2008 General Report of Group B1
(Insulated Cables)

Fredrik Rüter (SE)
Chairman Study Committee B1

0. Introduction

The Group Discussion Meeting of Study Committee B1 took place on August 28th, 2008 from 08.45 to 18.00. About 200 to 270 people attended the meeting. 43 prepared and 47 spontaneous contributions were presented, referring to 11 questions as proposed by the Special Reporter Gunnar Evenset (NO). The Special Report was based on 22 papers submitted for the 2008 CIGRE Session, addressing three Preferential Subjects.

This General Report aims at summarising the views expressed by speakers during the Group Discussion Meeting and at synthesising the aspects that were found to be of prime attention within the international power cable community, and also referring to ongoing or possible future work of Study Committee B1.

1. Challenges overcome in recently installed cable systems

Preferential Subject No. 1 referred to the state of the art of high voltage underground and submarine cable systems, both for AC as well as for DC.

The papers presented under Preferential Subject No.1 show that there are technical challenges to be overcome both with the cables that are regarded as mature technology and with new technology as represented by HTS cable systems.

The need for transmission of large amounts of energy into large cities creates challenges for the utilities and the cable industry. EHV power cable circuits have to be installed in tunnels which may be shared with other infrastructure and rivers may have to be crossed by using directional drilling and additional thermal challenges.
HTS cable systems are also being developed mainly to upgrade the power capacity of the grid in large cities with limited civil works. However, this technology is still in the development stage. It is interesting to see the different design philosophies that the cable manufacturers have for their systems. There is also a large scatter in the test voltages used for type testing of these systems as there are no recognized international test standards for HTS cable systems. The need for such test recommendations will increase as the HTS technology becomes more mature and available.

The need for interconnections between disconnected grids also gives new challenges for the submarine cable manufacturers. The submarine cable technology has to be further developed to meet depth and transmission capacity requirements. Installation of submarine cable systems at very deep waters also give challenges for the laying equipment and laying methods.

The general picture presented and discussed was one of technologies under steady development, but also the consolidation and use of state-of-the art techniques. The universal focus of any cable system is reliability, but given that, there are other clear driving forces for cable system technology, such as increased performance, speed of installation, aiming for cost efficiency both for construction, as well as for operation.

1.1 State-of-the-art for cables and accessories

In many ways the development of cable and accessories is incremental, and much of it is related to materials and manufacturing processes. The development of insulation materials (such as XLPE) is focusing in even better cleanliness, and better process ability for manufacturing. While it is essential for the performance of a cable that there are minimum contaminants in the insulation (or insulation interfaces), some of the material development is targeted at allowing longer extrusion lengths. Longer production lengths, cater for fewer joints, and usually simpler cable installation.
Cleaner materials cater for higher reliability and higher stresses,. which cater for thinner cables and fewer joints also.

Investments in cable production machinery and factories, and development of production know-how, allow very big conductors (exceeding 2,500 mm^2), and handling of long lengths (which is particularly interesting for submarine cables). Laminated metallic foils are often used as part of the cable screen, and B1 presently has a Working Group to address this, **WG B1.25 "Advanced design of laminated metallic foils"** (to be published in 2010)**.**

When it comes to submarine three-core AC cables, the development trend is clearly towards higher voltage (implying heavier and bigger cables), and longer lengths. There are now three-core XLPE 150 kV cable systems in operation, with cross-sections under 1,000 mm^2. A cable system that will become operational shortly consists of three-core 240 kV, with cross-sections of 500 mm^2.

SC B1 presently has WG active in this field: **WG B1.27 "Test recommendations on XLPE AC submarine cables from 170 kV to 500 kV"** (to be published in 2010).

Cable technology is only part of the issue, one need to have a system approach. In order to get a usable cable system, accessories (primarily joints and terminations) need to be qualified to the same electrical performance as the cable. A number of various jointing technologies are available, but for field jointing it is still so that premoulded joints are favoured for land cable installations. There are technologies that have similarly good performance (tape moulded or extrusion moulded), but given the possibility of pre-testing, and the need for short installation times, moves the preference to pre-fabricated joints. Cable systems that are very short may not require joints at installation, but nevertheless for repair and contingency reasons, a corresponding joint should also be qualified and available.

For any type of joint, the performance of the field jointing is always crucial for the reliability of the joint. Qualified jointers, professional equipment and tools, and controlled ambient conditions are some of the key factors, presently addressed in **WG B1.22 "Cable accessories workmanship"** (to be published in 2010).

It is getting more frequent to replace parts of older cable systems (that often are oil cables), with XLPE cable systems. In doing this, reliable transition joints need to be made. The transition joints per se are not something new, but the qualification and testing standards do not address these types of mixed cable systems. Therefore SC B1 has launched a new

Working Group: **WG B1.24 "Test procedures for HV transition joints"** (to be published in 2010)**.**

Presentations were also made addressing the technological state-of-the-art for extruded DC cable systems. There are today 320 kV and 500 kV cable systems qualified in laboratories, allowing power transmission of some 2,800 MW. The highest rating of extruded DC cable systems installed and in operation, is presently 350 MW at 150 kV (using molded flexible joints for submarine portions, and pre-fabricated joints for land portions). However there are presently extruded cable systems at 200 kV under installation. More than 1,400 km of extruded DC cables is today installed and in operation. The first HVDC connection to an off-shore wind park is presently under construction.

The number of installed cable systems with HTSC (High Temperature SuperConducting) cable systems is steadily increasing. Some installations were presented and discussed, and a focus was on testing of these systems. In response to an initiative from IEC TC90 (superconductivity) and TC20 (cables), SC B1 launched a Task Force: **TF B1.31 Testing of superconducting cable systems**

1.2 Innovations in installation techniques

Efficient installation of cables is a big challenge to utilities and cable makers. Jointing is rather time consuming and the utilities aim to install as long continuous lengths as possible. Cable lengths of up to 2500m of 245 kV cables have been installed in tunnels in Japan and of up to 3300 m of 63 kV cables in ducts in France.

More efficient installation can also be achieved by choosing slim cable designs resulting in longer drum lengths. However, the voltage level on the sheaths of cross bonded systems must be carefully considered when the installation lengths are increased.

In urban areas power cables (as well as other utilities) are often installed in conduits or tunnels. The reason is generally due to very limited access, and strict requirements on obstructing traffic. These techniques obviously generally provide a very good physical protection. In these cases special attention needs to be paid to jointing chambers, for availability to erect the joints.

Especially for underground cables (but also applicable to some extent for submarine cables), mitigation techniques for EMF (ElectroMagnetic Fields) are of interest. Study Committee B1 has launched a Working Group for this purpose, **WG B1.23 "Impact of EMF on current ratings and cable systems"**

2. Supporting Techniques for operation and maintenance

Preferential Subject No. 2 referred to maintenance policies, diagnostic methods, and remaining life assessment methods. The main focus of attention was set at on-site pd measurements.

2.1 PD measurements

It is clearly of interest to be able to measure PD activities on an installed cable system. The purpose may be to verify the quality of the installation work, but also checks may be valuable later on in the life of the plant, as a sort of health check.

Measuring PD on an installed cable system, outside of the controlled environment a laboratory would provide, is however related to some challenges. The challenges may include how to distinguish between internal partial discharges from noise, and how to qualify degradation mechanisms.

Although the experience of PD measurements at site, is slowly getting greater, it seems to be the general opinion that there is a need for guidelines, and possibly standardisation of test set-ups. In response to this need, SC B1 has set up a new Working Group **WG B1-28 "On-site Partial Discharge Assessment of HV and EHV cable systems"**

3. Future technical solutions addressing environmental and economical considerations

Economical considerations have always been important in the design and operation of power systems. However, the focus on environmental aspects is increasing in general, especially when planning new cable links. The environmental impact when constructing a cable system, may be quite visible but temporary, but for normal operation when installed the environmental impacts are generally limited to losses, magnetic fields, and/or leakages.

For long transmission lines on land, the extruded HVDC cable technology is a viable alternative, and the cost difference between HVDC underground cable systems and overhead lines may become as low as 2. This figure will certainly depend on the route conditions, but development of VSC converters and extruded HVDC cables has made HVDC transmission more attractive for transmission on land.

As the voltages and ratings of HVDC Systems using extruded cables are increasing, SC B1 has launched a new Working Group **WG B1.32 "Recommendations for testing DC extruded cable systems for power transmission at a rated voltage up to 500 kV"** (to be published in 2012).

EMF mitigation techniques is of increasing interest. Methods to reduce the EMF from power cable links were discussed; one being with a magnetic tape wrapped around the cables. This new design may be attractive in densely populated areas and may replace cables in steel pipes. Another one compared the EMF from underground cable circuits using 3 and 6 cores per circuit. The calculations show that the magnetic field from a cable circuit may be significantly reduced by using 6 cables installed in a special geometry. This may be an attractive alternative to circuits with large conductor cross sections and external magnetic shielding.

SC B1 addresses EMF mitigation techniques in **WG B1-23 "Impact of EMF on current ratings and Cable Systems"**

4. Conclusions

The Group Discussion Meeting of SC B1 was an active and lively forum of international experts, who frankly and competently discussed topical issues in the power cable world. Not all questions were answered conclusively, however, this was not the intention and the expectation of the auditorium. Open questions are considered the input for future activities of Study Committee **B1 "Insulated Cables".** They are partly already included in the scopes of the existing **Working Groups,** which are indicated in the respective chapters of this General Report. Readers and experts are invited to contribute with their comments and experience to the further progress of these working bodies of SC B1.