Workshop HT 84
High temperature use of polymer insulated high voltage cables.

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The use of certain synthetic materials such as XLPE may well lead certain users to operate HV cables at high temperature either continuously or temporarily. This sets a number of problems which were examined during the workshop held at Clamart on the 8th and 9th of March 1984.

Seventy experts from twelve countries took part in the work of workshop HT 84.

1. Behaviour of materials.

A broad discussion took place on the behaviour of insulating materials with respect to temperature:

- *Both 90 to 100°C EPR and XLPE insulating materials whether charged or not are likely to become deformed under the effects of external stresses producing structural modifications. In the case of XLPE residual de formation is observed if the external stress remains applied to insulating material throughout cooling. In the case of EPR this remanence is very low.*
- *As for dielectric strength the results showed that there was a considerable fall off in performances of XLPE between and 20 °C and 90 to 100 °C followed by stabilization above 110 °C. According to several delegates these changes can be explained by the evolution of the structure of XLPE.*
- *The changes in characteristics of semi-conductor mixtures with temperature was a very controversial subject while the semi-conductor / insulation interface part was stressed by many delegates.*

2. Behaviour of cables.

Various guidelines emerged from the discussions:

- *The dielectric characteristics of cables depend of course on their composition and differ considerably from the results obtained on materials. Various experiments showed that:*
  - *the AC breakdown voltage varies little with temperature;*
  - *the lightning impulse wave breakdown voltage decreases with temperature with acceleration of this decrease towards 100 °C.*
- *Radial and longitudinal thermomechanical behaviour was analyzed:*
  - *owing to the high expansion of XLPE, a cushion must be inserted between the insulation and the outer jacket. Different solutions were proposed: ribbed semi-conductor screen, compressive mat, etc.;*
  - *the high longitudinal thermomechanical stresses in the overload conditions (several daN/mm2 of conductor cross-section) can lead to lateral compression stresses in curves or in straight sections resulting in local buckling of several hundreds of daN (depending on the temperature and the cross-section). Various tests were proposed with the aim of studying the behaviour of cables by simulating these effects. The thermomechanical test proposed by the CIGRE working group 21.09 was especially discussed. It was generally deemed to be interesting and was considered worthy of improvement with regard to simulation of lateral stresses.*
- *The longitudinal shrinkage phenomenon was also discussed. This phenomenon which is nowadays much better understood and controlled is accentuated around the crystalline melting point of the insulating material. The shrinkage phenomenon affects mainly the accessories. There*

must therefore be compatibility between the inevitable cable shrink and the associated accessory technology.

Accessories and in particular joints are specific points whose permissible thermal limits are obstacles which may well prove higher to overcome than those of the cables themselves.

3. Behaviour of installed cables.

From the exchange of information concerning installation and operating constraints, it emerged that very few studies have been undertaken on the subject. Two important experiments have however shown that beyond 105 °C considerable deformation appears on XLPE cables which can lead to serious damage (in particular with metal strip type screened cables).

A high operating temperature or overload requires sophisticated installation devices. Certain solutions were described.

4. Operation problems.

It was generally agreed that a cable / environment interface temperature of 50 to 60 °C was an upper limit value beyond which ground drying phenomena might appear.

It was confirmed that improved use of cables was linked to a more accurate knowledge of their behaviour in the overload conditions. A number of users described computer controlled prototype installations indicating the overload possibilities in real time.

5. Economic benefits.

Generally speaking economic calculations cannot completely take into account all aspects of the problem. In particular they do not take into account the cost of the unavailability which would come about as a result of an increase in temperature. Accurate and final conclusions cannot therefore be expected. However certain results show that operation of cables at steady state temperature greater than 80 or 90 °C is probably not economic in most cases when compared with an increase in cross-section of the conductor. However operation at a higher temperature may in certain cases prove economically justified.

The solution of doubling the link which is much more costly does however offer the advantage of improving network reliability.

6. Conclusion.

In conclusion it does not appear that thermal ageing of materials is the controlling factor in the operational temperature of cables. Their thermomechanical behaviour and the cost of losses are the first considerations when defining the maximum permissible temperature. For example in the case of XLPE insulated cables limit temperatures of 90 °C at steady state operation and 105 °C at overload conditions were recommended by most of the experts.