



**STRATEGIC PLAN
2005-2014
ACTION PLAN
2005-2008**

CIGRE STUDY COMMITTEE D1

MATERIALS AND EMERGING TECHNOLOGIES

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1 INTRODUCTION

1.1 Purpose of the Strategic Plan

The purpose of the Strategic plan is to formulate the mid- to long-term ambitions of Study Committee D1, “Materials and Emerging Technologies” and it will be used for the planning of the activities of the SC and the related Working Groups and Task Forces. Furthermore the Strategic Plan will be used to keep and extend our knowledge base and the competency of our members, in order to be able to support our clients with a basic engineering background in the field of electrical materials, diagnostic systems and emerging technologies. The latter ambition needs a close co-operation with the other study committees of CIGRE, since SC D1 acts as a horizontal committee in this respect.

1.2 Relationship with Strategic Plans of CIGRE Technical Committee and Other Study Committees

The Technical Committee’s Strategic Plan provides the framework and work environment for the present plan, projecting a horizontal Materials and Emerging Technologies Committee within the field of the electrical power industry. In line with the general aims of CIGRE to facilitate and to promote the exchange of knowledge and information between all member countries and stakeholders in the general area of electric power system, SC D1 specifies the following mission and scope:

1.3 Mission

To facilitate and promote the progress of engineering and the international exchange of information and knowledge in the field of materials, high voltage and high current test and measuring techniques, diagnostic systems and emerging technologies for electric power systems. To add value to this information and knowledge by means of synthesising state-of-the-art practices and developing recommendations.

1.4 Scope

The activities of CIGRE Study Committee D1 concern the monitoring and evaluation of:

- **new and existing materials for electrotechnology,**
- **high voltage and current test and measuring techniques,**
- **diagnostic techniques and related knowledge rules,**
- **those emerging technologies which may be expected to have a significant impact on the Electric Power System in the medium to long term.**

Said activities are focused mainly on transmission and distribution but emerging generation technologies will also be specifically considered.

Within this scope the work of the Study Committee is principally scientific in nature and has as its main aim the provision of timely information on new developments and trends to other CIGRE Study Committees. Through its work the Study Committee strives to keep CIGRE fully aware of the evolution of materials and technologies relevant to its activities.

Where the scope of SC D1 work overlaps that of other study committees, we will strive for good communication and co-operation, the co-ordination of all activities, and, where appropriate, joint activities. Such interactions will extend to all study committees.



1.3 Time Horizon

The present plan is long term, heading for a period of ten years (2005-2014). It should be revised on a timely basis, consistent with the evolution of CIGRE and the trends in the electric power industry and science.

The action plan, that forms the final part of this Strategic Plan, addresses the scheduled tasks of SC D1 in three major area's for a period of four years (2005-2008). The action plan should be updated yearly.

2. INTERNAL FACTORS

The committee remains the home for experts in the electrical power industry with an interest in scientific and engineering backgrounds. Our expertise focuses on performance and behaviour of insulating materials in electrical constructions under service conditions, testing and measuring techniques, diagnostic methodologies and related knowledge rules and emerging technologies related to electric power systems.

2.1 Organisation of SC D1

The Study Committee is mandated by the Technical Committee. The chairman, regular members, and observer members are each appointed by the CIGRE Administrative Council. The present organisation is as follows:

- A Chairman (member of the Technical Committee), appointed by the Administrative Council. Term of office: 4 years with a possible extension of two years
- A secretary, who is appointed by the chairman. No set term of office.
- 24 regular members, appointed by the Executive Committee. Term of office: 2years; potentially extendible by two times two years.
- 7 observer members. Term of office: 2 years, with one possible extension of two times 2 years.
- 9 Working Group chairmen, who are nominated by the SC chairman.
- 6 Advisory Group chairmen, who are nominated by the SC chairman.
- Liaisons with the following IEC bodies
 - IEC TC 2 Rotating Machinery
 - IEC TC 10 Fluids for Electrotechnical Applications
 - IEC TC 28 Insulation Co-ordination
 - IEC TC 33 Power Capacitors
 - IEC TC 36 Outdoor Insulators
 - IEC TC 42 High Voltage Test Techniques
 - IEC TC 112 "Evaluation and Qualification of Electrical Insulating Materials and Systems Electrical Insulation Systems

Members and observer members of SC D1 are drawn from 31 countries. The distribution of members throughout the electric power industry in 2005 is:

SCD1 affiliations:	regular member	observer member	WG convenors
Utility	1	1	1
Manufacturer	8	1	1
University	9	4	6
Institutes	6	1	1

As the area of Materials and Emerging Technologies covers a very wide range, the disciplines represented are equally as diverse: organic chemists, physical chemists, material scientists and engineers, physicists, power and electronic engineers, mechanical engineers, statisticians, and T&D-infrastructure managers, to name the majority.

The secretary maintains a web-site: <http://www.cigre-d1.org/> which is linked to the central CIGRE site.

SC D1 meets every odd year in conjunction with meetings of the working groups and task forces. Typically, this is conducted in a week-long meeting, often including a one day colloquium or symposium on a topic of broad interest of the hosting country. The odd year meetings have often been combined with related conferences (e.g. ISH), and often they have been co-organised with either another study committee or with a professional organisation in the host country.

In even years, most working groups meet during the Paris session.

In addition working groups have their individual meetings.

In 2007 A2 and D1 will jointly organise a colloquium in Bruges, Belgium, on “Transformer insulation systems (preliminary title)”.

2.2 Fields of Activity

The activities of the SC D1 “Materials and Emerging Technologies” includes the expertise in insulation constructions and its profound knowledge about electrical ageing processes under service conditions, the diagnostics and related knowledge rules as basis for asset management techniques, the high voltage and current measuring techniques and the large field of emerging technologies related to electric power systems.

SC D1 addresses the properties and the physical phenomena of all existent, improved and new materials, including their ageing processes that have to be diagnosed for proper asset management. A further important point is the high voltage and current test and measuring technique, which is used to test and evaluate the performance of material and systems. Moreover alternative solutions offered by emerging technologies have to be evaluated on the future performance of their basic elements as well, i.e. can we expect proper applicability and feasibility in the electric system. By evaluating down to the materials and physical processes we can provide engineers a critical assessment of the options of an emerging technology.

From new material technologies towards new technologies can be scientifically a relative small step, however the next step to practice is often not easy. In this respect the assessment of how far an emerging technology is from practical application is of great relevance to potential users in CIGRE study committees.

SC D1 has a horizontal function supporting the other study committees with generic information concerning the above described fields of activity.

2.3 Overview of working groups, advisory groups and task forces

SC D1 has reorganised its structure to fit within the New Reference Model for Study Committees. Due to the changes in the activities of the SC D1 and the requirements of the New Reference Model the future organisation of the SC D1 should take into account two important aspects:



- To establish active working bodies with clear defined scope and deliverables. The work shall be done within four years or preferably shorter by a well selected group of experts in the related field.
- To keep highly experienced experts within SC D1 without a formal limitation of time in order to get the benefit of their experience in the actual and future work of the established working bodies

As a result of these conditions we will have in the future the following organisation (after approval of the TC of CIGRE) as shown in the attached organisation plan.

The following table shows the Working Groups, Task Forces and the Advisory Groups, its field of activity and the related SC within CIGRE.

WG	Field of activity (shortly)	of interest to SC
WG D1.01	Liquid Impregnated Systems for Transformers	A1, A2, B1
WG D1.03	Insulating Gases	A3, B1-3, C4
WG D1.07	Solid Insulating Materials for Rotating Machines	A1
WG D1.12	Materials for HVDC Applications	B1-4
WG D1.14	Material properties for non-ceramic outdoor insulation	B2, C4
WG D1.15	Superconducting and Insulating Materials for HTS Power Applications	A2-3,B1, B2-4,C1
WG D1.16	High Field phenomena and solid insulation and interfaces	B3
WG D1.17	HV Condition assessment tools, data quality, expert systems	B3, C4
WG D1.18	Emerging generation technologies in power systems	A1, C6
WG D1.33	High Voltage and Current Test Standard Recommendations	A1-A3, B1 B3-B4, C1, C4
TF D1.19	Solid insulation endurance under transient voltages	A1-A3, B3-B4, C1, C4, C6
TF D1.20	Non-destructive Water treeing detection in MV XLPE cables	B1, C1, C4

Moreover we established 7 advisory groups for monitoring and timely indicating the need of new work or working groups:

AG	Field of activity (shortly)	of interest to SC
SC D1	Strategic and customer related advisory group	All SC's
01	Liquids and Liquid Impregnated Systems	A1, A2, B1
02	High Voltage and Current Test and Measuring Technique	A1-A3, B1 B3-B4, C1, C4
03	Insulating Gases	A3, B1-3, C4
04	Insulating Solids	A1-A3, B1 B3-B4, C1, C4, C6
05	Capacitors	A3
06	Emerging Technologies	All SC's

At the Study Committee meeting in 2003 SCD1 has urged its subgroups to adapt to the new reference model, implicating that all Working Groups and Task Forces have a non-permanent status now. The Advisory Groups can have an open term of office, as they are considered to follow the development in a specialised area of possible future relevance to D1. The main activity is exchanging, tracking and tracing of information and to evaluate mainly the relevance



of possible new projects to create new working groups, by proposing new work items and terms of reference.

The customer/strategic advisory group is reflecting our horizontal duties, which involves to establish priorities, monitoring results and gauging internal customer satisfaction.

The WG D1.33, transferred from the former SC 33, concentrates its work on the high voltage and current test standard recommendations, supporting the relevant IEC TC 42. Experts worked in the past from their permanent home SC 33, are now member of an Advisory Group to keep the expertise for high voltage and current testing and measuring techniques as well as for monitoring and diagnosis.

2.3.1 WG concerning Materials

Working groups D1.01, D1.07, D1.14 and D1.16 are mainly focused on conventional HVAC insulation, which in addition to the former insulation scope includes the increased interest in environmental and diagnostic concerns.

New AC/DC high performance constructions are investigated by three other working groups , WG D1.12 deals with HVDC materials and the threshold set by space-charges in polymers. At cryogenic conditions WG D1.15 came into force, which investigates superconducting and insulating materials for HTS Power applications.

2.3.2 WG concerning Diagnostics

New diagnostic methodologies and knowledge rules for HV asset management can be build upon this base. Knowledge rules and data quality for the decision support systems for advanced on line monitoring and failure mode recognition techniques are issues of great need, which are addressed by WG D1.17.

2.3.3 WG concerning Testing and Measuring Technique

The work of this Working group is an important prerequisite to give adequate support to testers and users of equipment and therefore a closed connection to the other study committees is required. The output is the basis for IEC recommendations. The actual work deals with voltage and current test standard recommendations.

2.3.4 WG concerning Emerging Technologies

For the emerging part of the scope a working group D1.18 has been given the objective to assess the feasibility of new generation techniques. In the wider field of emerging technologies the WG concentrates its work on the subjects connection of emerging technology generation, renewable energy sources and energy storage.

2.3.5 TF concerning Emerging Technologies

After approval by the TC this TF will categorise the exposure of solid insulation to repetitive transient voltages, analyse the insulation endurance test methods and identify new test methods for transient endurance.



2.3.6 TF Non-destructive Water treeing detection in MV XLPE cables

After approval by the TC this TF should evaluate detection methods for XLPE cables in the medium voltage range as a basis for asset management of distribution cables within the utilities.

3 EXTERNAL FACTORS

3.1 Evolution of the Electric Power Industry

In our fields of activity the specialised working groups have to strive to be at the material's forefront of a series of major external influences, i.e.:

- Materials science breakthrough's have spun off new polymers, ceramics and other materials in a technical and economical acceptable range, enabling new applications in the coming decade as for example more compact HV designs.
- Power electronics devices have large impact on the conversion, manipulation and control of power.
- Further electrification breaks through in the third world, which will be important from environmental considerations particularly.
- The invention of high temperature superconductors will penetrate the electricity market within upcoming decades. It may take up a role in power systems with such devices as SMES (small magnetic energy storage), fault current limiting devices and HTS cables.
- The increasing competition on the electricity market drives utilities more and more to get the most out of their equipment, i.e. an increased interest in economic savings, asset management and overloading capabilities. The intended and extended life time performance of equipment and the effects over overloading on lifetime consumption become of serious concern.
- Due to the liberalisation and global energy market large amounts of electricity have to be transported through and between the grids. The future large scale generation of sustainable energy at remote locations also asks for an increased connectivity of the HV grids. In this scenario HVDC may get an important role in a future super grid, in more sea links and inter-grid connections. Also at moderate HV level remote connections will be optimised using the high transport capacity of MVDC connections.
- Due to environmental issues a series of new high performing designs will come under scrutiny due to such aspects as EMF influences and effects of synthetic materials solvents, antioxidants, and plasticisers, which may disrupt new material developments at an earlier stage than in the past.
- However, major on-going changes are foreseen over the next 20 years and beyond mainly as a result of new and emerging materials enabling prospective solutions in the energy services of future power networks. Developments being directed towards environmental friendliness, low energy loss, more compact design, intrinsic safety/reliability, intelligent solutions coupled with a greater move towards distributed generation and energy storage systems. On the other hand, customer pressure for continuous, reliable, high quality, low cost and environmentally friendly supplies is becoming dominant. The EPI must optimise these issues to the benefit of Society as a whole.

3.2 Projected Impact on SC D1 Activities

The following future projections for D1 can be made:

- Increased interest in integrated designs with power electronics
- Relevance of enhanced test methods for materials placed in compact designs with higher design field strengths
- Increase of activity in the field of material's stressed at HVDC conditions, to obtain dedicated testing and evaluation methods
- Feasibility assessment and development of requirements and tests for new emerging technologies
- The need to understand unresolved physical processes and interactions on a material's level, affecting the condition of installed equipment.
- New working groups focusing on assessment of electrical ageing and overloading effects
- Increased interest in on- and off line measurement methods for in situ condition monitoring of material life and risk assessment, e.g. application of statistical representation, and expert system methods to phase-resolved partial discharge analysis
- Development of inexpensive and intelligent diagnostic means needed for the transition from corrective and time based maintenance to condition based maintenance methodologies
- Information technology support system in combination with the upcoming diagnostic possibilities of sensors and smart materials, provide power systems with first aid intelligence on site and enable remote maintenance control to system operators
- The significant pressures on utilities to reduce costs have brought about the introduction of condition-based maintenance (CBM). In addition an acceptable level of risk has to be taken into account. It is important to stress the fact that the backbone of re-designing as well as of diagnostic lifetime management is the ability to measure and to understand the impact of the service conditions on long term performances, e.g. insulation ageing.
- Continued attention for such items as soft changes:
 - effect on insulation quality as manufacturers seek to reduce manufacturing time
 - effect on insulation performance as chemical processing methods, additives or other material components are substituted
 - properties are changed to meet new safety standards and reduce manufacturing costs



3.3 Evolution of Other Organisations

SC D1 maintains formal and informal contacts with a number of other professional groups in the insulating materials field as well as testing and measuring field and tries to maintain awareness of any developments underway world-wide.

3.3.1 Standards Organisations

SC D1 has contributed many documents to IEC in the past, which have formed the basis for the development of standards or for the issuance of guidelines. In part this is because our work has not selected a final method but, rather, has examined and compared a number of methods, performed round-robin evaluations on each, and then provided guidance on how they should and should not be used. Such studies have often taken many years to complete, because we have been comparing prospective methods side-by-side, sometimes against a less-than-desirable existing test. Achieving the required level of repeatability has not always been easy to achieve until the important factors affecting the results have been confirmed.

3.3.2 Learned Societies

Members of SC D1, its working groups and task forces are active in many other professional societies in Europe, Japan, Australia and North America; and other countries. The odd year meetings are often planned annex to an international or regional conference.

3.3.3 Research Organisations

We are also well-tuned into the activities of research organisations such as Technical Universities and Institutes around the world, e.g. CESI in Italy, SINTEF in Norway, KEMA in the Netherlands, CRIEPI in Japan, ERA in England, NMIST in Australia, and NIST and EPRI in the USA. We have active members from each of these organisations. Informal and formal contacts with CIRED and large number of IEC Technical Committees are being pursued.

4 AMBITIONS AND GOALS OF SC D1

The SC D1 Study Committee is dealing with the performance of material structures and associated ageing processes, which are of relevance to equipment in the field of electric energy generation and transmission and which includes all kinds of material structures and interfacial processes.

Testing and measuring are developed to evaluate the performance of material systems for multi-factor stresses at normal and abnormal operating conditions. Condition monitoring and diagnostic tests of the insulating system are of special concern for lifetime management of installed equipment. Furthermore, SC D1 has to cope with the optimised and integrated component designs in the future, requiring material structures with improved endurance for higher stress densities and other advanced abilities, e.g. self-restoring and sensing.

Further areas of interest are advanced materials including conducting polymers, polymeric outdoor insulators, interfacial phenomena, semi- and superconductor material applications, in-service lifetime optimisation and space charge formation in DC equipment. The possibilities of information support systems to store and analyse large amounts of diagnostic data opens new



ways for a further understanding and detection of degradation processes, which couldn't be revealed in the past (e.g. data-mining).

From innovative materials technologies to emerging technology is one step further towards the application, but the question remains when and what is the feasibility. In that respect SC D1 fulfils a warning function to inform study committees timely about new technologies that show to have an impact on the power system of the near future.

The market is not "technology push" anymore. Technology development is nowadays economically driven, even moving towards environmentally driven. On the other hand the need for and dependency on electricity is ever increasing world-wide. So, how energy supply security develops under the changing market drivers is challenging, in particular for SCD1 from the point of view of the basic limits and possibilities set by emerging technologies.

5 NEW WORK

TF: "Non-destructive Water treeing detection in MV XLPE cables"

TF: "Solid insulation endurance under transient voltages"

6 ACTION PLAN 2005 - 2008

The following activities are planned for the years 2005 - 2008 (will be updated after the SC meeting in 2006)

Finalised 2005

- Instrumentation and measurements for in-service monitoring of high voltage insulation CIGRE Brochure No. 286 from TF D1.02.08 (former D1.33)
- Guide for space charge measurements in dielectrics and insulating materials CIGRE Brochure No. 288 from TF D1.12.1

Scheduled for 2006-2007:

- Recent Developments in DGA Interpretation, Brochure, Spring 2006, JWG D1.01/A2.11
- Generic guidelines for condition assessment of HV components and related knowledge rules, Brochure, Mid 2006, WG D1.17
- Emerging technologies in power generation, Electra Mid 2006, D1.18
- Data mining, Brochure Mid 2006, WG D1.11
- Risk assessment of defects in GIS by PD diagnostics, Brochure End 2006, D1.03.09
- Properties of materials suitable for HVDC applications, Final report, D1.12.01, 2004
- Gas insulated systems for HVDC, D1.03.11, Final report 2006



- Emerging Nanocomposite Dielectrics, Electra 2006, TF D1.16.03

Study Committee meetings

- The 2005 SC D1 meeting took place in Crete, Greece, June, 20 and 21, 2005, in combination with WG and AG meetings
- WG D1.33 met September 26 - 30, 2005 in Eforie, Romania
- The next SC D1 meeting will be held in Paris September 1, 2006 during the Main Session of CIGRE; WG, TF and AG will also meet during the Main Session of CIGRE in Paris
- WG D1.33 meeting will be in October 1 - 5, 2006 in Warsaw, Poland

SC participation to Regional meeting and Symposia/Tutorial

- In Romania 2005 a tutorial has been organised by D1.33 " Asset condition assessment - transformer maintenance and diagnostics".
- In 2007 a colloquium together with SC A2 Transformers will be organized in Bruges, Belgium.
- The next SC D1 meeting and WG, AG, TF meetings will be in September 2007 in Seoul, Korea, in combination with a SC colloquium. The subject of the colloquium will be fixed at the next SC meeting.

Study Committee D1: Materials and Emerging Technologies

Secretary
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