Annual Report of Study Committee D1 – Materials and Emerging Test Techniques

Study Committee D1 activities

Study Committee D1 is a horizontal Study Committee and has within its scope the support of the equipment committees (Study Committee A1 – A3), the subsystem committees (Study Committee B1 – B5) and system committees (Study Committee C1 – C6) in the field of electrical insulating and electrical conducting materials, high voltage and current test and measuring techniques combined with diagnostic tools. The mission of the Study Committee is to facilitate and promote the progress of engineering and the international exchange of information and knowledge, to improve the information and knowledge by synthesising state-of-the-art practices and developing recommendations, to make recommendations to relevant study committees, to investigate, monitor and report upon the use of new or novel materials, test techniques and diagnosis concepts.

The Study Committee is highly research oriented and therefore the members are predominantly engaged in universities and research institutes.

Based on the knowledge of the materials performance regarding electrical, mechanical, chemical and environmental stress and strength the relevant testing and measuring procedures will be developed and prepared in this SC to be used for diagnosis purpose and asset management of all electrical apparatus in the electric power systems.

The report is grouped thematically according to the main activities as materials, testing and measuring techniques and diagnosis.

Materials

Within the materials for electrical apparatus the insulating materials are the most important here. Beside the intrinsic electrical performance the behaviour of insulating materials under different stresses like electric field, temperature, mechanical forces and service time will characterize an insulating material. One of the key insulating system is the liquid or liquid impregnated system used e.g. in all power transformers. In former Task Forces within WG D1.01 the treatment of the insulating liquids like reclamation and dechlorination was investigated. The diagnosis of the liquid and also the impregnated paper could be evaluated by Furans and this will also be handled in WG D1.01. Furthermore the actual condition of insulating systems in transformers can be evaluated by the dielectric response of the insulating system and this task was also integrated in WG D1.01 activities, which as a strong liaison with the Study Committee A2 Transformers.

The improvement of the Gas-in-Oil Analysis (DGA) is important for mineral oil insulated apparatus as well as for apparatus filled with alternative fluids. WG D1.32 is dealing with this point.

The actual problems concerning oxidation of mineral oil and its consequences for transformers will be handled in WG D1.30 again in close cooperation with the transformer Study Committee.

The increasing importance of High Voltage DC will be reflected by the Joint Working Group A2/D1.41 dealing with HVDC transformer insulation and in particular with the influence of the

oil conductivity on the performance of the insulating system and with the measurement of the conductivity.

Solid materials used in different apparatus will be handled in WG D1.19 dealing with stress due to repetitive impulse generated by power electronics. This kind of electrical stress becomes more and more important due to the development of the power electronic devices and the increase of DC systems. The stress is similar to lightning impulses but with frequencies in the range of some up to some ten kHz. In addition a superposition of AC and DC stress should be taken into account.

Nano materials can also improve the performance of solid insulating materials. The strong expectations in such materials cause the work of WG D1.24 describing the fundamentals and the application of nano polymer in the apparatus for electric power systems.

Replacing porcelain by composite insulators requires definition of parameters to identify polymeric materials, its physical parameters and to develop relevant test methods for such materials. WG D1.27 is responsible for this subject.

Apparatus with superconducting elements are a mixture between electrical conducting and electrical insulating materials. WG D1.15 has prepared a report on the status of development and field test - experience with high-temperature superconducting power equipment. The progress in this field will be handled by a new WG D1.38 dealing with emerging test techniques common to high-temperature superconducting power applications.

Gas insulated apparatus are used for a long time. However the performance can be improved by details such coating of the surface. WG D1.28 is evaluating an optimized gas-insulated system by advanced dielectric coatings and functionally graded materials. Insulators with inbuilt voltage gradient could lead to a reduction of the geometrical size of an gas-insulated systems.

The qualification of materials and the evaluation of the actual condition of an insulation system require in most cases specific test techniques and this is the second major topic of Study Committee D1.

Test techniques

Testing and measuring are developed to evaluate the performance of material systems for multi-factor stresses at normal and abnormal operating conditions. The purpose of testing could be a check of the design (design test), a check of the quality (routine test), a check of the assembling (on-site test) and a check of the actual condition of the systems which is often named as diagnosis test. The results of all these tests are the basis of the diagnosis which will be handled later in a separate chapter.

The conventional test technique is based on the common voltage types like AC, DC and impulse voltage. The combination with Partial Discharge (PD) measurements improves the quality of the test. WG D1.25 deals with an application guide for PD detection in Gas-insulated substations (GIS) using UHF or acoustic method. The design of the GIS allows this particular measuring method, but the interpretation of the results requires a certain knowledge.

A more general use of PD measuring systems will be handled in a future WG D1.37 dealing with maintenance and evaluation of measuring procedures for conventional and unconventional partial discharge testing. The revision of an existing IEC standard for PD measurement and the use of new, so called unconventional systems are the main topic of these WG. Particularly the comparison between different methods and the calibration procedures are of importance.

Partial discharges in transformers are a special problem due to the complex design of the apparatus. Therefore WG D1.29 was established dealing with the available detection systems and influence of detection sensitivity, including all methods that can respond to individual PD pulses.

The increase of the transmission system voltage up to 1200 kV AC and 800 kV DC requires a check of the existing IEC recommendation for high voltage testing and measuring technique due to the large dimensions of the apparatus. A new WG D1.36 takes care on special requirements for dielectric testing of Ultra High Voltage (UHV) equipment in close cooperation with a WG C4.306 of SC C4 System Technical Performance. The technical requirements for dielectric testing of equipment in this voltage range have largely been developed by individual users, manufacturers and laboratories such that there is limited worldwide standardization. Therefore a review of the present state-of-the-art and problems during dielectric testing of UHV equipment will be done with a comparison to the applicable international standards.

Related to the same topic a new WG will be established dealing with the evaluation of parameters and correction factors according to IEC 60060-1 and IEC 60060-2 High Voltage Testing and Measuring Techniques. The main part is the evaluation of lightning impulses with superimposed oscillations or overshoot near the peak, because the increase of the apparatus size leads to an increase of the test set-up with higher inductance.

Diagnosis

The measurements during usual voltage tests or specific tests with voltages not related to the service voltage are the basis for the diagnosis. The main points of the diagnosis are the reliability and meaning of the results and their interpretation. WG D1.26 deals with the basic principles to determinate methane content of cross-linked solid extruded insulation of MV and HV cables and WG D1.20 with non destructive water-tree detection in XLPE insulation. These WG will evaluate the methods and its sensitivity to detect methane or water trees in cables, but limits or threshold values for the user of the cables or the asset managers regarding reliability and availability will not be within the responsibility of WG´s of SC D1.

A similar topic has the work of WG D1.34 regarding condition assessment for self-contained oil-impregnated insulation used in ac cables. The status of the different diagnostic methods for this type of cables will be evaluated and the required tests for the verification of the cable condition will be recommended. The intent here is on data interpretation and not just test methods showing the sensitivity, but without defining criteria.

The existing data should be analysed and evaluated. In order to use data from different sources a common method should be established. A new WG D1.39 deals with methods for diagnostic/failure data collection and analysis. The main goal is to provide component specific guideline(s) for the use of statistics and statistical tools to describe the ageing and

failure processes, thus facilitating the asset manager to make sound decisions. This will be done in close cooperation with apparatus committees like SC A3 High Voltage Equipment or subsystem committees like SC B3 Substation.

Tutorials and Workshops

SC D1 can deliver tutorials in the field of liquid and liquid impregnated insulations systems as well as in the field of high voltage testing and measuring techniques. Workshops can be organized in all relevant fields of the SC, insulating materials, superconducting apparatus, high voltage testing and measuring techniques. Themes concerning diagnosis have to be tailored and are also available e.g. for Partial Discharge diagnosis.

This capability will be constantly developed in line with the activities of the SC.

Publications

The following technical brochures are published or will be published soon:

TB 409	Report on Gas Monitors for Oil-Filled Electrical Equipment
TB 413	Insulating Oil Reclamation and Dechlorination
TB 414	Dielectric response diagnoses for transformer windings
D1.15	Status of Development and Field Test Experience with High-Temperature Superconducting Power Equipment
D1.17	Generic guidelines for life time condition assessment of HV assets and related knowledge rules
D1.33	Guidelines for Unconventional Partial Discharge Measurements
D1.24	Polymer nanocomposites – fundamentals and possible applications to power sector
D1.14	Report on resistance to weathering and UV of polymeric materials
D1.14	Requirements on testing flammability of polymeric materials for outdoor insulation