IEEE/PES Transformers Committee
Fall 2005 Meeting
Memphis, Tennessee, USA

"Transformer Insulation Upgrading and the Loading Guide Equations"

-- Technical Presentation --
Tuesday, October 25; 4:45 to 6:00 p.m.

By T. V. Oommen, Thomas A. Prevost, and others

1. Abstract

Thermal upgrading of transformer insulation paper is done since the 1960s to raise insulation life, and therefore transformer life of oil-filled power transformers. Upgraded papers are used mostly in North American transformers. The superiority of upgraded insulation over non-upgraded insulation has been demonstrated through aging studies.

The IEEE Loading Guides published up to 1995 contained Arrhenius life plots for both non-upgraded and upgraded insulation used in transformers classified as 55C and 65C rise units respectively. The basis for construction of the life-plots was the end-point criteria in aging, taken as 50% retention of tensile strength of paper for power transformers, and passing the functional life tests for distribution transformers. The life predicted by these two end-points differed considerably by a factor close to 3. It was recognized that power transformers lasted much longer than the predicted end of life. This was part of the background that led to the revision of the Loading Guides in 1995, which equated the predicted life at a reference hot-spot temperature of 110C to 180,000 hours for both power and distribution transformers. In place of the tensile strength basis, the end-point was set as the degree of polymerization (DP) of the paper decreasing to a value of 200, which was roughly equivalent to a life of 150,000 hours. The 1995 Loading Guide dropped Arrhenius life plots, but instead, gives now equations and plots for per-unit life, based on life at 110C hot-spot temperature.

IEC has adopted the IEEE definition of thermally upgraded paper. They have also incorporated a sub-clause that illustrates the difference in aging rate between upgraded and non-upgraded paper.

2. Learning Objectives

Three areas will be covered:

- A short description of thermal upgrading and agents -- definition, chemical composition, how they work, upgrading process, and assay in upgraded paper. Some issues in quality control and consequences will also be discussed.

- Arrhenius Life Plots. How they are constructed; and a discussion of life-plots based on the tensile strength, life tests and 1995 Loading Guide criteria for both the 55C and the 65C rise units (although the former is not covered in the 1995 Loading Guide). The DP end-point criterion will be discussed in more detail.

- A short summary of IEC activities regarding use of thermally upgraded insulation.

3. Learning Outcomes

Attendees at the presentation will gain:

- A better understanding of thermal upgrading and its importance
- An understanding of why the need for including the old fashioned Arrhenius plots in the upcoming revised Loading Guide, in addition to the equations provided in the existing 1995 Loading Guide.
- An understanding of the activities of IEC to incorporate thermally upgraded paper into their loading guide.

4. Presenter's Biographies

T.V. Oommen: Mr. Oommen is a consultant, mainly with ABB Power Technology Division of ABB Inc. He worked as R&D Engineer/Scientist for 24 years at the Westinghouse Electric and ABB power transformer divisions and retired in October of 2000. During this period, he led research projects related to insulation degradation, gas generation, moisture equilibrium in transformers, bubble generation from overload, and biodegradable natural ester fluids. He earned his bachelors and masters degrees in chemistry in India, and his doctorate degree in chemistry at the University of Washington in 1970. His did postdoctoral work in spectroscopy and electrochemical synthesis at the University of Washington and the Southern Illinois University in Carbondale before he joined Westinghouse in 1977.

Dr. Oommen has published over 70 technical papers in IEEE and CIGRE electrical journals and magazines, and has presented symposia and seminars on electrical insulation and transformer diagnostics. He is a Senior Member of IEEE, a member of PES and DEIS, and is also member of Insulation Life and Insulating Fluids subcommittees of the IEEE/PES Transformers Committee. He and his wife reside in Raleigh, North Carolina.

Thomas A. Prevost: Mr. Prevost is an active member of IEEE. He is currently the secretary of the IEEE/PES Transformers Committee. He is a past-chair of the IEEE/PES Standards Coordinating Committee and served on the IEEE-SA Board of Governors from 2002 until 2004. Tom is the Vice President of Technical Service at EHV Weidmann Industries in St. Johnsbury, Vermont where he has been employed since 1985. Prior to that, he worked at Tampa Electric Company as an engineer in distribution and production.

Tom received his BSEE from Virginia Polytechnic Institute. He is also active in ASTM D-9 Committee on Solid Insulating Materials and has written several technical papers on the subject of electrical insulation materials. He and his wife and children reside in Vermont.