbreak capability
Current Limiting Fuse	Limits let-through fault energy
Vacuum Fault Interrupter	Provides adjustable, resettable overcurrent protection. Eliminates the need for a separate switchgear cabinet
Secondary Breaker	Provides overcurrent protection on the low voltage side of transformer
Under-Oil Arrester	Protects against damaging voltage surges
Ground Fault Interrupter	Senses ground faults for improved secondary protection
Loadbreak Sectionalizing Switch	Allows switching to alternate feed circuits and on/off switching
Tap Changing Switch	Allows multiple voltage selections
Rapid Pressure Rise Relay	Indicates transformer internal faults
Top Oil Temperature Relay	Indicates transformer overload condition
Deadfront Terminations	Improved reliability, enhanced safety

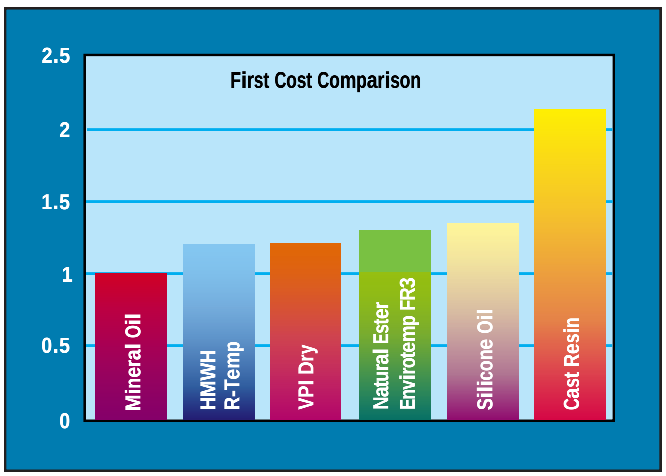
Total Life Cycle Cost

The purchase price of a transformer, although significant, is only one part of the equation needed to determine the Total Life Cycle Cost of a transformer. Other costs and criteria that should be included when evaluating a transformer are: ***installation costs, maintenance costs, reliability, transformer life expectancy, recycling and disposal costs, and energy costs.***

First Cost

The purchase price or first cost of a transformer, in many cases, dominates the selection process. If first cost is the only issue, conventional mineral oil-filled transformers are the most economical solution because they typically have the lowest purchase price. Cast resin type transformers, in contrast, have the highest first cost.

Comparison of Initial Purchase Price of Transformer Types



Installation Costs

Installation costs can vary significantly, depending on the application. Installation location (indoors or outdoors), operating environment, and code requirements are examples of factors affecting cost. For example, standard dry or cast resin type transformers require a separate enclosure for outdoor applications, and clean rooms for adverse indoor applications. In contrast, a liquid-filled transformer is suitable for indoor and outdoor applications, without the need for special enclosures. Liquid-filled transformers provide the highest flexibility and typically the lowest installed cost, regardless of the application.

Maintenance Costs

Liquid-filled transformers do not require regular cleaning maintenance. In contrast, dry-types, because their coils and leads are typically exposed to the environment, should be cleaned on a periodic basis. This requires that the transformer be de-energized and the access panels removed, so that the coils and leads can be cleaned either by vacuuming or blowing with compressed air.

Reliability

The reliability and life expectancy of a transformer are interrelated and should be considered in tandem. Reliability is based on the ability of a transformer to provide uninterrupted service throughout its life. Liquid-filled transformers, because of their standard sealed construction and their self-restoring insulation system, are better able to withstand the negative effects of adverse electrical, thermal, and environmental conditions. Service history indicates that most liquid-filled transformers operate reliably for decades, even with no preventative maintenance being performed. Dry-type transformers can also provide reliable service, but because of their non-sealed enclosure and non-self restoring insulation system, may not provide the same length of life under adverse conditions as liquid-filled transformers.

The ability to determine the electrical and mechanical health of a transformer can lead to improved reliability and help reduce or eliminate costly unplanned shutdowns due to transformer failure.

By performing routine diagnostic tests, including key fluid properties and dissolved gas analysis (DGA), the health of a liquid-filled transformer can be determined. Although sampling is not required for safe operation of the transformer, it can provide the user with valuable information. With this information, repair or replacement of the transformer can be scheduled, minimizing the duration and inconvenience of an outage. Conversely, there is no equivalent way to measure the health, and the probability of an impending failure, with a dry-type transformer. This can result in a costly unplanned outage while the transformer is being repaired or replaced.

Environmental Impact

Total Life Cycle Cost analysis should also include the total environmental life cycle impact. Factors that should be considered include: relative resource depletion, energy depletion, disposal in landfill, recyclability, toxic impact, health issues, noise pollution, life expectancy, and impact on global warming. The following factors are particularly important when considering the Total Life Cycle Cost of a transformer: ***repairability, recyclability, and environmentally friendlier fluids.***

Repairability

When a transformer fails, a decision to repair or replace the transformer must be made. Liquid-filled transformers, in most situations, can be economically repaired at local independent service repair facilities. Failed coils of cast resin type transformers typically cannot be repaired, and must be replaced by the original equipment manufacturer.

Recycling and Disposal

When it comes time to decommission a transformer, recycling provides a positive cash flow. Most components of liquid-filled and dry-type transformers can be reclaimed or recycled. Cast resin type transformers are an exception. Because of their construction, the materials in cast resin type transformers can be difficult and uneconomical to reclaim or recycle. When a cast coil fails, the entire winding, encapsulated in epoxy resin, is rendered useless and typically ends up in a landfill. This creates additional costs for disposal, plus long-term liability exposure to the original owner. In contrast, liquid-filled transformers can be easily recycled after their useful life. The transformer fluid can be reconditioned and used again, and the steel, copper, and aluminum can be completely and economically recycled, providing a positive cash flow.

The scrap values and disposal costs for a 2500 kVA transformer are shown below. Positive cash flows are shown in parentheses ().

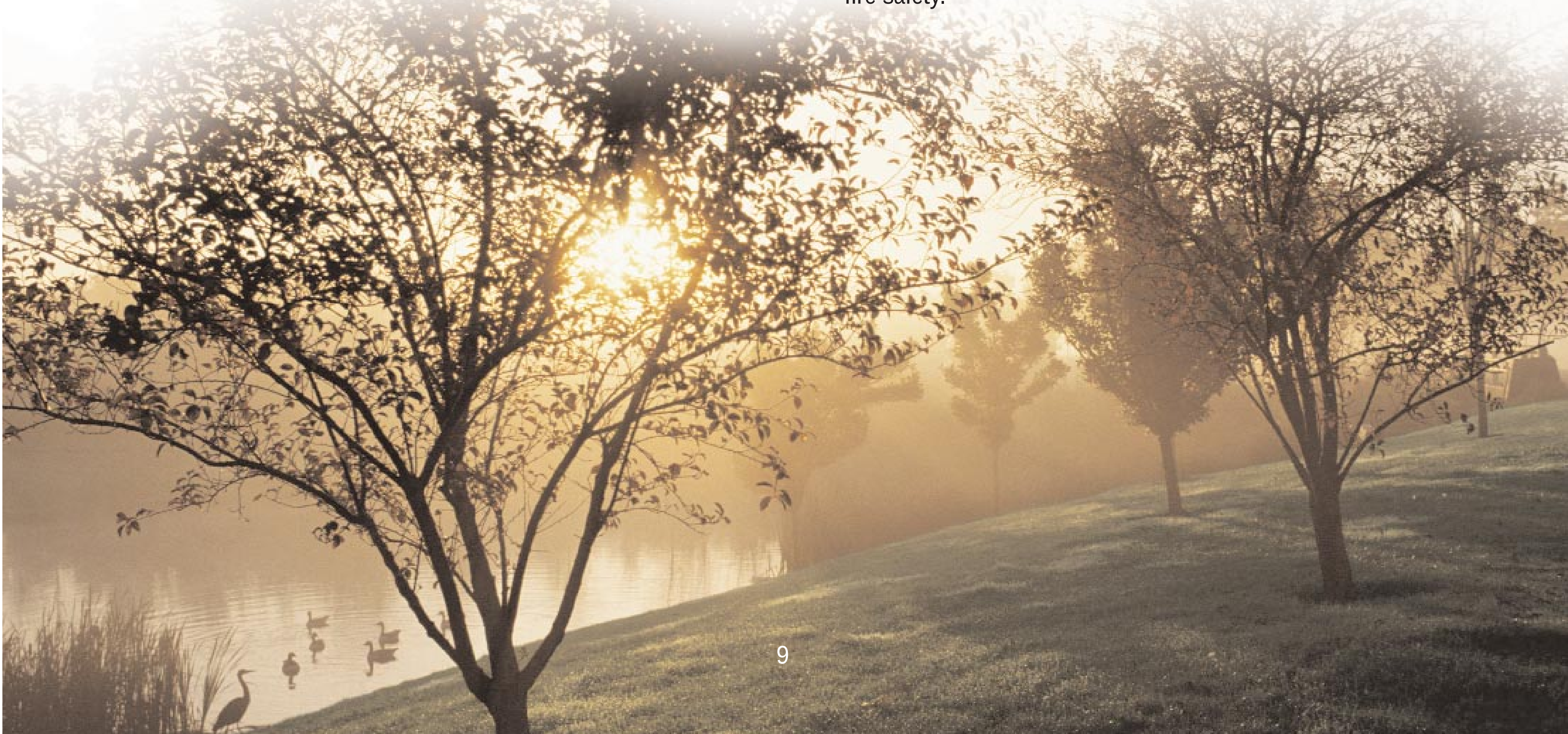
Recycling and Disposal Costs

	VPI Dry	Cast Resin	Liquid-Filled
Dielectric Fluid	$0	$0	($500)
Core & Coil	($1,100)	($100)	($1,200)
Tank & Fitting	($400)	($100)	($400)
Disposal Costs	$0	$400	$0
Total Cost or (Savings)	($1,500)	$200	($2,100)

2500 kVA transformer.

Environmentally Friendlier Fluids

Today's conventional transformer oil is not classified as a hazardous substance by the U.S. EPA. Fluid choices now available can minimize the impact they have on the environment. With the introduction of natural seed oil-based dielectric fluids, an even more favorable option is available. These non-toxic dielectric fluids are made from a renewable resource that biodegrades much more rapidly and completely than mineral and silicone oils. In addition, some of these fluids have a high fire resistance, making them not only environmentally desirable, but also providing enhanced fire safety.



Total Life Cycle Cost

The two biggest factors that affect Total Life Cycle Cost are ***first cost*** and ***energy costs***. Although first cost is a significant factor, energy costs are typically the dominant factor in Total Life Cycle Cost analysis. Because of their higher efficiencies, liquid-filled transformers at equal load use less energy over equal lifetimes than standard dry or cast resin type transformers. Over its lifetime, the energy cost savings from a more efficient transformer typically add up to more than the initial purchase price of the transformer.

Energy Costs

By multiplying the transformer losses by the price of electricity, the total annual energy cost can be calculated. Multiplying this value by the life expectancy will provide a total energy cost. Typically, liquid-filled transformers will provide the lowest energy cost regardless of the fluid chosen. Dry-type transformers, with their higher losses, will subsequently have higher energy costs.

In addition, because liquid-filled transformers run cooler, indoor units place a smaller demand on the building cooling system and, consequently, reduce the amount of energy used.

Transformer Energy Costs

	VPI Dry	Cast Resin	Liquid-Filled
Transformer Load Loss Data (kW)	21.00	18.52	16.38
Transformer No-Load Loss Data (kW)	7.00	7.55	2.66
Transformer Manufacturer Loss Data (total load and no-load losses, kW)	28.00	26.07	19.04
Transformer Operating Efficiency	98.89%	98.97%	99.24%
Present Value of Load Losses	$79,500	$70,100	$62,000
Present Value of No-Load Losses	$41,400	$44,700	$15,700
Present Value of Total Energy Costs	$120,900	$114,800	$77,700

This Present Value of Total Energy Cost calculation is based on a 2500 kVA transformer operating for 30 years at 80% load, with a cost of energy of $0.06 per kilowatt hour and an interest rate of 8% per annum.

Total Life Cycle Cost Summary

The Total Life Cycle Cost of a transformer considers not only first cost and energy costs, but also other peripheral costs such as the cost of installation, maintenance, and decommissioning. This method is the most comprehensive way to evaluate the true costs of a particular transformer alternative. In order to make a comparison of different transformer alternatives, the years evaluated should be equal for each alternative. When the total costs of liquid-filled and dry-type transformers are compared, liquid-filled transformers prove to be the best economic and performance value.

The following is an example of a Total Life Cycle Cost calculation.

Total Life Cycle Cost

	VPI Dry	Cast Resin	Liquid-Filled
First Cost	$25,400	$40,000	$23,000
Energy Costs	$120,900	$114,800	$77,700
Installation & Maintenance Costs	$8,000	$5,000	$4,000
Recycling & Disposal Costs	($1,500)	$200	($2,100)
Total Life Cycle Cost	$152,800	$160,000	$102,600

2500 kVA transformer.

Summary

Each transformer application has its own unique set of requirements that make one transformer type more appropriate than another. In some applications all of the transformer attributes will be important in the decision process, in others only a few. This table provides a thorough comparison of transformer attributes discussed in this bulletin.

When the benefits and cumulative costs for each alternative are compared, liquid-filled transformers provide more flexibility, performance, safety, and value than any other transformer type. Let our staff of sales representatives, application engineers, and customer service personnel help you make the best transformer choice for your project. To find the Cooper Power Systems representative nearest you, visit our website at www.cooperpower.com or call us at 1-877-CPS-INFO.

Standard Transformer Attributes

		High Firepoint Less-Flammable Liquid-Filled				
	Mineral Oil-Filled	**HMWH R-Temp**	**Silicone Oil**	**Natural Ester Envirotemp FR3**	**VPI Dry**	**Cast Resin**
INSTALLATION						
Outdoor	Good	Good	Good	Excellent	Poor	Poor
On Rooftop	Poor	Good	Good	Excellent	Poor	Poor
Adjacent/Attached to Building	Poor	Good	Good	Excellent	Poor	Poor
Public Access	Good	Excellent	Excellent	Excellent	Poor	Poor
Indoor	Poor	Good	Good	Good	Good	Excellent
Code Requirements	Moderate	Low	Low	Low	Low	Low
Environmental Impact	Moderate	Moderate	Moderate	Low	Low	Moderate
PERFORMANCE						
Efficiency	High	High	High	High	Low	Moderate
Design Flexibility	Excellent	Excellent	Excellent	Excellent	Excellent	Fair
Reliability	High	High	High	High	Low	Moderate
Overload Capacity	Good	Excellent	Good	Excellent	Poor	Fair
Life Expectancy	High	High	High	High	Moderate	Moderate/High
Repairability	High	High	Moderate	High	Moderate	Low
Operating Temperature	Low	Low	Low	Low	High	High
Sound Level	Low	Low	Low	Low	High	Moderate
CAPABILITIES						
Standard Impulse Rating	High	High	High	High	Low	Low
Partial Discharge	Excellent	Excellent	Excellent	Excellent	Fair	Good
Harmonic Withstand	Good	Good	Good	Good	Poor	Fair
TRANSFORMER ACCESSORIES						
Integrated Protection Devices	Excellent	Good	Good	Good	Fair	Fair
Other Integrated Components	Excellent	Good	Fair	Good	Poor	Poor
TOTAL LIFE CYCLE COST						
First Cost	Low	Low/Moderate	Moderate	Moderate	Low/Moderate	High
Energy Costs	Low	Low	Low	Low	High	Moderate
Installation Cost Indoor	High	Low	Low	Low	Low/Moderate	Low/Moderate
Installation Cost Outdoor	Low	Low	Low	Low	High	High
Maintenance Costs	Low	Low	Low	Low	Moderate	Moderate
Recycle/Disposal Costs	Low	Low	High	Low	Low	High
Total Life Cycle Cost	Low	Low	Low/Moderate	Low	High	High

Distribution Class Transformers — An Historical Perspective

In 1885, the first distribution class transformer was built. It was a dry-type design, using air as the dielectric coolant. Although the idea that transformers using mineral oil as the dielectric coolant could be smaller and more efficient was patented in 1882, it took another decade before this idea was put into practice. In 1892, the first mineral oil-filled transformer was manufactured and installed.

Since their introduction, mineral oil-filled distribution class transformers have been the transformer of choice. They are specified in more than 97% of distribution transformer applications. Other alternatives to mineral oil-filled distribution transformers, such as dry-type and non-flammable liquid-filled types, were also commercialized, but were used predominately in specialty applications. Most of these applications were for installations that required additional fire safety, primarily for indoor locations and urban network vaults.

In 1975, the first fire-resistant, high molecular weight hydrocarbon-based fluid (HMWH), R-Temp®, was introduced. This less-flammable fluid provides the fire-resistant characteristics without the undesirable environmental characteristics of non-flammable fluids.

In 1976, the Toxic Substance Control Act targeted PCB's, the key component of askarel used in non-flammable liquid-filled transformers. Extensive U.S. EPA regulatory limits soon followed, banning the further production and commercialization of PCB's. Due to the increasingly restrictive governmental regulations, other fire-resistant transformer alternatives were introduced.

Some dry-type transformer manufacturers responded by adding a more robust dry design using vacuum pressure impregnation (VPI), and increased the range of power and voltage ratings. European manufacturers introduced cast coil (cast resin) type transformers that provided improved performance, but cost more than conventional dry or VPI dry-type transformers.

However, most of the askarel-filled transformers selected for removal were replaced with transformers that used less-flammable fluids. Silicone and R-Temp are two of the less-flammable fluids that were predominantly used. Both are commercially available today from major transformer manufacturers.

The introduction of natural ester (seed oil) based fluids, such as Envirotemp® FR3™, is the latest example of innovations in the Industry. Natural fluids provide an environmentally preferred alternative to mineral oil, silicone, and fire-resistant hydrocarbons. These fluids are not only more environmentally desirable, but also have an even higher fire-resistance. Proven with hundreds of unit/years of documented field experience, they now are becoming an accepted alternative to dry-type transformers.

Today, the choices of transformer types and transformer dielectrics provide distinct advantages over the past. Better performance, increased installation flexibility, and improved safety are just some of the advantages of modern day transformers. This brochure provides a comprehensive overview of the attributes of each transformer type and serves as a guide for selecting the best transformer for each application.

You Can Count On Cooper Power Systems Down The Line.

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