FR3®

G2040

Retrofilling Power Class Transformers Guide

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.

RETROFILLING PROCEDURE

Replacing the mineral oil in a power class transformer (retrofilling) with Cargill FR3® fluid can be an effective way to upgrade fire safety, slow the thermal aging of insulation, lower the environmental risk and improve the short term overload-ability of an otherwise healthy transformer.

Extensive laboratory testing and field 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). 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 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.

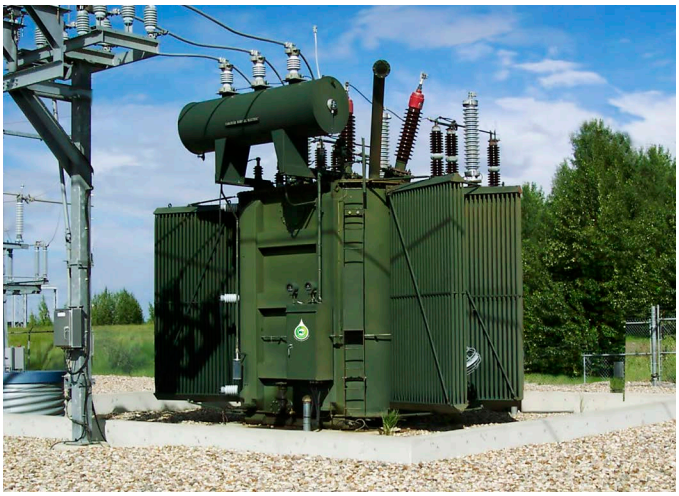
Draining and flushing cannot remove all the dielectric fluid from a transformer, particularly from insulating paper. The mineral oil in the paper insulation will eventually leach out into the FR3 fluid until equilibrium is achieved. Mineral oil is fully miscible and compatible with FR3 fluid; however 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 ratings up to 10 MVA, a 4-5°C increase is typical. 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. Because insulating paper aging rate is significantly slower when impregnated with FR3 fluid, any typical temperature increase should not negatively impact the insulation life.

It is strongly recommended that filling power class transformers be completed under vacuum, within the constraint of the tank capability. Some transformers may not be rated for full (or partial) vacuum. When filling units at atmospheric pressure with FR3 fluid, heating and filtering the fluid are strongly recommended to maximize performance. Fluid temperatures during tank filling operations at atmospheric pressure should be 75°-80°C (165°-175°F). Longer set times to allow for trapped air bubble gas absorption are recommended when filling at atmospheric pressure.

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. 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), Dissolved Gas Guide (R2060), Transformer Power Factor and FR3 fluid (R2100), Loading Guide A and B Factors for FR3 fluid and Thermally Upgraded Kraft Insulation (R2110).



FR3 fluid has been used in distribution and power transformers through 420kV.

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. Adhere to all safety precautions, codes and regulations. Follow all locally approved safety practices and procedures
2. Obtain original Operation and Maintenance guide for each transformer
3. Obtain transformer gasket set
4. Order needed replacement parts
5. Note site limitations for service equipment
6. Schedule old oil disposal
7. Schedule new fluid deliver
8. Obtain container for flush fluid
9. Note location of drain, fill, & vacuum connections
10. Limit air and moisture exposure whenever possible
11. 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 (S10) for additional information

REPLACING MINERAL OIL WITH FR3 FLUID IN PAD MOUNTED, NETWORK, OR DISTRIBUTION SUBSTATION TRANSFORMERS 500kVA THROUGH 7500kVA

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. 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	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 (34 kPa) using dry gas. Otherwise, pump out oil through drain valve	Radiators must be completely drained byremoving drain plugs after oil level is belowthe 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	Original gaskets that weep or leak should be replaced. Elastomers including NBR types with higher nitrile content, silicone or fluoropolymer are recommended. Gaskets with higher temperature demands warrant the use of silicone or fluoropolymer (Viton) compositions
7. Allow minimum ½ hour drip after draining	Two 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	To reduce viscosity, Cargill 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	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. Top with dry air or nitrogen blanket. Bring headspace pressure to 2-3 psig (13-20 kPa).	Verify gaskets and seals are working properly	Limits exposure to oxygen and atmospheric contaminants
13. Install retrofill label	Fill out label using #2 pencil	
14. Wait to energize unit	24 hours is preferred. Wait time depends on fluid fill temperature	Allows gas bubbles to dissipate
15. Take oil samples	Check & maintain positive pressure. Take samples as in 4	Verifies the unit is leak-free. Provides a base line for new fluid
16. a. Energize unit (no load)		
b. Wait prior to adding load	Three hours minimum	
c. Connect load	Observe unit for leaks	
17. Next day, check the temperature and pressure	Observe unit for leaks and other signs of problems	
18. Follow the standard maintenance schedule and procedures	Pay close attention to signs of leaks from gaskets. Take samples as in 4 after six months	
19. Periodically monitor and record tank pressure to confirm tank seal.	A constant 0 psig (0 kPa) on gauge, despite temperature changes, indicates a leak	

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