Envirotemp® FR3® Fluid

Recommended Procedures for the Replacement of Oil

COOPER Power Systems

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Recommended Procedures for Replacing Oil with Envirotemp® FR3® Fluid

Introduction

Replacing the mineral oil in a transformer (retrofilling) with Envirotemp® FR3® fluid can be an effective way to upgrade fire safety, slow the thermal aging of insulation, lower the environmental risk and for other benefits in otherwise healthy transformers.

Extensive laboratory testing and field retrofill experience has confirmed excellent miscibility and overall retrofill compatibility for FR3 natural ester fluid with conventional mineral oil and high temperature hydrocarbon fluids (i.e. R-Temp fluid). We do not recommend natural ester retrofill of units previously filled with silicone, due to unpredictable dielectric behavior.

FR3 fluid has service-proven excellent stability and long life in sealed tank design transformers. Designs with free-breathing conservators must be refitted with a positive pressure nitrogen preservation system or expansion bladder-lined conservators to prevent fresh air contact and ensure long-term stability of the natural ester fluid. Please refer to CPS Reference Section R900-20-1, Envirotemp FR3 Fluid Storage and Handling Guide, for additional information on oxidation stability.

Draining and flushing cannot remove all the oil from a transformer, particularly from insulating paper. The conventional mineral oil in the insulation will eventually leach out into the FR3 fluid. There are no known compatibility issues between the two fluid types related to dielectric performance. At greater than 7.5% mineral oil contamination the fire point falls below 300°C. Following this procedure should limit the residual oil to 3-5%. Depending on the size, type and operating temperature it may take 6-18 months to reach equilibrium.

A transformer designed for conventional mineral oil may run at higher temperature after retrofilling with FR3 fluid. For ratings up to 5 MVA, a 1-2 °C increase is typical. For larger transformers the increase will be greater. Forced oil cooling design (FOA and OFAF ratings) operating temperatures will be closer to those for mineral oil. Since the fan operation is triggered by fluid temperature, the higher temperature rise will only affect operating temperatures at the fan-cooled rating.

Performance issues related to deficient dielectric design and construction, such as corona or partial discharge may not be remedied by fluid replacement. Retrofilling may be viable for reducing PCB or other contamination levels, thereby simplifying regulatory requirements for labeling, monitoring and spill reporting. However, this guide does not address regulations for the handling or disposal of PCB or other regulated hazardous materials.

Refer to the following CPS FR3 fluid documents for additional information: Product Information (B900-00092), Storage and Handling Guide (S900-20-1), Testing Guide (R900-20-12), and Dissolved Gas Guide (R900-20-19).

Transformer Condition Assessment for Retrofill

A visual inspection to confirm integrity of all seals/ bolted connections, and proper operation of gauges should be performed. The complete transformer and insulating fluid test and maintenance history should be compiled and reviewed, including current sample testing. Analysis of moisture, dissolved gases and furans should be compared to known loading history. This may indicate whether retrofill is appropriate, as well as additional maintenance operations to be performed while the unit is out of service.

Before and After De-Energizing Equipment:

1. Obtain transformer gasket set
2. Order needed replacement parts
3. Note site limitations for equipment
4. Schedule old oil disposal
5. Schedule new fluid delivery
6. Obtain container for flush fluid
7. Note drain, fill, & vacuum connections
8. Limit air and moisture exposure whenever possible
9. Most moisture removal methods are acceptable, however hot air drying is not. Contact CPS with questions.

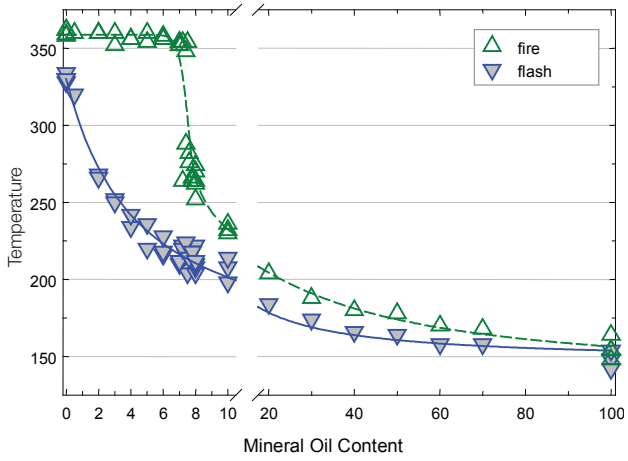

Figure 1. Envirotemp FR3 fluid flash and fire point variation with conventional transformer oil content

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Step	Key Points	Comments
1. Access the unit	Follow owner's regulations. Record all nameplate information and determine allowable tank vacuum.	Make sure the unit is isolated from the power system.
2. Ground all equipment	Includes transformer, pump, and tanks.	Ensures complete discharge.
3. a. Perform insulation resistance and power factor tests	Use procedure recommended by instrument manufacturer. Record the fluid temperature.	Should be done with fluid at ambient temperature.
b. Discharge transformer	HV windings and cable	Eliminates capacitive charge.
c. Reground equipment		Controls static charge buildup.
4. a. Take oil samples	Take samples for fluid analysis and dissolved gas per ASTM procedures.	Provides a baseline of transformer condition at the time of retrofill.
5. Drain oil	If transformer is level or tilted towards the drain plug, force oil out by applying a positive pressure of 5 psig using dry gas. Otherwise, pump out oil through drain valve.	Radiators must be completely drained by removing drain plugs after oil level is below the lower headers, if upper headers are not accessible for flushing (see step #8).
6. Replace all oil-immersed gaskets.	Tighten to proper compression based on component function and gasket material.	Aged gaskets may leak after retrofill.
7. Allow minimum ½ hour drip after draining	2 hours is preferred. Pulling vacuum within tank mechanical limit will accelerate drip.	A longer drip time is advantageous to reduce residual mineral oil.
8. Flush with hot FR3 fluid (≈ 5% of fluid volume)	Use minimum pressure to avoid dislodging contaminants. Flush through the fill plug or bolted access. Be sure to flush radiators. Set bolted access in place ASAP.	Recommended flushing fluid temperature is 50-80°C.
9. Allow ½ hour drip		A longer drip time is advantageous.
10. Remove dregs from bottom of transformer	Access can be gained by removing drain valve.	Minimizes the residual mineral oil.
11. Pull vacuum within tank mechanical limits.	Start fill through drain plug when base pressure is reached.	Minimum 50°C fluid temp. Use 0.5 μm filters. Limit base pressure to tank rating.
12. Dry nitrogen blanket	Bring headspace pressure to 2-3 psig.	
13.a. Wait prior to repeating insulation resistance test	4 hours is preferred. Wait time depends on fluid fill temperature.	
b. Perform insulation resistance and power factor tests	If temperature-corrected value decreased, investigate cause.	Insulation resistance may decrease due to lower resisivity of FR3 fluid. Power factor may increase due to higher dissipation of FR3 fluid.
c. Discharge & reground	As in 3b and 3c.	
14. Install retrofill label	Fill out label using #2 pencil.	
15. Wait to energize unit	24 hours is preferred. Wait time depends on fluid fill temperature.	Allows gas bubbles to dissipate.
16. Take oil samples	Check & maintain positive pressure. Take samples as in 4a.	Verifies the unit is leak-free. Provides a base line for new fluid.
17.a. Energize unit (no load)		
b. Wait prior to adding load	3 hours minimum.	
c. Connect load	Observe unit for leaks.	

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Step	Key Points	Comments
18. Next day, check the temperature and pressure	Observe unit for leaks and other signs of problems.	
19. Follow the standard maintenance schedule and procedures	Pay close attention to signs of leaks from gaskets. Take samples as in 4a after six months.	
20. Monitor tank pressure to confirm tank seal.	A constant 0 psig on gauge, despite temperature changes, indicates a leak.	

CAUTION: The above recommendations apply to retrofilling in general. Each installation may require additional steps. Stricter compliance with the above steps, or additional steps not listed, may be indicated by service records, test results, manufacturer recommendations, site inspection of the transformer or other industry maintenance and operating practices. All applicable safety codes and procedures must be followed.

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