



STUDY COMMITTEE A2 TRANSFORMERS

Transformer Tutorials

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Objectives

One of the prime objectives of Cigre is the promotion of technical exchange and dissemination of information among experts in the field of electric transmission systems. Several technical brochures have been published by Study Committee A2 (Transformers) over the past few years and a Tutorial version has been produced for each one. The most recent ones are listed below.

Some of the tutorial presentations generated by Study Committee D1 (Materials and emerging technologies) should also be considered. Particularly, tutorials arising from AG D1.01 (Fluid Impregnated Systems) are often closely related to power transformers technology. Some of these reports are mentioned below but complete update of tutorials and speakers should be obtained from D1.01 chairman Lars Lundgaard.

The name of the convenors is indicated. In practice, the tutorial speakers may be somebody else, depending on schedule and availability.

Guide for transformer maintenance

In the mid eighties and in the nineties, transformer users were asked to optimize transformer maintenance activities in order to reduce maintenance cost. Nowadays, transformer reliability has become the most important preoccupation for transformer users. A guide for transformer maintenance was prepared to identify best practices and the recommended periodicity for the various maintenance actions, considering transformer usages and environments. The guide also addresses advanced maintenance activities such as oil additives, oil filtering, oil regeneration, and insulation drying. It also provides guidance on the parameters that can be tracked with on-line monitoring methods for continuous condition assessment.

- Author: Cigre WG A2.34, Brochure to be published, 2011
- Convenor: Claude Rajotte (CA)

HVDC Converter Transformers - Design Review, Test Procedures, Ageing Evaluation and Reliability in Service

Findings from a reliability studies covering a period from 1971 to 2009 are presented. Data have been analysed with the objective to identify design related problem areas, which cannot be fully verified by the standard tests. Recommendations are made to address such issues by means of thorough and rigorous design review process. Special consideration is given to the Polarity Reversal test to assess the effect of the oil conductivity and polarization time with a view of representing the real service conditions. HVDC transformer in service are often filled with oils different from those used during the factory tests, it follows that the effectiveness of the PR tests can be questionable. Even though a possible improvement has been identified, the JWG concluded that the existing test should not be modified at this stage due to the logistical and practical constraints.

- Author: Cigre JWG A2/B4.28, Brochure to be published in 2011
- Convenor: Milan Saravolac (FR)



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Experience in service with new insulation liquids

The use of alternative fluids in transformers is not new technology; these fluids have been used for many years, mainly in distribution transformers. Lately there has been a clear trend to use these fluids at ever increasing voltages and power ratings, and now there are many examples of these fluids being used in high voltage and high power transformers. This Tutorial covers the in service experience of synthetic esters, natural esters and silicone fluids. It is designed to give the reader an overview of the current knowledge about these fluids, the advantages they have to offer, and how they perform in service. Topics covered include an overview of how the fluids are currently used, their properties, considerations impinging on transformer designing and manufacturing, testing regimes, handling precautions and reliability.

- Author: Cigre WG A2.35, Technical Brochure 436, 2010
- Convenor: Russell Martin (UK)

Copper sulphide in power transformer insulation

In recent years there have occurred several failures, in different classes of equipment, connected to Cu_2S formation. These were through various failure modes, normally without warning in DGA. They involved mostly equipment operating at elevated daily average temperature, although within accepted limits. Relevant test methods for corrosive sulphur in oil are now available. Precise diagnostics and risk assessment methods are still not well developed. Conditions leading to failures are reviewed and several mitigation techniques are proposed.

- Author: Cigre WG A2.32, Technical Brochure 378, 2009
- Convenor: Mats Dahlund (SE)

Moisture Equilibrium and Moisture Migration within Transformer Insulation Systems

There has been renewed interest in the subject of water contamination in transformers in recent years, which can be attributed to the aging of transformer population and need to reassess the detrimental effect of moisture on solid insulation. To prevent in-service failures and schedule drying, reliable techniques are needed to determine whether a critical level of water contamination has been reached. This tutorial describes moisture equilibrium and migration in oil-paper-insulated power transformers. It reviews the main sources of moisture contamination, the solubility of water in oils, the physical background for moisture adsorption in the cellulose insulation. Practical advice for moisture determination via equilibrium diagrams and for migration time constants are provided as well. The appendix presents moisture measurement techniques and gives valuable comments about them.

- Author: Cigre WG A2.30, Technical Brochure 349, 2008
- Convenor: Victor Sokolov † (UA), Maik Koch (DE)



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Mechanical-Condition Assessment Of Transformer Windings Using Frequency Response Analysis (FRA)

Frequency Response Analysis (FRA) is a recognized method of detecting winding displacement in power transformers. This technique involves the injection of a high frequency signal at one terminal of a transformer the measurement of the response of the winding to that signal. The tutorial presents an introduction of the FRA test for detecting winding movement and presents recommendations for standardisation of good measurement practices. Guidance on recommended practices is provided along with description of typical responses and controlling factors, together with a collection of case examples, which illustrate how FRA can detect various types of winding movement

- Author: Cigre WG A2.26, Technical Brochure 342, 2008
- Convenor: Patrick Picher (CA)

Thermal Performance of Power Transformers

The fundamentals mechanisms of thermal ageing are reviewed along with diagnostic methods available to assess the condition of paper and oil. Thermal modelling of transformers in IEEE and IEC guides are compared in term of actual hot spot temperature under steady and transient conditions. Methods for thermal testing of transformers are reviewed to establish the thermal behaviour under rated load and under emergency loading conditions. Practical application of measurement of degree of polymerisation is presented.

- Author: Cigre WG A2.24, Technical Brochure 393, 2009
- Convenor: Jan Declercq (BE)

Recommendations for condition monitoring and condition assessment facilities for transformers

Transformer on-line condition monitoring has been the subject of significant research and development over the past few years and it is becoming increasingly important that monitoring can be easily and safely applied to a transformer at whatever point in its lifetime. In order to facilitate the future installation of such systems, there are certain sensors and facilities that should be provided on new transformers. Such facilities include external core grounding, oil sampling points, separate neutrals for each phase, separate compartment for tap-selector, etc. The brochure considers the benefits of possible standardisation of the interface between monitoring systems and the transformer with the aim to provide a guide to the specification of a transformer intended to be "condition monitoring ready".

- Authors: Cigre WG A2.27, Technical Brochure 343, 2008
- Convenor: Paul Jarman (UK)



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Transformer Lifetime Data Management

Operation of power transformers implies a number of decisions on loading, maintenance, repair and replacement. These decisions can be made more systematic, precise and repeatable if proper lifetime data is available. This data has to be relevant, sufficient and accurate, for any individual transformer of interest. Methods and strategies are proposed for an optimum selection of significant data to be collected over the life of the transformer.

- Authors: Cigre WG A2.23, Technical Brochure 298, 2006
- Convenor: Nicolaie Fantana (DE)

Life Management Techniques for Power Transformers

As significant segment of transformers in service are getting older or approaching end of life, it is appropriate to reassess tools that can be used to minimize operational costs, while taking into account the specific differences arising from local circumstances, practices, and needs. The tutorial review key deterioration processes, failures mode related to aging phenomena, diagnostic and monitoring techniques, condition assessment recommendation, and review of operation that can be performed on transformers to extend life. The presentation is based on concepts developed in WG 12.18 final report.

- Authors: Cigre WG A2.18, Technical Brochure 227, 2003
- Convenor: Victor Sokolov † (UKR)

Transformer short circuit performance

The ability of a transformer to withstand mechanical stresses ensuing from short circuits on electrical system is an important concern for several utilities. It is not always possible to proceed with short circuit withstand testing but it is possible to evaluate the stresses and the strength build in the design to prevent winding deformation or displacement. Review of design principle, field experience, testing, and modern methods of winding displacement detection.

- Authors: Cigre WG A2.19, Technical Brochure 209, 2002
- Convenor: Jim Fyvie (UK) J. Veens (NL)

Economics of transformer life management

Transformers are crucial not only to power system performance and reliability of supply but also to the financial performance of electric utilities. The technical complexity of power transformer, their high capital costs and long life expectancy pose unique decision-making challenges to asset managers. The risk management methods are reviewed and the application of these rules to the specification; operation, maintenance and replacement of power transformers are presented in line with material developed by Cigre WG 12.20.

- Authors: Cigre WG A2.20, Technical Brochure 248, 2004
- Convenor: Pierre Boss (CH)