

Proven performance in non-free breathing transformers

In non-free breathing transformers (transformers where ambient air and oil are not in continuous, direct contact for extended time periods), there is no concern about the oxidation stability of Envirotemp™ FR3™ fluid. FR3 fluid has been formulated to meet IEC and IEEE standards for oxidation stability, while also achieving best-in-class environmental properties.

Dielectric Fluid Oxidation

All dielectric fluids oxidize, and the byproducts of oxidation may affect the performance of a transformer. However, each fluid type oxidizes differently. The differences between mineral oil and natural esters are as follows:

- The byproducts of mineral oil oxidation form substances that precipitate from the fluid; in application, the long term effect could be sludge formation on surfaces within the transformer, and likely will weaken dielectric strength.
- The byproducts of natural ester oxidation form oligomers (larger molecules) that stay in solution; in application, the long term effect could be a slight increase in the fluid viscosity, but no sludge formation, and no impact to dielectric strength or dielectric performance.

In transformer application, this process takes years – even within a free-breathing transformer.

Oxidation Stability Tests and Their Relevance

Laboratory oxidation stability tests for any dielectric fluid are not intended to simulate operational performance within a transformer. They are an accelerated method for assessing the amount of oxidation in a given time. The resultant byproducts (sludge and acid products formed when the mineral oil is tested under prescribed conditions) are then compared against standard, predictable, acceptable limits. Whether it's a mineral oil standard test (ASTM D2440) or a natural ester standard test (IEC 61125 C), **“there is no proven correlation between performance in this test and performance in service, since the test does not model the whole insulation system (oil, paper, enamel, wire).”** [taken from ASTM D2440]. These tests are to be used as control tests for evaluating the relative oxidation stability of dielectric oils in a laboratory environment. FR3 fluid meets the IEC oxidation stability requirements for natural ester fluids.

To add a bit of clarity, the common mineral oil oxidation stability tests involve bubbling oxygen through the fluid. No transformer applications include bubbling oxygen. To reiterate, oxidation stability tests provide a relative/comparative measure and do not simulate in-service application.

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Application Experience

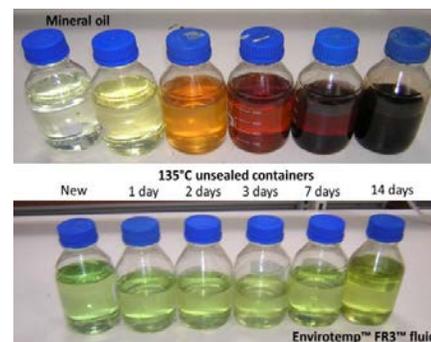
Within a non-free breathing transformer, fluid exposure to the atmosphere is miniscule; even intermittent exposure (as experienced in a transformer that leaks, or when a gasket fails) will not cause FR3 fluid to react quickly, allowing for standard maintenance practices to identify the leak and reseal the transformer without significant oxidation occurring. Subsequently, natural esters perform beyond the life of the transformer.

FR3 fluid has performed effectively in over 750,000 transformers on six continents for up to 20 years. This application experience includes:

- True free-breathing transformers (for up to 11 years) and LTC's
- Sealed transformers and transformers retrofit with bladders in the conservators, including units with incorrectly installed bladders
- Five-year large volume and thin film oxidation studies, supported with numerous laboratory tests conducted over extensive time periods, which verify FR3 fluid's performance in application

Even though the rate of oxidation is faster than mineral oil, the time required to oxidize thin films is typically long enough to allow normal maintenance procedures (lasting days through a few weeks) to be used during transformer repairs (when the components are outside the transformer, or the exposed transformer tank has been emptied). FR3 fluid stability has been proven to be sufficient for real life application at most climate conditions and maintenance practice throughout the world. Within a transformer, oxidation stability is not a limiting factor for FR3 fluid.

Simple 'good housekeeping' handling steps and recommendations minimize the potential for any issues.



Comparison of mineral oil and FR3 fluid in unsealed containers up to 14 days

Reference Material: Cargill R2080 FR3 Thin Film Oxidation 9-15; Cargill Leesburg Case Study. For additional information, contact your local Cargill Dielectric Fluids group.

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