Materials and emerging test techniques

By Dr. R. Pietsch, Chairman SC D1

Scope, organisation and membership

The scope of Study Committee D1 covers new and existing materials for electrotechnology, diagnostic techniques and related knowledge rules, and emerging test techniques which may be expected to have a significant impact on power systems in the medium to long term. As a horizontal Study Committee, SC D1 strives to support the other CIGRE Study Committees and external customers as well. The mission of the Study Committee is to facilitate and promote the progress of engineering and the international exchange of information and knowledge. It achieves this through the synthesis of state-of-the-art practices and developing recommendations, as well as identifying, investigating and monitoring the use of new or novel materials, test techniques and generic concepts for diagnosis.

Test and measurement procedures are developed using knowledge of the performance of materials and electrical insulating systems (EIS) with regard to electrical, thermal, mechanical, chemical and environmental stresses. These can then be applied to the development of new diagnostic and analytical methods for asset management of electrical apparatus to aid the work of equipment, subsystem and system committees.

The current membership of the SC consists of 24 regular members and 9 observer members. Two new WGs has been approved by the TC chairman during the last year, thus SC D1 counts presently 23 WGs, including three Joint WGs with SC A2, one JWG with B3 and one JWG with SC B1. In total, about 350 expert members from 41 countries are active in SC D1 working bodies. The activities can be grouped in four areas, namely “Insulating gases”, “Liquid and liquid impregnated insulation systems”, “Solid materials” and “High voltage and high current testing and diagnosis”. The major activities in the various areas covered by D1 WGs are given below.

Materials

SC D1 deals with materials for electrotechnology which covers a wide variety of conducting and insulating materials including novel materials such as superconductors and nanocomposites. The majority of materials considered are insulating materials and the focus is on material characteristics and performance.

In practical applications, insulating materials are used in structures containing one or more electrical insulating materials together with associated conducting parts employed in an electrical device, thus forming an electrical insulating system (EIS). The life of an EIS is frequently determined by the life of electrical equipment under electrical, thermal, mechanical and environmental stresses, acting either individually or in combination (IEC 60505). SC D1 deals with the associated ageing processes which affect materials which are used in generation, transmission and distribution of electric energy and not only covers the materials but also interfacial phenomena.

Insulating gases

Even though gas insulated equipment and switchgear are mature technologies there is still a need for new diagnostic tools, miniaturisation and eco-friendly materials. WG D1.51 is studying the dielectric performance of eco-friendly gas-insulated systems. The focus is on insulation performance and in particular small current interruption capacity of environmentally-friendly gases, as well as the diagnostic and monitoring requirements. Based on the phenomena in electrical gas-insulated systems under DC and transient voltage stress and taking into account the properties of the involved materials JWG D1/B3.57 is investigating appropriate testing strategies

for gas-insulated HVDC systems. In the field of insulating gases two new WGs have been approved in 2016. New WG D1.66 is dealing with requirements for partial discharge monitoring systems for gas insulating systems and new WG D1.67 focuses on the dielectric performance of non-SF6 gases and gas mixtures for gas-insulated systems.

Liquid and liquid impregnated insulation systems

The work is focussed on basic phenomena and mechanisms of conductivity, dielectric performance, dielectric strength and ageing of relevant materials and insulating systems, covering traditional insulating fluids as well as biodegradable fluids. The work aims to discover and understand the basic physical and chemical mechanisms associated with ageing, thus forming the basis for diagnostics and asset management of products like transformers and liquid impregnated cables. WG D1.52 deals with moisture measurement of insulating fluids in transformers, comparing chemical methods (Karl Fischer Titration) and measurement by solid state sensors for their accuracy and reproducibility; resulting in a practical guideline for measurement and comparison of results achieved through different methods. In response to the increasing use of thermally upgraded cellulose and cellulose impregnated with new synthetic and organic ester liquids, WG D1.53 has been established with the aim to revise CIGRE TB No. 323 and update it with the latest results. Jointly with experts from power transformers JWG D1/A2.47 is heading for new frontiers of Dissolved Gas Analysis (DGA) interpretation. The work is performed in close cooperation with IEC TC 10 "Fluids for electrotechnical applications". JWG A2/D1.46 is summarising field experience with transformer solid insulating ageing markers in comparison to degree of polymerisation of solid insulating samples taken from transformers and considering design information and oil sampling temperature. And, JWG A2/D1.51 strives to develop improvements to partial discharge measurements for factory and site acceptance tests of power transformers by measuring high electromagnetic waves with the ultra-high frequency (UHF) method.

Solid materials

In the field of solid materials the current focus is on polymeric insulating materials. To support the application of very low frequency (VLF) testing of medium and high voltage cable systems, including the interpretation of test results, WG D1.48 is studying the properties of relevant materials in relation to breakdown voltage, electrical breakdown strength, electrical treeing resistance and partial discharge characteristics under VLF voltage stress. In view of the lack of a standardised test to evaluate the residual content of methane and other flammable gases evolved as by-products during the crosslinking process of XLPE insulation, JWG D1/B1.49 is developing a harmonised test procedure for the measurement of residual flammable gases in insulating materials. WG D1.56 reviews established field grading technologies in electrical equipment, and the experience with different materials, designs and applications. The characterisation of field grading materials including emerging materials (e.g. micro varistors) and simulation techniques for electric field distribution will be studied. WG D1.58 studies suitable test procedures for the evaluation of dynamic hydrophobicity of polymeric insulating materials under AC and DC voltage stress. WG D1.59 studies methods for dielectric characterisation of polymeric insulating materials for outdoor application with the aim to elaborate guidelines for performing precise and repeatable measurements of dielectric properties. The experts of WG D1.62 are dedicated to explore the root cause and mechanisms of surface degradation in polymeric materials for outdoor use, and to derive potential countermeasures for various material groups. WG D1.64 was established to explore electrical insulation systems at cryogenic temperatures.

High voltage and high current testing and diagnosis

In general, methods of testing and related techniques of measurement can be very different depending on the test object, the purpose of testing and on the conditions of testing. For example, the object of the test can be the materials, insulating systems, equipment, subsystems and systems; the purpose of testing can be to determine characteristic properties of the test object, such as electrical, thermal, mechanical and chemical properties as well as ageing performance under various stresses. Further, the purpose can be for design, type, sample or a routine test of the equipment. The test can also be performed on-site or off-site as well as under on-line or off-line conditions. Testing always goes along with the requirement to measure the stresses as well as the response of the device under test in order to analyse the test result and to evaluate the performance of the test object. Lastly, testing can be used to collect information which form a basis for diagnosis, e.g. to evaluate the condition of a test object. The development of test techniques is driven by various factors, like the introduction of new materials or electrical insulating systems (e.g. polymeric materials, nanocomposites), new requirements on accuracy (e.g. more precise correction factors) or on higher stress levels (i.e. UHVAC, UHVDC) or new test objects (e.g. testing•••

of artificially or naturally polluted insulators). SC D1 studies and synthesises state-of-the-art techniques of testing and measurement, develops relevant recommendations and new diagnostic and analysis methods for asset management, all in close cooperation with its customers.

WG D1.44, established on request of IEC TC 36, is dealing with guidelines for tests on naturally polluted insulators of the ceramic and polymeric type and under AC and DC stress. According to a request from IEC TC 42 the WG D1.50 has been established, dealing with atmospheric and altitude correction factors for air gaps and clean insulators. After having checked and evaluated the existing correction factors for installations up to 6.000 m above sea level round robin tests will be performed by the members of the WG. Finally, guidance shall be given on modifications of the atmospheric and altitude correction factors. WG D1.54 studies basic principles and practical methods to measure the AC and DC resistance of conductors of power cables and overhead lines. The aim is to define a test procedure including suitable equipment for the measurement of AC and DC resistance taking into account the major factors of influence, e.g. frequency of current, current density and conductor temperature. WG D1.60 has been established to coordinate the development of suitable hardware and software for traceable measurement techniques for very fast transients, e.g. very fast transient overvoltages (VFTO), in order widen the basis for reference measurement capabilities meeting the relevant calibration requirements. WG D1.61 accepted the challenge to develop objective methods and indicators which can be used for optical corona measurements on overhead lines and equipment, preferably by performing comparative measurements on different sites and laboratories and by application of different types of cameras. To support the development of existing IEC standards, new WG D1.63 studies methods of partial discharge detection under DC stress and the analysis of partial discharge activity with respect to pulse patterns and the sequence of pulses under various factors of influence, e.g. slope of voltage change, voltage magnitude, and material properties of the test object. The response of measuring instruments and possibilities of noise suppression will be addressed.

Relations to other organisations

SC D1 strives to establish and maintain good relations to internal customers, i.e. equipment and sub-system committees, as well as to external organizations, like IEC, IEEE and CIRED. The main partners within IEC are TC 2 “Rotating Machines”, TC 10 “Fluids for Electrotechnical Applications”, TC 14 “Power Transformers”, TC 28 “Insulation co-ordination”, TC 36 “Insulators”, TC 42 “High-voltage and high-current test techniques”, TC 90 “Superconductivity”, and TC 112 “Evaluation and Qualification of Electrical Insulating Materials and Systems”. SC D1 also has a good relationship with the relevant IEEE organisations. With some technical committees of these organisations SC D1 has established formal liaisons.

Tutorials and workshops

SC D1 has established a set of tutorials covering specific topics in its field of activity. A list of tutorials (16 at present) is available on the D1 website (http://d1.cigre.org/). This year the following tutorials and workshops were held:

- Tutorial “Partial Discharges in Transformers”; Jitka Fuhr (WG D1.29), Cigre Australia, November 2016, Sydney (AU)
- Tutorial “PD Diagnostics of GIS/GIL: Sensitivity Verification and Risk Assessment based on UHF Method”; Wojciech Koltunowicz (tutorial is based on results of WG D1.03, D1.25 & WG D1.37), GCC POWER 2016, Doha - State of Qatar, 7-10 November 2016

Publications

The following CIGRE Technical Brochures and Reports have been published in 2016:

- CIGRE TB 646 “HVDC Transformer insulation: oil conductivity”, (JWG A2/D1.41), January 2016
- CIGRE TB 654 “UHF partial discharge detection system for GIS: Application guide for sensitivity verification”, (WG D1.25), April 2016
- CIGRE TB 661 “Functional nanomaterials for electric power”, (WG D1.40), August 2016
- CIGRE TB 662 “Guidelines for partial discharge detection using conventional (IEC 60270) and unconventional methods”, (WG D1.37), August 2016

Meetings and events

For the 46th CIGRE Session in Paris, SC D1 has accepted 32 papers and 30 posters were presented. The D1 group discussion meeting included 30 prepared contributions and 63 spontaneous contributions, questions and comments. This reflects the wide interest of topics covered by the scope of SC D1, in particular by the preferential subjects chosen for the session.

SC D1 will have its next annual meeting in conjunction with the A3/B4/D1 Colloquium on "HVDC & HVAC Network Technologies for the Future" in Winnipeg, Canada, October 1 – 6, 2017, http://cigrewinnipeg2017.com/venue.

Awards

The Technical Committee Awards 2016 has been granted to Orsino Borges Filho to acknowledge his exceptional contribution to CIGRE's technical work.

Based on profound knowledge and long experience in the field of High Voltage Testing and Measurement, Orsino Borges Filho has been very active in SC D1; in particular he made valuable contributions as an active member of WG D1.36 and WG D1.60. He was the Brazilian member of CIGRE Study Committee D1 from 2008 to 2014, and it was due to his initiative that the D1 Colloquium 2015 was held in Rio de Janeiro. There, he was in charge as head of the organizing committee and thanks to his engagement the colloquium went extremely well and was very successful.

Last but not least the incoming chairman of SC D1 likes to express in the name of all members of SC D1 and the colleagues from other study committees our thanks to Prof. Josef Kindersberger for his fruitful contributions and most successful guidance of SC D1. Additionally, the incoming chairman thanks Prof. Josef Kindersberger for his perfect handover, support and introduction to this new task. ■