Dielectric Fluids

Reference Data

Cold Start Recommendations for Envirotemp™ FR3™ Fluid Filled Transformers

R2120

IMPORTANT:

This reference guide applies to only transformers filled with Envirotemp FR3 fluid and is not intended to convey safety information. Refer to original manufacturer's Operation and Maintenance guide for additional considerations. All applicable safety codes and procedures must be followed.

INTRODUCTION

Envirotemp FR3 fluid behaves differently at low temperatures than does mineral oil. IEEE defines the lower limit of usual service conditions as -20°C (-6°F). For those transformers operating in environments colder than this, these difference are important.

Mineral oil may shrink, crack, and create voids as it cools beyond its pour point temperature. Energizing a transformer when the dielectric liquid contains voids could create an immediate dielectric failure as air is a significantly poorer insulation media than oil. Additionally, mineral oil will tend to condense out water, especially since it has a low water solubility limit. Moisture in a dielectric liquid like mineral oil, either dissolved or free, can contribute to low dielectric strength and cause dielectric failure.

Envirotemp FR3 fluid shows a reduced tendency to develop voids when cooled beyond its pour point temperature compared to other dielectric liquids. Envirotemp FR3 fluid has a high water saturation point and it is unlikely that water will condense out of the liquid upon cooling. Over 300 ppm moisture in Envirotemp FR3 fluid is required to saturate it at 0°C. This level of moisture is not typically in normally operating transformers.

WHAT HAPPENS TO ENVIROTEMP FR3 FLUID WHEN IT'S COLD?

Physical

The pour point of Envirotemp FR3 fluid is about –20°C, the same as the pour point of R-Temp fluid. This is the lowest temperature at which it will flow. The pour point of transformer mineral oil is typically ≤ -40°C (≤-40°F).

Unlike water, Envirotemp FR3 fluid does not have a well-defined solid/liquid phase transition temperature. During extended exposure to very cold temperatures, Envirotemp FR3 fluid does not change immediately from liquid to solid, but instead begins to thicken, and with time, can gel. Its viscosity near the pour point depends not only on the temperature, but also time at temperature (see Figure 1).

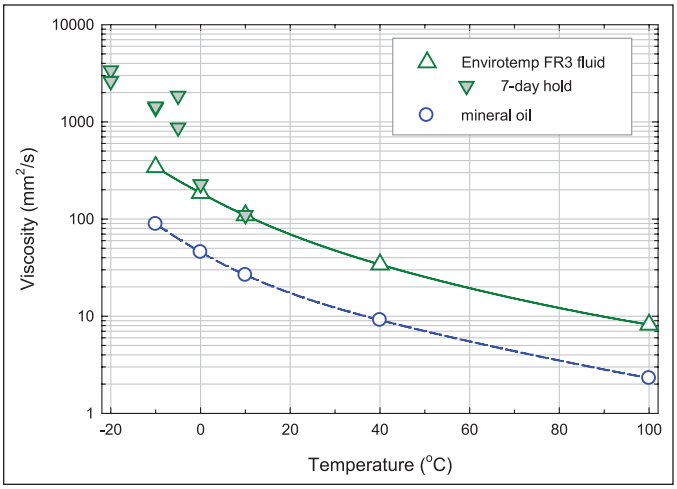

Figure 1.
Kinematic Viscosities of Dielectric Fluids

Although Envirotemp FR3 fluid maintains acceptable electrical strength at temperatures below its pour point, the more viscous fluid may hamper mechanical movement, and extinguish arcs more slowly. Consult your transformer or component equipment suppliers to confirm their test results and to obtain their recommended procedures for cold starting transformers when fluid temperatures are below –20°C.

Electrical

Envirotemp FR3 fluid maintains its dielectric strength down to at least –50°C (-58°F). Unlike mineral oil, Envirotemp FR3 fluid is not likely to saturate and allow formation of free water, greatly reducing risk of dielectric failure at low temperatures.

WHAT DOES THIS MEAN IN PRACTICAL TERMS?

It is important to recognize that for transformers in service, the temperature of fluid is significantly higher than ambient. Even no load losses are typically enough to keep the fluid temperature above concern. In the event of prolonged outages or extended periods of time where equipment is exposed to temperatures that are continuously lower than –20°C, the viscosity of the fluid could increase, hampering fluid flow. However, full scale tests confirm that transformer losses quickly warm the fluid such that normal flow and cooling result, without undue aging of the insulation system.

Envirotemp FR3 Fluid Filled Transformers

Transformers containing Envirotemp FR3 fluid can be energized at any fluid temperature so long as no moving components are actuated immediately before or soon after energization.

The discussion of cold starting transformers can be broken down into three events.

1. An Envirotemp FR3 fluid filled transformer was energized when an upstream event caused an outage. The upstream device has been repaired, and the de-energized transformer needs to be re-energized. Cargill recommends re-energizing this transformer using normal cold start procedures regardless of ambient temperature or state of Envirotemp FR3 fluid in the transformers. Since the transformer was energized prior to the event, no mechanical movement should be required to re-energize the transformer.

2. An Envirotemp FR3 fluid filled transformer will be taken from inventory and installed and energized. Cargill recommends storing all Envirotemp FR3 fluid filled transformers such that no mechanical movement is required to energize the transformer (i.e., store the transformer with the On/Off switch in the 'On' position). If this approach is adopted, no mechanical movement should be required to energize the transformer, once installed, Cargill recommends energizing this transformer using normal cold start procedures regardless of ambient temperature or state of Envirotemp FR3 fluid in the transformers.

3. An Envirotemp FR3 fluid filled transformer was energized, and an under oil component caused an outage (for example, a Bay-O-Net fuse blew). If this event occurs during a severe cold snap (-30°C or colder for extended period of time), it is possible the the fluid in proximity to the component will reach ambient temperature, and could impact the ability to repair the component. In this event, Cargill recommends heating the transformer with an external heater (can be facilitated by placing a tent around the transformer and using a torpedo heater for example) until the fluid around the component is liquid. When appropriate, repair or replace the failed component and re-energize the transformer regardless of the ambient temperature or state of the fluid in the transformer.

Fans

During cold start, the fluid in the radiators will warm up considerably slower than the fluid in the main tank. For this reason, the fans should not come on immediately, but should turn on when the additional cooling is required.

Switches

Follow the manufacturer's recommended practice.

Bay-O-Net Fusing

Follow the manufacturer's recommended practice.

COLD START TEST

Distribution class transformers instrumented to measure core, coil, and oil temperatures were tested. They were energized at full rated load at -30°C (-22°F) without incident or unusual temperature excursions [1].

References

[1] K.J. Rapp, G.A. Gauger, J. Luksich, "Behavior of Ester Dielectric Fluids Near the Pour Point", IEEE Conference on Electrical Insulation and Dielectric Phenomena, October 17-20, 1999, Austin, TX

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