Retrofilling Mineral Oil Transformers with Beta Fluid

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Transformers originally filled with conventional transformer oil can be retrofilled with a fire-resistant oil to increase the fire safety margin of these units. Electrical service and repair companies have discovered this to be a valuable service to offer their customers. This paper discusses the reasons why transformer owners are retrofilling their units and gives guidelines to observe when performing this procedure.

Why Are Transformers Being Retrofilled?

Transformer owners are choosing to retrofill their units for a variety of reasons. The common denominator between them is the need to increase the fire safety of the transformer. Because of changing circumstances, building owners and utilities are often being advised by their insurance companies or attorneys to protect their buildings or to reduce their exposure to potential liability of explosion or fire.

Some of the most common reasons are:

1. Expanding a building: When a building is expanded or remodeled, a transformer that was once a safe distance from exterior walls may now be too close to use conventional transformer oil.
2. Changing regulations or fire codes: As building codes and insurance regulations change, transformers may be reclassified or be required to meet more stringent fire protection guidelines.
3. Liability exposure: Transformers located near public roads or walkways may present an exposure to a potential liability that the owner would like to reduce.

Many times, a building owner will be faced with the requirement of constructing a barrier or enclosure around a pad mounted transformer. Changing the dielectric fluid from conventional mineral oil to a fire-resistant fluid is often a far less expensive option that may be acceptable to the regulatory parties involved. Retrofilling the transformer with a fire-resistant fluid is an easy way to increase the fire safety margin of the unit, lowering the risk of fire or explosion.

Retrofill Fluids

Fire resistant oils are defined as having a fire point of at least 300°C. This is significantly higher than the typical 160°C. fire point of conventional transformer oil.

Look for the following characteristics when choosing which fire-resistant fluid to use:

1. Choose hydrocarbon fluid. There are several hydrocarbon fire-resistant fluids on the from which you can choose. Silicone-based fluids have not traditionally been used in oil retrofill jobs because of problems that may arise as residual oil leaches out of the core and coil of the transformer and mixes with the silicone fluid. Hydrocarbon fluids mix easily with this residual oil without any foaming or dielectric problems. In addition, hydrocarbon fluids are biodegradable. Beta Fluid is 100%2 hydrocarbon and is completely compatible with conventional transformer oil and materials of construction that are used with transformer oil.
2. Choose a fluid with lower viscosity: When comparing fluids, pay particular attention to the viscosity of the retrofill fluid. As the transformer was designed to be cooled with conventional transformer oil, it will run warmer with a thicker fire-resistant fluid. Choosing a fluid with the lowest viscosity possible will minimize this problem.

Transformer Cooling

Transformers that were designed for use with conventional transformer oil will run warmer when filled with a fire-resistant oil. This is because of the higher viscosity of the high fire point fluids. Table One shows the characteristics of Beta Fluid, compared with those of conventional transformer oil. Typically, a transformer designed for conventional oil will run 4-8 °C. warmer after being retrofilled with a fire-resistant fluid.

Residual Transformer Oil

A successful retrofill job depends on removing as much of the original fill transformer oil as possible. A small amount of transformer oil will remain in the unit, saturated in the porous paper and wood components. The majority of this residual oil will be replaced by the Beta Fluid within six months after the unit is retrofilled.

Mixtures of residual transformer oil and Beta Fluid will have good electrical characteristics. Because transformer oil is more flammable than the fire-resistant oil, the mixture will have a lower fire point than the fire-resistant fluid would by itself. If a 300 °C. Fire point is required, a second full or partial retrofill may be considered when the equilibrium between the two fluids has been established (approximately six months).
Approximately 50% of the units retrofilled will require a second drain and fill procedure because of the lowered fire point of the mixture.

Retrofill Procedure

The procedure to retrofill conventional mineral oil with Beta Fluid is relatively simple and straightforward.

These are some of the key points to be used in retrofilling electrical equipment originally filled with PCB fluids or conventional transformer oil.

This list should be used as a guideline; it is not intended to be a complete list of all procedures that may need. Of course, all work should be done in accordance with applicable regulations and good engineering practice.

Key Steps in Retrofilling

1. Access the unit in accordance with owner's regulations. Make sure that the unit is de-energized.
2. Ground all equipment (transformers, pump, tanks, etc.) to control static discharges while you are working.
3. Perform transformer insulation tests (at minimum, a "Megger" test @ 2,000 volts d.c.)
4. Discharge the transformer's high voltage windings and cables.
5. Reground the transformer windings.
6. Drain the existing oil.
7. Allow a minimum time of one-half hour for transformer oil to drain out of the core and coil.
8. Using a small pump and hoses, manually flush the interior of the unit with warm Beta Fluid (5% of the unit's oil volume is recommended) The procedure will be easier if the Beta Fluid is warmed to at least 100°F. Be sure to flush down the core and coil if possible. Try to wash as much of the original fluid as possible out of the unit. Discard this flush fluid and replace the manhole as soon as possible.
9. Allow the unit to drip for 30 minutes, then vacuum or pump the remaining fluid from the bottom of the tank.
10. Replace gaskets if needed (high fire point hydrocarbon fluids are compatible with gaskets used with conventional transformer oil)
11. If the transformer is rated for full vacuum, apply a vacuum of 30 mm Hg on the unit.
12. Begin the retrofill, with warmed Beta Fluid, if possible.
13. Filter the Beta Fluid through 5-micron filters as it is being pumped into the unit.
14. Wait before performing the next insulation tests. This gives air bubbles an opportunity to rise to the top of the fluid. The wait time is dependent on the fluid's temperature. Four hours wait time at a fluid temperature of 50-80°C. is recommended.
15. Perform another set of insulation tests, as in step 3. If the test value has decreased, investigate to determine the cause.
16. Wait again before to energizing the unit. This gives the retrofill fluid time to saturate any porous materials that may have become dry during the process. The wait time is dependent on the temperature of the retrofill fluid. Twenty-four hours wait time is recommended.
17. Observe the unit for leaks during this wait time.
18. Energize the unit without load.

19. Wait three hours minimum after energizing, before adding the load.
20. Apply the load.
21. On the following day, check the unit's temperature and pressure, observe it again for leaks and perform other standard observations and checks.
22. After the retrofill, follow standard maintenance intervals and procedures. Pay close attention to possible leaks from any old gaskets that were not replaced.

Conclusion

Retrofilling a transformer from conventional mineral oil to Beta Fluid can significantly increase the fire safety of electrical equipment. Transformer service companies can solve problems for their customers by performing this procedure, thus providing a valuable service.

Transformers that were designed to use conventional transformer oil will run slightly warmer with fire resistant fluids. Choosing a hydrocarbon-based fluid with low viscosity will ensure that this temperature rise is kept to a minimum.

When performing a retrofill, remove as much of the residual transformer oil as possible. Transformer oil that leaches from the paper and wood in the unit will mix with the Beta Fluid, possibly lowering the fire point. The fluid should be tested in six months to determine if additional work is needed.

Table One

Typical Properties of Dielectric Fluids

Property	Conventional Transformer Oil	Beta Fluid
Viscosity, cSt. @ 100ºC.:	3.0	12.0
Pour Point, ºC.: ASTM D97	-40	-18
Dielectric Strength: ASTM D877, kV:	30	40
Power Factor, % @ 100ºC.,: ASTM D924	0.01	0.01
Spec. Gravity ASTM D1298	0.86	0.87
Flash Pt, ºC.	145	280
Fire Pt, ºC.	160	308