

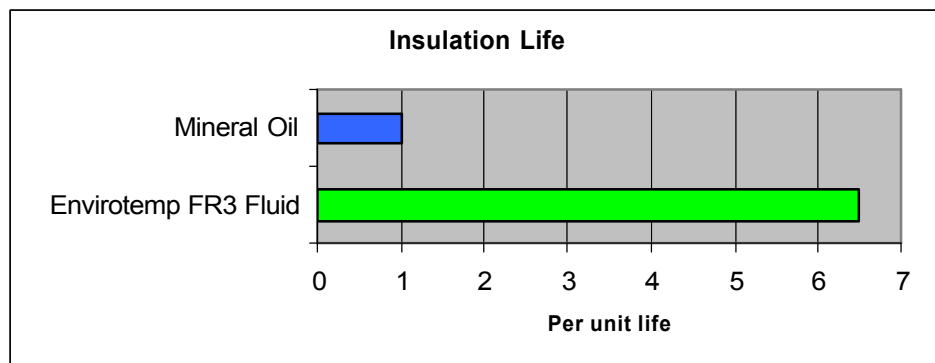
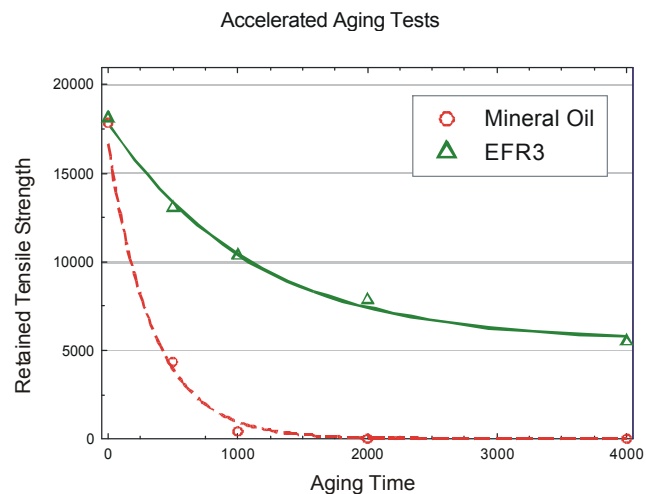
Transformer Insulation Life: Envirotemp® FR3™ Fluid and 80°C Hot Spot Rise

Envirotemp® FR3™ Fluid

It's well known that excessive heat is a primary factor in reduced transformer life. With Envirotemp® FR3™ fluid, Cooper has made a quantum leap forward in improving transformer insulation life. While developing this innovative seed oil-based fluid, its high fire point and environmental advantages were readily identified - it was only during performance testing that improved insulation life came to the forefront.

Extensive testing was performed to compare the aging characteristics of insulation paper in mineral oil and Envirotemp FR3 fluid. The testing was done in accordance with ANSI/IEEE C57.100 test procedures. The results showed that insulation paper tested in Envirotemp FR3 fluid retained its tensile strength much longer than paper tested in mineral oil. The adjacent graph shows this tensile strength comparison.

This means a large increase in transformer insulation life. The testing showed that paper aged in Envirotemp FR3 fluid took 5-8 times longer to reach end of life parameters as paper aged in mineral oil.



Bulletin R900-20-4
Reference Information
December, 2003

80°C Hot Spot Rise (HSR)

Most transformers are specified to ANSI C57.12.00, which states:

"The average winding rise above ambient temperature shall not exceed 65°C when measured by resistance. The winding hottest-spot temperature rise shall not exceed 80°C."

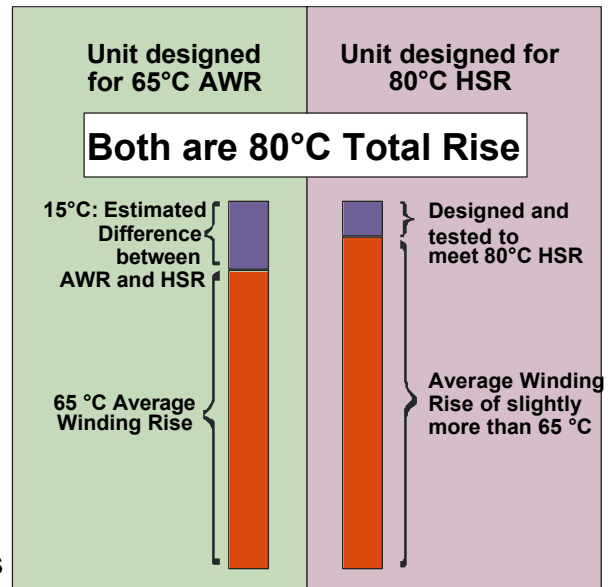
The intent of the specification is to limit the maximum temperature in the transformer to 110°C (80°C rise of the hottest-spot over a 30°C ambient), which is the temperature at which the insulating paper undergoes significantly increased aging.

Historically, 65°C AWR (Average Winding Rise) was chosen because designing for and measuring the actual hottest spot temperature is difficult. The difference between the HSR and AWR was estimated to be 15°C. Thus, the ANSI standard specifies both a 65 °C AWR and an 80 °C HSR, providing both an easily measured temperature reference (65°C) and a maximum temperature for transformer protection (80°C).

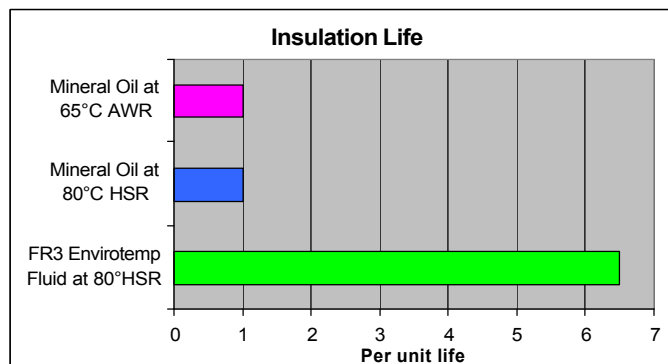
Now Cooper has developed advanced thermal analysis tools and performed extensive testing to accurately predict the hottest spot location and temperature. This allows cooling duct design to be optimized, providing improved performance.

Designers can now meet the intent of the ANSI standards - limiting the hottest spot temperature to 110°C - while disregarding the 65°C AWR limitation. This is shown graphically in the adjacent figure. The maximum temperature in the transformer does not increase above that called for in ANSI standards.

Cooper has done extensive analysis and testing to verify the thermal performance of 80°C HSR units. These units perform equally well as 65°C AWR units, and in some loading scenarios, even better. Cooper has produced over 30,000 80°C HSR units for a large utility, with excellent results. Few manufacturers can claim this design and testing expertise or can provide optimized units with this degree of confidence.



Designing a unit for 80°C HSR will not increase the maximum transformer temperature and fully meets the intention of ANSI C57.12.00. Transformer insulation life is calculated to be as follows:



Increased Overload Option

The longer thermal life of insulating paper in Envirotemp FR3 fluid systems could be used for greater overload capability for the same nominal life, instead of extended life at nominal loading. Applying the CPS paper aging data to the thermal algorithms of Standard C57.91, IEEE Guide for Loading Mineral Oil-Immersed Transformers results in a 14% increase in steady state load while maintaining the nominal thermal life of 20.55 years. This increased load capability may be limited by other standard transformer design components.

Summary

Envirotemp FR3 fluid dramatically increases transformer insulation life. Combining this with Cooper's proven 80°C HSR design provides a unit that fully complies with the intent of ANSI temperature guidelines. Insulation thermal life could be 5-8 times that of a comparable 65°C AWR mineral oil transformer or continuous overload could be 14% for the nominal 20.55 year life.