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WAUKESHA ELECTRIC SYSTEMS' POSITION ON LOADING BEYOND NAMEPLATE OF A TRANSFORMER RETROFILLED WITH ENVIROTEMP™ FR3™ FLUID

Background

Generically, you can load a transformer that has been retrofilled with Envirotemp™ FR3™ fluid, beyond its nameplate value. As with a mineral oil filled transformer, the question is, what are the consequences of that loading. The IEEE Std C57.91-1995 IEEE Guide for Loading Mineral-Oil-Immersed Transformers, describes many aspects that should be considered when loading a transformer beyond nameplate rating. Even though the Guide was written specifically for mineral oil immersed transformers, much of the information is still pertinent to natural ester fluid immersed transformers but there are some differences. Section 4 of the Guide is a good overview of the consequences of loading beyond nameplate rating.

One of the most significant concerns about loading beyond nameplate rating is the effect on cellulose insulation life. Section 5 of the Guide and several of the Annexes deal with transformer insulation life. Section 5.2 has an aging equation that relates insulation deterioration to time and temperature. The equation has two constants, A and B. These constants for natural ester fluid are different than for mineral oil. Cooper Power Systems has used laboratory derived data to determine the values for A and B for their Envirotemp™ FR3™ fluid.

Waukesha Electric Position

Based on calculations made with Cooper's values for A and B, the aging rate of cellulose in FR3 fluid is significantly less when operated at the same temperature in mineral oil. When cellulose is operated at higher temperature, as would be the case in loading beyond nameplate rating, the aging rate increases, but does not increase as much if immersed in natural ester fluid. Cooper's laboratory data has shown that the aging rate of cellulose slows after being retrofilled with FR3 fluid. For a better understanding of the A and B constants, how they were derived and the insulation life estimations, please see Cooper Power Systems Bulletin R900-20-22 Titled "Envirotemp FR3 Fluid and Thermally Upgraded Kraft Insulation System Loading Guide", Subtitle "Determination of Arrhenius Equation A and B Factors for the FR3 fluid/TUK System". This paper can be viewed on the Waukesha Electric website at www.WaukeshaElectric.com. Roll your cursor over TOOLS/RESOURCES located on the right side of the top toolbar. Then click on Waukesha Library from the drop down menu. Scroll down to the fourth colored horizontal bar titled "Envirotemp™ FR3™ Natural Ester Fluid. There are a couple dozen papers here covering a broad range of subjects on FR3 fluid.

In the IEEE Guide, Table 8 temperature for Insulated conductor hottest-spot temperature, Short-time emergency loading note and section 9.2.3 discuss dangers caused by gassing and bubble formation. Waukesha believes these problems are reduced with natural ester fluid but the user should still exercise caution when loading to these levels.

Effects due to loading on bushings, current transformers, deenergized tap changers, load tap changers, tank pressure, effects of higher stray flux heating and lead temperatures are much the same as with mineral oil and should be considered. Relative to mineral oil, data from Quality Switch tests published in IEEE Conference proceedings [1] suggests that stationary contact stability improves with FR3 fluid as it has a lower tendency to have higher resistance due to thin film buildup on contacts which can lead to thermal runaway (coking). Cooper has had FR3 fluid tested well beyond current ASTM test methods for corrosive sulfur and no sulfur effect was found.

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[1] L. Dix and P. J. Hopkinson, "Tapchangers for De-energized Operation in Natural Ester Fluid, Mineral Oil and Silicone", 2005/2006 IEEE Transmission & Distribution Conference, May 21-26, 2006, Dallas, Texas, USA



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