FR3® Technical Perspectives

Interactive chart for Arrhenius curves.

Degradation rate of cellulose based materials immersed in Cargill's FR3® fluid is reduced in comparison to the reference values in mineral oil, leading to new A and B parameters of insulating paper.

"Nominal life" is a defined value of testing hours for the solid insulation. The temperature resulting in such life expectation is the thermal index and it leads to the defined "Thermal Class" when 10 degrees are added to it. For example, for the end of life criteria of reaching a degree of polymerization (DvP) of 200, a thermally upgraded paper impregnated in mineral oil will take 165,000h when tested at 110°C. The thermal index is 110°C, defining the hottest spot temperature, and the thermal class is 120.

When the temperature is increased, the "normalized unit of life" is reduced. Conversely, it increases when temperature is reduced. The relation between temperature and unit of life is defined by the Arrhenius curve, specifically by the A and B parameters.

Arrhenius curve is defined as an exponential equation:

$$\text{Unit of Life } (T) = A \times e^{\frac{B}{T + 273.15}}$$

The B parameter of the Arrhenius curve is defined for all cellulose based materials as 15, 000. A number of researchers estimated different values for it along the years, leading to the definition of this value. More details can be found in the informative Annex I of IEEE C57.91:2011.

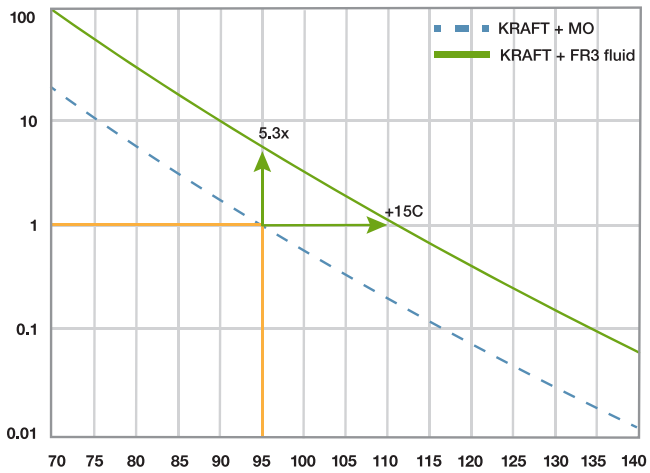
The different "grades" of paper will lead to different values for the A parameter, calculated by data fitting after a number of sealed vessels tests, as described in IEEE C57.100.

The following table shows the values of A parameters for both neutral kraft and thermally upgraded kraft paper immersed in mineral oil and in FR3 fluid.

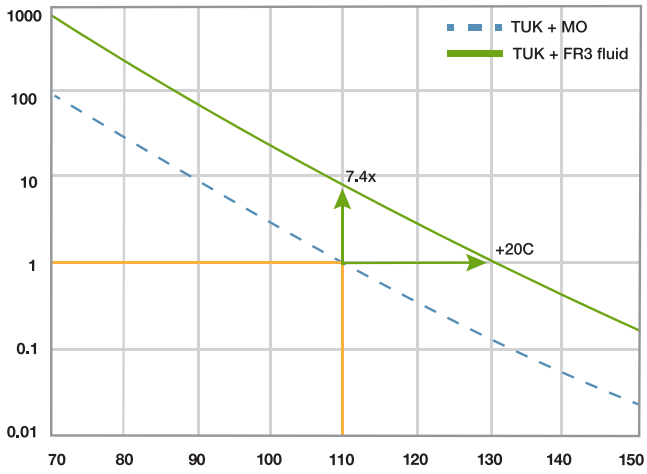
	Values of A ($x10^{-18}$)
Kraft paper in Mineral oil	**2.0**
Kraft paper in FR3 fluid	**10.6**
TUK paper in Mineral oil	**9.8**
TUK paper in FR3 fluid	**72.5**

When the A and B parameters are applied to the equation, the following charts are obtained.

Normalize Unity of Life - Kraft Paper



Normalize Unity of Life - TUK Paper



Possible operating conditions

Taking as a start point any combination of unit of life and temperature at the Arrhenius curve for the paper immersed in mineral oil, a rage of alternatives is depleted by the projection of this upon the curves of the paper immersed in FR3 fluid. All possible point on the curve varying from the "same life" to "same temperature" will represent possible conditions.

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