

LIQUID INSULATED TRANSFORMERS

INTRODUCTION

In the past, few cost effective options for insulating fluids in liquid filled transformers existed. For this reason, flammable mineral oil was the only viable option associated with liquid filled transformers. This edition of The Wire updates the liquid filled transformer technology and compares with dry-type transformers. Specifically, the following will deal with only indoor applications.

INSULATING FLUIDS

The National Electric Code (NEC) includes three classifications for insulating fluids. These are Flammable, Less Flammable, and Non-Flammable. The fire point of the insulating determines the flammability classification.

Fire point is the temperature at which the flame becomes self-sustained so as to continue burning the liquid. The lower the fire point, the easier it is to ignite the material.

A closely related term is **flash point** and is defined, as is the lowest temperature at which a liquid can form an ignitable mixture in air near the surface of the liquid. Fire point is temperature at which the flame becomes self-sustained so as to continue burning the liquid where at the flash point; the flame does not need to sustain. Typically, the fire point is a few degrees above the flash point. Chart 1 shows the fire points and flash points of the most common transformer insulating fluids.

The temperature ranges that define flammable insulating oils are those below 300°C / 572°F and less-flammable are insulating oils greater than 300°C / 572°F. A defined non-flammable insulating oil is not yet available.

In the past, the commercially available non-flammable oil Askarel was in use. However, the manufacture and use of this oil was discontinued after the EPA ruled against fluids containing PCBs.

NATIONAL ELECTRIC CODE REQUIREMENTS

The 2002 NEC allows for liquid insulated transformer installation in non-combustible buildings, with no combustible materials stored in the area under one of the following three requirements, per NEC 450.23 for all installation 35kV and below:

1. Containment for the liquid **WITH EITHER** an Underwriters Laboratories (UL) or Factory Mutual transformer seal of approval.

OR

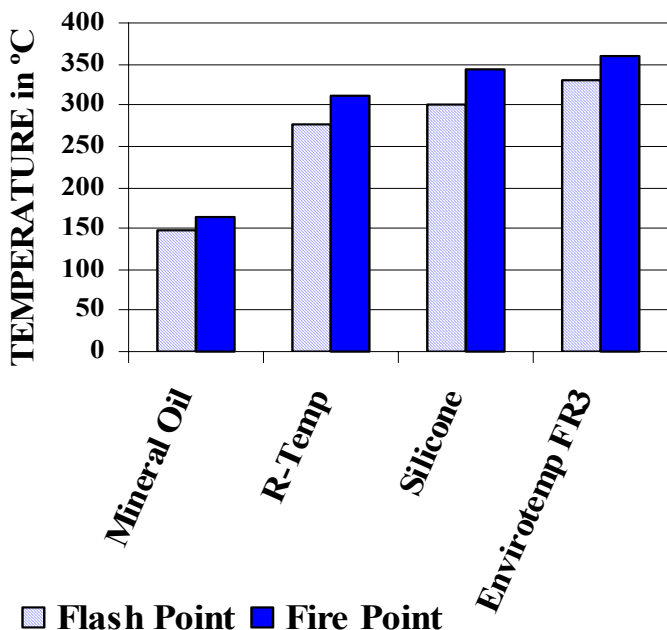


CHART 1 - Insulating Fluid Temperature Ratings

**LIQUID FILLED TRANSFORMERS HAVE BETTER
PERFORMANCE OVER DRY-TYPE TRANSFORMERS**

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- Both liquid containment **AND** auto extinguishment (such as a wet fire protection system)

OR

- Vault** per NEC 450, Part III – this includes 3 hour fire rating, flooring of 4-inch thick concrete, with out occupied space below, If protected by an automatic fire suppression system, the vault can be downgrade to 1 hour fire rating rather the 3 hours as required by NEC-450

A common misinterpretation of the NEC is that **all** liquid transformers require either a separate vault to house the transformer or automatic fire suppression systems. This is not necessarily the case!

Only **flammable** insulating fluids (those with a fire point below 300 °C) require a vault or automatic fire suppression without any exception. In the past, flammable insulating fluids were the only cost effective option available. Given the added construction cost for vaults and/or sprinkler systems, dry type transformers were concluded to be the more cost effective option.

NEC 450.23 also has an exception and defers to NEC 450.26 for the below reason not to comply to NEC 450.23:

- Transformer size less than 112.5 kVA
- Nominal voltage is below 600 - Therefore, the primary and secondary cannot be above 600 volts – note that the NEC does not differentiate between AC or DC voltage and the power cannot exceed 600 volts.
- Electric furnaces below 75kVA
- Charge-Particle- Accelerating not exceeding 75 kVA, 600 volts (what ever this is)
- Detached buildings not complying with NEC 450 part III used for electric service only
- Portable and mobile mining equipment

As you can see, the exceptions offered above address rare, specific exceptions for narrow applications and are sited section 450.26 of the NEC.

VENTILATION

NEC 450.9 dictates ventilation requirements for transformers – both dry and liquid filled. The code requires “ventilation adequate for the transformer full load losses without creating a temperature rise in excess of the transformer rating”. Further, the ventilation opening must be clear of obstructions which prohibit placement of a transformer against a wall.

SOUND LEVELS

A major drawback of dry-type transformers is high sound levels, particularly for indoor applications. The buzzing of dry-type transformers often permeates through surrounding walls and becomes an annoyance for offices, classrooms, and other “quiet” working areas.

Liquid filled transformers offer a lower sound level and, due to immersion in liquid, vibration transmitted to the floor from the transformer is reduced. **Table 1** are the NEMA sound ratings for both liquid filled and dry-type transformers. Although the decibel (dB) may not seem significantly lower, remember that the dB scale is exponential. Meaning, the higher the number, the louder the sound increases.

As a rule of thumb, every ten decibel increase makes the noise seem twice as loud. For example, normal conversation is 50dB. A 1500 kVA liquid filled transformer has a

kVA Rating	Liquid	Dry Type
301 to 500	56	60
501 to 700	57	62
701 to 1000	58	64
1001 to 1500	60	65
1501 to 2000	61	66
2001 to 2500	62	68
2501 to 3000	63	68

TABLE 1 - Transformer Sound Levels

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dB level of 60 dB is twice as loud as normal conversation. A 1500 kVA dry-type transformer at a sound level of 65dB is three times as loud as a conversation. The liquid filled transformer is significantly quieter than dry-type transformers.

SAFETY

The over whelming reluctance to use liquid filled transformers is fire hazard. Mineral filled transformers have a relatively low fire point (160 °C / 320 °F) making the possibility of an insulating fluid pool fire a higher probability when compared to dry-type transformers. By contrast, an Envirotemp liquid filled transformer has a high fire point of 360 °C / 680 °F, over double the fire point of common mineral oil.

Bottom line, Envirotemp has a high fire point and since its released in 1985, not one fire has been reported. Beyond this: **UL, NEC and Factory Mutual now classify vegetable base Envirotemp fluid as not requiring fire suppression systems and special fire walls or vaults.** Therefore, sprinklers and a special room are not required if a liquid transformer with Envirotemp is installed.

Can Fire Resistant fluids ignite? Sure (as can dry-type transformers), however both UL and Factory Mutual have concluded that the risk is so minor the necessity for special vaults, automatic fire suppression and containment are removed.

ENVIRONMENTAL & SECONDARY CONTAINMENT

Does a vegetable – based fluid need special environmental clean-up? Yes, however these clean-up requirement requirements are base on the on biodegradation rates – how long it takes for the fluid to break down into an environmentally benign substance. **Chart 2** shows the biodegradations rates on several transformers.

The environmentally friendly, vegetable based Envirotemp has far faster break-down properties than mineral oil, or for that fact, R-Temp and Silicone insulating fluids. Envirotemp contains no hydrocarbons.

Secondary containment is still required when using Envirotemp fluid. However, the requirements are strictly for

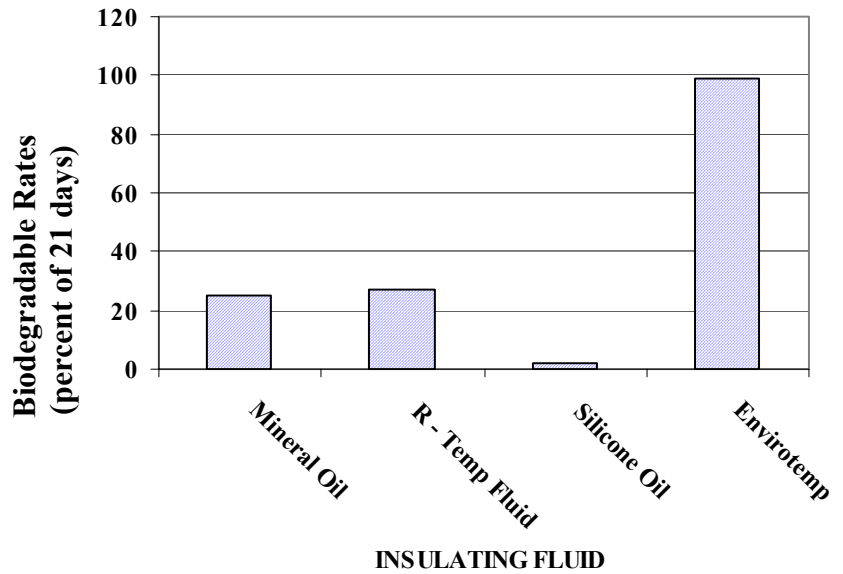


CHART 2 - Transformer Biodegradable Rates

containment. Manufacturers, including Eaton-Electrical, manufacture transformers that have secondary containment. UL requires a 12 psi rating for the secondary containment.

100% of the insulating fluid needs containments in the unlikely event of a tank rupture.

Further, fluid insulated transformers are manufactured with an FM approved, secondary containment tank furnished by the manufacturer is allowed thus eliminating the need for an engineered secondary containment system.

MAINTENANCE

Another perceived draw back to liquid filled transformers is added maintenance. This perception cannot be more false. For approximately \$200 every several years, the fluid is tested for dielectric break-down. This assures the fluid can still insulate the transformer.

FACTORY MUTUAL REQUIREMENTS

Factory Mutual (FM) is an insurance testing agency, similar to UL, specifically testing for fire hazard. FM provides an approval for transformers that were tested under the FM requirements, as does UL. These requirements assure safety and fire requirements. When specifying, always

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requires the more stringent Factory Mutual requirement for transformers.

The needed label designates the transformer is tested and approved as less-flammable, per the Factory Mutual (FM) testing requirements.

COST

Again, the perception is that Envirotemp is more expensive than dry-type transformers which is untrue – technology has arrived. **Chart 3** shows relative cost between transformers. As shown, the cost of an environmentally friendly, liquid filled transformer is only several percent more expensive than a dry-type transformer.

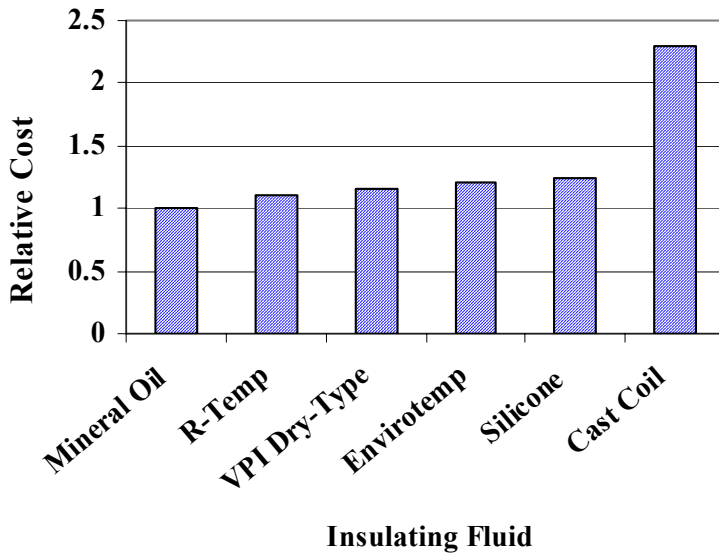


CHART 3 - Relative Cost of Transformers

Now technology provides liquid transformers that are:

1. **Low cost**
2. **Environmentally friendly**
3. **Low maintenance**

Before environmentally friendly transformer fluid technology, mineral oil was the only alternative to dry-type transformers. However, technology has provided a low cost, environmentally friendly, and less flammable transformer insulating fluid.

LIQUID TRANSFORMER ADVANTAGES

Liquid filled transformer offer superior advantages over dry-type transformer including low noise and low cost. Further, liquid filled transformers are low maintenance and environmentally friendly.

So why use a liquid filled transformer? Better insulating properties inherent to liquid transformers increase transformer life and efficiency.

SPECIFICATION of LIQUID TRANSFORMERS

When specifying liquid transformers, the below need to be included:

- **FM Approved** - Eliminates the need for vaults and sprinklers
- **Envirotemp** - Eliminates the potential for costly environmental clean-up
- **Integral Secondary Containment** - Eliminates the need for expensive field constructed dikes and containment