Dielectric Fluids

Reference Data

Guide for Atmospheric Retrofilling of 25KV (or lower) Distribution Class Transformers ≤ 7500KVA

R2010

IMPORTANT:

This reference guide applies to retrofilling transformers in general and is not intended to convey safety information. Refer to original manufacturer's Operation and Maintenance guide for each transformer prior to beginning the retrofill process. 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 and installer's recommendations, applicable code requirements, site inspection of the transformer or other industry maintenance and operating practices. All applicable safety codes and procedures must be followed.

GENERAL

Replacing the mineral oil in a distribution transformer (retrofilling) with Envirotemp FR3 fluid can be an effective way to upgrade fire safety, slow the thermal aging of cellulose insulation, and lower the environmental risk 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 many dielectric fluids including conventional mineral oil, high temperature hydrocarbon fluids (i.e. R-Temp fluid), PCBs, and most PCB substitutes except silicone. FR3 fluid is not miscible with silicone and should not be applied in transformers previously containing silicone.

FR3 fluid has service proven stability in sealed transformers. Transformers with a free breathing conservators should be modified to prevent the dielectric fluid from coming in contact with replenishing air. This will help ensure long term stability of the natural ester fluid.

Draining and flushing cannot remove all the dielectric fluid from a transformer, particularly from insulating paper. The mineral oil in the paper insulation will eventually leach out into the FR3 fluid until equilibrium is achieved. Mineral oil is fully miscible and compatible with FR3 fluid, however if the concentration of residual mineral oil exceeds 7.5% by volume, then FR3 fluid's fire point will fall below 300 °C. Following this guide should limit the residual oil to 3-5%.

A transformer designed for conventional mineral oil may run at higher temperature after retrofilling with FR3 fluid. For CPS transformer designs, up to 4-5 °C increase is typical. Because insulating paper aging rate is significantly slower when impregnated with FR3 fluid, any typical temperature increase should not negatively impact the insulation life.

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 potentially 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 FR3 fluid documents for additional information: FR3 Data Sheet (R2000), FR3 Fluid Storage and Handling Guide (S10), FR3 Fluid Test Summary (R2030), and Dissolved Gas Guide (R2060), Loading Guide A and B Factors for Envirotemp FR3 Fluid and Thermally Upgraded Kraft Insulation (R2110).

TRANSFORMER CONDITION ASSESSMENT

A visual inspection to confirm integrity of all seals/ bolted connections, and proper operation of gauges should be performed. This may indicate whether additional maintenance operations should be performed while the unit is out of service.

Pre-Retrofill Steps:

1. Obtain original Operation and Maintenance guide for each transformer
2. Obtain transformer gasket set
3. Order needed replacement parts
4. Note site limitations for service equipment
5. Schedule old oil disposal
6. Schedule new fluid delivery
7. Obtain container for flush fluid
8. Note location of drain, fill, & vacuum connections
9. Limit air and moisture exposure whenever possible
10. If moisture removal (dry out) of coils is required, several methods are acceptable, however hot air drying is not. Refer to Storage and Handling Guide (S900-20-1) for additional information.

IMPORTANT:

Unlike assemblies impregnated with mineral oil, hot air drying is an unacceptable process for reducing power factor of assemblies already impregnated with a natural ester fluid. For additional drying of natural ester impregnated assemblies, a method of drying that does not expose the impregnated insulation to air is required to avoid polymerization of the dielectric fluid. See Storage and Handling Guide (S900-20-1), Reprocessing Impregnated Insulation section in Power Factor Measurements for recommended procedures.

GUIDE A: REPLACING MINERAL OIL WITH FR3 FLUID IN DISTRIBUTION TRANSFORMERS < 500KVA AT A TRANSFORMER SERVICE SHOP

Step	Key Points	Comments
1. Adhere to all required safety precautions, codes, and regulations	Follow manufacturer's recommendations for servicing each transformer; additionally, adhere to all required safety precautions, codes, and regulations	
2. Visual inspection	Confirm integrity of seals, bushings, and bolted connections	
3. Drain oil	Allow time for oil to drip to bottom of tank	A longer drip time is advantageous to reduce residual mineral oil
4. Rinse with FR3 fluid (~ 5-10% of the fluid volume)	This step rinses most of the remaining free oil to the bottom of the tank	Minimizes residual oil and other contaminants
5. Remove dregs from tank bottom	Minimizes the residual oil and other contaminants	
6. If required, dry coils	Hot air drying is unacceptable; see Storage and Handling Guide (S900-20-1) for additional information	
7. Replace Gaskets with new set	Helps ensure proper sealing	Old gaskets may leak after retrofill
8. Fill transformer directly from tote or drum	Heating and filtering are not required	FR3 fluid as-received in sealed totes and drums is satisfactory for use in small distribution transformers
9. Top off with dry air or nitrogen and bring headspace pressure to 2-3 psig	Verify gaskets and seals are working properly	Limits exposure to oxygen and atmospheric contaminants
10. Install retrofill label	Fill out CPS Retrofill label using indelible pen	Document FR3 fluid batch number from tote or drum for future reference
11. Wait to energize unit	24 hours is preferred	Allows gas bubbles to dissipate
12. Next day, check pressure to ensure proper seal	Limits exposure to oxygen and atmospheric contaminants	

GUIDE B: REPLACING MINERAL OIL WITH ENVIROTEMP FR3 FLUID IN PAD MOUNTED, NETWORK, OR DISTRIBUTION SUBSTATION TRANSFORMERS 500KVA THROUGH 7500KVA

Step	Key Points	Comments
1. Obtain original Operation and maintenance guide for each transformer	Follow Manufacturers recommendations for servicing each transformer, adhering to all required safety precautions, codes and regulations	
2. Access the unit	Follow applicable safety precautions and regulations. Record all nameplate information and determine allowable tank vacuum	Make sure the unit is isolated from the power system
3. Ground all equipment	Includes transformer, pump, and tanks	Ensures static discharge
4. Take oil samples if required	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	If required, after level is below the lower header, completely drain radiators by removing drain plugs. Properly seal drain plugs when reinstalling
6. Replace all oil-immersed gaskets	Tighten to proper compression based on component function and gasket material	Old gaskets may leak after retrofill
7. Allow minimum ½ hour drip after draining	>2 hours is preferred	A longer drip time is advantageous to reduce residual mineral oil. If the tank can withstand forces, pulling vacuum within tank mechanical limit will accelerate drip
8. Flush with 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	To reduce viscosity, CPS recommends flushing fluid temperature between 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. Fill transformer	Bottom filling is recommended to avoid trapping air bubbles. Optimal fill process includes heating and filtering fluid. For fluid received in bulk tanker shipments, processing the fluid is mandatory	To reduce viscosity and minimize set time, CPS recommends minimum 50 °C fluid temp. Filling under vacuum or partial vacuum will limit fluid exposure to atmospheric contaminants and is the preferred method
12. Top with dry air or nitrogen blanket. Bring headspace pressure to 2-3 psig	Verify gaskets and seals are working properly	Limits exposure to oxygen and atmospheric contaminants
13. Install retrofill label	Fill out CPS Retrofill label using indelible pen. Attach to transformer	
14. Wait to energize unit	Wait time depends on fluid fill temperature	Allows gas bubbles to dissipate
15. a. Energize unit		
b. Connect load	Observe unit for leaks	
16. Next day, check the temperature and pressure	Observe unit for leaks and other signs of problems	
17. Follow the standard maintenance schedule and procedures	Pay close attention to signs of leaks from gaskets. Take samples, as mentioned in step 4, after six months	
18. Periodically monitor and record tank pressure to confirm tank seal	A constant 0 psig on gauge, despite temperature changes, indicates an air leak	

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