

How Envirotemp™ FR3™ fluid helps improve the transformer insulation.

Envirotemp FR3 fluid has been proven to have an insulation life of 5 to 8 times over mineral oil. More specifically, a 5.3x reduction is proposed with neutral kraft paper and a 7.4x reduction with thermally upgraded kraft paper. A large number of international studies, including IEC and IEEE standards' annexes, support this feature. The main underlying processes follow:



Figure 1 - Thermally upgraded paper accelerated aging in FR3 fluid and mineral oil side-by-side comparison. Cooper Power Systems ML-152-2000.

Continuous drying process

Water moves between solid and liquid to reach relative saturation equilibrium. FR3 fluid can hold 10x more water than mineral oil (Fig. 2), therefore, the moisture balance is shifted towards FR3 fluid. The drying is activated by hydrolysis, where the excess water is consumed by the chemical reaction with FR3 fluid. No paper “over drying” occurs, as the water equilibrium is maintained.

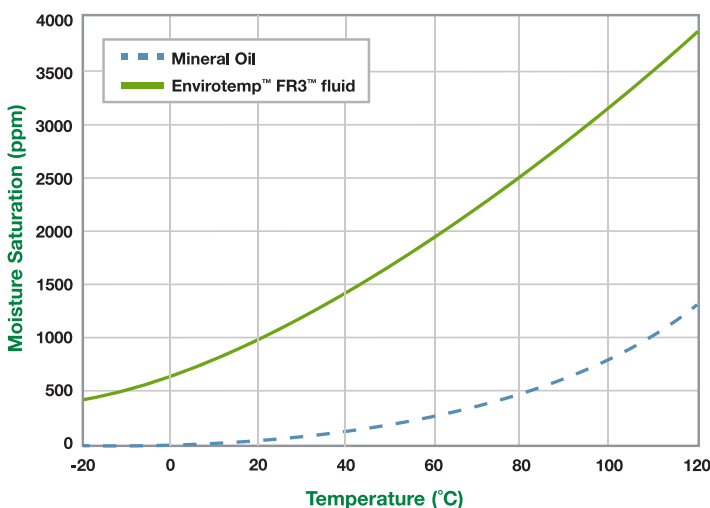


Figure 2 - Moisture saturation of mineral oil and FR3 fluid.

Water is both a cause and a byproduct of the paper degradation, a self-induced reaction. FR3 fluid breaks this mechanism, maintaining initial paper dryness throughout transformer life, thus extending the lifespan, (Fig. 3)

Mild behavior of long-chain fatty acids

The mild byproduct of the hydrolysis reaction are long chain fatty acids, which are more soluble in FR3 fluid than in paper. Conversely, in mineral oil, the short chain acids are more reactive and remain in paper, leading to a higher paper degradation and sludge formation.

Transesterification

Transesterification may occur under the conditions of elevated temperature to chemically modify and protect the paper, further reducing paper aging rate. The OH groups on the cellulose molecule become esterified with the free fatty acid esters via transesterification, hindering cellulose degradation mechanisms utilizing these sites.

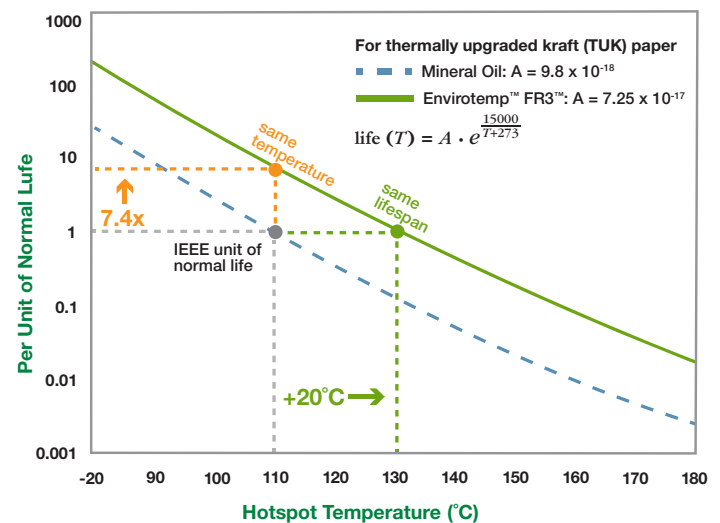


Figure 3 – Arrhenius curve for thermally upgraded kraft paper immersed in mineral oil and in natural ester liquids.

Benefits of FR3™ fluid filled transformers

Per Figure 3 the degradation rate of thermally upgraded kraft paper immersed in FR3 fluid is either reduced by 7.4x or the temperature can be increased by 20°C.

Or any balance in between, leading to relevant benefits:

- **Higher thermal class of cellulose insulation** allows increasing average winding and hotspot temperature limits without sacrificing paper life
- **Higher thermal class of liquid insulation** allows increasing average winding and hotspot temperature limits without sacrificing paper life
- **Improved transformer reliability** as, in a sealed unit, moisture content remains relatively constant through the years, preserving the dielectric capacity
- **No transformer outages** from drying the insulation
- **Extended capability and lifespan**

Cargill's technical team is ready to help your company to make the most of this advantage.

Contact us - envirottempfluids.com

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