Conseil international des Grands Réseaux Électriques
INTERNATIONAL COUNCIL ON LARGE ELECTRIC SYSTEMS

SC D1 MATERIALS AND EMERGING TEST TECHNIQUES

Tutorial Advisory Group
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SC D1 TUTORIALS

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General

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 D1 (Materials and Emerging Test Techniques) over the past few years and a Tutorial version has been produced for most of them. The most recent ones are listed below. The name of the person in charge of the tutorial is indicated. In practice, the tutorial speakers may be somebody else, depending on schedule and availability.

D1-T001 Liquid and liquid impregnated insulation

The tutorial gives an overview of cellulose materials and the ageing mechanisms that dominate. Influence of oxygen and water in addition to temperature will be described. Examples of diagnostics for asset management and examples from service experience are described. Also possibilities for maintenance and life extension are discussed. The tutorial will also cover topics from the work under progress on ageing in non mineral oil liquids.

Authors: WG D1.01 TF 15 and Technical Brochure 323 (currently under revision by WG D1.53)
Person in charge: Lars Lundgaard (NO)

D1-T002 Oxidation Stability of Insulating Fluids

The tutorial summarizes existing experience with oxidation stability methods and their use for the characterization and evaluation of new insulating fluids, as well as the influence on diagnostic characteristics. A survey among users of insulating fluids has been performed, as well as a round robin test with different fluids and methods. Methods for prolonging the life of oil in service has been reviewed. The tutorial arguments why choice of insulating fluid should consider design and operation conditions.

Authors: WG D1.30; Technical Brochure 526, February 2013
Person in charge: Ivanka Atanasova-Hoehlein (DE)

D1-T003 Dielectric Response Diagnoses for Transformer Windings

This tutorial presents the influences of different types of solid insulation and ageing products on dielectric response measurements, provides detailed guidance on the practicalities of carrying out such, and provides collected case examples illustrating the value of such measurements. The attention is mainly focused on the two techniques which allow the clearest discrimination between the effects of oil condition and solid insulation moisture content: FDS and PDC. It is concluded that different types of pressboard and ageing products, in particular low molecular weight acids, can have a significant effect on measured dielectric responses. As a result, as shown by a case example, the solid insulation moisture content in aged insulations can be overestimated and improvements to interpretation schemes are desired. As regards verifying dielectric response moisture determinations by comparison with basic chemical measurements, it is concluded that there are too many uncertainties associated with the application of equilibrium diagrams based on moisture estimation in oil obtained by Karl Fischer titration for this to be a useful reference, but relative saturation measurements are seen as a promising alternative.

Authors: WG D1.01 TF 14; Technical Brochure 414, April 2010
Person in charge: Stanislaw Gubanski (SE)

D1-T004 Furanic Compounds for Diagnosis

The tutorial gives an answer to important questions like:

- What are the ageing mechanisms?
- How do temperature, water, dissolved by-products etc. act on insulation ageing?
- Which diagnostic indicators can be used to assess ageing?
- How can ageing be slowed down?
- Which maintenance practices can be recommended to extend transformer life?

Important issues discussed are how ageing proceeds depending on the transformer materials, transformer condition and service conditions etc. and the possibilities for diagnosis, life assessment and maintenance. New information including ageing of cellulose in non-mineral oils is included.

Authors: WG D1.01 TF 13; Technical Brochure 494, March 2012
Person in charge: Marie-Claude Lessard (CA)

D1-T005 Choice and Use of On-Line Gas Monitors

Dissolved gas analysis (DGA) is widely used for monitoring faults in insulating fluid-filled, high voltage electrical equipment in service. Still today, DGA is performed mostly by laboratories using standardized methods for the extraction and analysis of gases dissolved in oil. Hydrogen on-line monitors allowing the detection of abnormal gassing in service, continuously or at much more frequent time intervals than with regular laboratory analysis, have also been available for a long time. However, in the past decade, an increasing number of multi-gas on-line monitors have appeared on the market, able to follow the formation of some or all of the other DGA gases and to provide on-line diagnosis. This has raised questions among potential users of these devices, such as:

- Which monitors should be used for which applications?
- How to verify that monitor readings are accurate and reliable in service, especially when they do not agree with laboratory results?
- What is the long-term stability of gas monitors?

The purpose of this Tutorial is to give an overview on existing monitoring devices and their characteristics.

Authors: WG D1.01 TF 15; Technical Brochure 409, February 2010
Person in charge: Michel Duval (CA)

D1-T006 DGA in Non-Mineral Oils and Load Tap Changers and Improved DGA Diagnosis Criteria

Dissolved gas analysis (DGA) is widely used for detecting faults in insulating fluid-filled, high voltage electrical equipment in service. Historically, DGA has been applied mainly to transformers filled with mineral oils. This Tutorial presents progress made by WG D1.32 concerning:

- The application of DGA to non-mineral oils.
- The application of DGA to load tap changers.
- The effect of oil sampling on DGA results.
- The use of DGA during heat-run tests on repaired or upgraded transformers.
- Gas losses from transformers of the open conservator-type.
- Stray gassing of passivated oils.
- The use of DGA in continuously degassed transformers.
- The formation of carbon oxides in mineral oilfilled transformers.

Authors: WG D1.32 and JWG D1/A2.47; Technical Brochure 443, October 2010
Person in charge: Michel Duval (CA)

D1-T007 High-Voltage On-Site Testing with Partial Discharge Measurement

The tutorial discusses and presents the commonly used HV sources and PD measurement techniques developed for on-site tests. As opposed to most dielectric measurements which are characteristics of the whole dielectric volume, partial discharges are “weak point phenomena” as it is also the electric breakdown. In case of the new insulation, the critical defects/weak points are e.g. the result of an assembling failure which can be found by a routine test consisting of the HV withstand test including PD measurement. In case of the insulation of HV equipment in service (which has been tested successfully and which operates for years) a critical defect might be caused by high electrical, thermal or mechanical stresses and by the “aging” of the insulation itself. The tutorial arguments that HV on-site testing with PD measurement will play an increasing role for the improvement of the reliability of equipment for electric power generation, transmission and distribution.

Authors: WG D1.33; Technical Brochure 502, June 2012
Person in charge: Ralf Pietsch (DE)

D1-T008 Past, present and future of IEC and IEEE high-voltage and high current testing standards

Recently, IEC and IEEE have published a number of revised and new standards for high-voltage and high-current testing. Significant changes and additions have been introduced to these revised and new standards. CIGRE WG D1.35 has developed a guide to give high-voltage test engineers a broader knowledge of how to apply the latest high-voltage and high-current testing standards. The guide presents a brief account of the history of these standards with the aim to allow readers to gain a better appreciation of the technical background followed by sections summarize the major changes made to the standards in their latest revisions to provide a general picture of the revisions. Finally, some discussion is given on the practical implications of these changes. Practical examples are provided to illustrate some of the new techniques and new procedures. The guide also lists areas of possible improvements to the standards for future revisions.

The tutorial will introduce the guide whereby areas of difficulty in interpretation of certain clauses of these standards are pointed out.

Authors: WG D1.35; Technical Brochure 593, August 2014
Person in charge: Yi Li (AU)

D1-T009 Materials, Technologies, Testing and Diagnosis for Polymeric Overhead Lines Insulators

The Tutorial covers following topics which are published in relevant CIGRE Technical Brochures:

1. Tracking & Erosion under DC voltage stress [CIGRE TB 611]
2. Retention of Hydrophobicity under DC voltage stress [ELECTRA 272_03]
3. Fingerprinting of polymeric insulating materials / Material Diagnostic [CIGRE TB 595]
4. Relevance of material test results to the long term performance of composite insulators in DC overhead lines; design-reviews of existing line insulation, empirical and statistical design method [CIBGE TBs 518 & 555]
5. Activities in IEC (project IEC 60815-4, Material and pollution testing, considerations on a DC T&E test and insulator pollution test, open questions)

Authors: WG D1.27
Person in charge: Jens Seifert (DE)

D1-T010 Diagnostics & Monitoring of Gas-insulated Systems – Present & Future

The tutorial gives a brief overview of diagnostic methods and techniques to analyze the status and dielectric performance of gas-insulated systems. This includes factory tests, in-service measurement, and diagnostic methods. Concentration is laid on GIS, especially on definitions, failure Statistics, life cycle, diagnostic functions, circuit-breaker diagnostics, SF6 gas density, partial discharges and contact erosion. The focus is on partial discharge diagnostic and monitoring. Moreover, the functions of controlled switching and the physical limits for those methods are discussed.

Authors: AG D1.02
Person in Charge: Uwe Riechert (CH)

D1-T011 HVDC Transformer Polarity reversal: Role of oil conductivity

JWG A2/D1.41 (HVDC transformer insulation: Oil conductivity) has been initiated in order to continue CIGRE activities on looking into performance and reliability of HVDC converter transformers. JWG A2/B4.28 judged that the issue of oil conductivity in relation to dielectric testing effectiveness had first priority. Considering that there is no standard procedure which is consistently applied to the measurement of oil conductivity, it was recommended that the priority shall be assigned to measuring oil conductivity throughout the transformer lifecycle and evaluating the effect of the oil conductivity during the design and design review stage.

Authors: JWG A2/D1.41
Person in charge: Andreas Kuechler (DE)

D1-T012 Application guide for PD detection in GIS using UHF or acoustic methods

The TB collects the available experience on sensitivity verification of the UHF partial discharge system after 15 years of its application (after introduction by ELECTRA Report in 1999) and describes its practical applications for GIS. A detailed description of the two-step procedure: Step 1 in laboratory and Step 2 on-site is given and supported by examples. Guidelines will help manufacturers and users in the effective application of the UHF method for PD detection on GIS.

Authors: WG D1.25
Person in charge: Uwe Schichler (AT)

D1-T013 Common Characteristics and Emerging Test Techniques for High Temperature Superconducting Power Equipment

The TB summarizes the impressive progress in the past towards power applications based on HTS materials possible firstly because the material is available in larger quantitiesand has been improved steadily, secondly because electrical insulating material is adapted and used appropriately, and thirdly because progress has been made in cooling and cryogenic issues. Therefore this report aims to address and focus on these issues for the power equipment like cables, fault-current limiters, rotating machines, transformers and magnetic energy storage.

Authors: WG D1.38
Person in charge: Mathias Noe (DE)

D1-T014 Insulation degradation under fast, repetitive voltage pulses

This TB is aimed at presenting, for a number of equipment typologies, the reasons behind accelerated degradation of insulation systems subjected to repetitive surges induced by power electronic converters. Also, the solutions provided by the International Electrotechnical Commission for induction motors is discussed, as they might be used as a reference for other type of electrical components. The TB is structured as follows: (1) Stress enhancement phenomena, (2) Aging and breakdown, (3) Apparatus-specific issues, (4) Testing components with impulse voltages, (5) Nanocomposites.

Authors: WG D1.43
Person in charge: Andrea Cavallini (DE)

D1-T015 Guidelines for partial discharge detection using conventional (IEC 60270) and unconventional methods

This Technical Brochure presents the state-of-the art in the field of partial discharge measurements with conventional (IEC 60270) and unconventional methods. The guide gives recommendations for effective application of unconventional methods for PD testing of high voltage gas insulated substations, power cables, and power transformers with 'best practice' solutions being discussed and explained with actual on-site PD measurement cases. The advantages and disadvantages of the discussed PD detection methods are shown.

Authors: WG D1.37
Person in charge: Edward Gulski (CH)

D1-T016 Partial Discharges in Transformers

The Brochure summarizes the main progress in partial discharge measurements on transformers during the last 10 years, covering scenarios in laboratories during factory acceptance tests (FAT) as well as on-site PD diagnostic measurments and site acceptance tests (SAT). Both the application of advanced measuring systems and different measurement principles as well as analysing methods are covered. As a major result WG D1.29 established a procedure for PD-measurements comprising three steps to assess PD problems in power transformers in a reliable and efficient way. A number of practical case studies are included in the Annex of the TB.

Authors: WG D1.29
Person in charge: Jitka Fuhr (CH)