

Oxidation Stability of Envirotemp™ FR3® Natural Ester Fluid

Stability is an important property for the long-term reliability of a dielectric fluid in a transformer. When mineral oil ages it produces sludge and aggressive acids that hurt the performance of the insulation system and the overall transformer.

Accelerated insulation aging tests performed by Cooper Power Systems have shown excellent stability of Envirotemp FR3 fluid (E-FR3). In-service transformer monitoring of distribution transformers has confirmed E-FR3 to be non-sludging and stable after more than 7 years of service. Doble Engineering has performed their Power Factor Valued Oxidation (PFVO) Test and confirmed E-FR3 to be non-sludging. Although acids are formed as E-FR3 ages, they are much less aggressive than those formed in mineral oil.

Industry-wide test methods and acceptance limits have not yet been established for assessing the oxidation stability of natural esters and requirements for application in electrical equipment. This is confirmed in the recently published ASTM D6871-03, Standard Specification for Natural (Vegetable Oil) Ester Fluids Used in Electrical Apparatus.

Appropriate use of ASTM D2440-99, Standard Test Method for Oxidation Stability of Mineral Insulating Oil, and ASTM D2112-01 Standard Test Method for Oxidation Stability of Inhibited Mineral Insulating Oil by Pressure Vessel, is limited to quality assurance analysis of new mineral oil and in the case of D2240-99, also evaluating the effectiveness of oxidation inhibitors in mineral oil. Both standards state that there is no correlation of test results to performance of mineral oil in service. To use either of these methods to evaluate natural ester oils runs directly counter to their stated scope and purpose.

Although vegetable oils are inherently less resistant to oxidation than mineral oil, manufacturers have varying opinions on the degree of oxygen resistance that is required of a dielectric fluid for use in a transformer. One manufacturer favors higher oxidation stability at the expense of low temperature flow. Numerous tests have shown that the oxidation stability of E-FR3 is adequate for use in transformers. CPS prefers to extend the low temperature flow limits and reduce the viscosity across all temperatures, than to pass tests that have no bearing on performance in transformers.

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Short term exposure to air during periodic maintenance presents no risk of oxidation of Envirotemp FR3 fluid. However, we do not recommend using our fluid in transformers designed to be free breathing. If a unit designed to be sealed were to breath, you could detect this in at least two ways. First, the nitrogen preservation system would no longer be able to maintain a positive pressure and the PV gauge would show zero pressure. Second, the dissipation factor of the fluid would rise long before any performance related properties such as viscosity and dielectric strength were affected.

For more than 5 years CPS has operated free breathing outdoor transformers, with 1/16 inch diameter holes in the tank walls. The fluid showed an increased dissipation factor fairly early in the process, but only recently has started to polymerize enough to slowly increase viscosity. Dielectric strength remains good.

Exposure of the fluid to air while doing routine maintenance would not be detrimental to the fluid as long as it was limited to 2 weeks or less. In this time frame it is very unlikely that even the dissipation factor would show any change. A breathing transformer might start to show a small change in dissipation factor after a year in such a condition. Therefore, routine annual or semi-annual inspections would detect this problem just when the fluid might show the earliest sign. In both the maintenance and breather scenarios, the dissipation factor will signal an abnormal condition long before there are any performance issues. Only after the service-aged fluid test limits were exceeded would there be any need to replace or reprocess the fluid by filtering or degassing.