EXECUTIVE SUMMARY

01. There are basically two ways by which electricity is transported from generating plants to load areas. These are by overhead transmission lines and by underground cables. Overhead transmission is more favoured for economic reasons. The cost of underground cables is invariably higher than that of overhead lines with equivalent capability, particularly for extra high voltage transmission system.

Inspite of the higher cost, the need for underground installations has been pronounced with each passing year owing to :

(a) Ever growing concern for safety and amenities in densely populated areas.

(b) Preservation of aesthetic values in many localities.

These factors have led to the continuous growth of cable system in many countries in the world. Different types of underground cables are:

(i) Paper insulated lead covered (PILC) cables.

(ii) Poly vinyl chloride (PVC) cables.

(iii) Polyethylene (PE) cables.

(iv) Ethylene propylene rubber (EPR) cables.

(v) Cross linked polyethlene (XLPE) cables.

Among these, PILC and XLPE are the two competitors. PILC cables are the most primitive cables used in entire voltage range starting from 1.1KV to 750KV AC. Inspite of the well established service reliability, the PILC cables are being gradually replaced by less hygroscopic polymeric insulated cables, mainly XLPE. XLPE cables have distinct advantages viz, lighter weight, better electrical and thermal properties, less maintenance, and easier terminating and jointing procedure etc. Today XLPE cables are being extensively used in many countries all over the world. In 1959, Japan and USA commercialized XLPE cables upto medium voltage rating. Since then a fast development of XLPE cables has taken place. Presently, XLPE cable of 500KV class has been installed in Japan.

0.2 THE XLPE CABLE TECHNOLOGY

The basic material for XLPE cable is polyethylene (PE). PE has very good electrical properties, however, its mechanical strength decreases significantly above 75°C restricting its continuous operating temperature to 70°C only. The improved thermal characteristics of PE are obtained by establishing a large number of cross-links between its liner molecular chains employing suitable techniques. The rigid structure of crosslinked polyethylene results in higher continuous current carrying capacity and short circuit temperature (250°C) than that of PE.

There are three processes for converting PE to XLPE. They are:

(i) Electron irradiation.

(ii) Chemical Cross linking.

(iii) Organic silane method.

Electron irradiation is a slow process and it is difficult to ensure an even degree of crosslinking throughout the thick insulation required for power cables. Therefore this process is usually restricted to thin insulation of 1 to 2 mm thickness only. Chemical crosslinking process is the process by which cross-linking of PE is established using an organic peroxide such as dicumyl peroxide (dcp) at high temperature in the range 250 to 350°C and pressure 15-20 kg/cm^2. This method is employed in the production of XLPE cables of all voltage range, from LV to EHV. Sioplas technique is a relatively new method of crosslinking PE into XLPE. Cross linking is achieved by mixing suitable silane to PE and exposing this to ambient conditions. This method has the distinct advantage of lower capital expenditure as no special arrangements to maintain high pressure and temperature are required. But the process is very slow for thick insulation and hence restricted to low voltage and medium voltage XLPE cables.

The general construction of XLPE cable consists of copper or aluminium conductor, extruded layer of semiconducting material over conductor (for voltage class above 3.3KV), extruded XLPE insulation, extruded layer of semiconducting material (for cables of voltage rating above 3.3KV), copper wire or tape as metallic screen, armour, inner sheath and outer sheath, usually made of PVC etc. Three core XLPE cables are generally used upto maximum 33KV. Cables of 66KV and above voltage rating are off single core construction.

The manufacturing process of XLPE cables consists of mixing of PE with crosslinking agent (dcp) and antioxidants, extrusion of semiconducting layers and insulation over the conductor, crosslinking the PE compound in curing lines at high temperature and pressure and cooling the core to ambient temperature. All these processes are carried out in one step employing catenary lines for curing and cooling, hence the name continuous catenary vulcanization. Semiconducting layers and insulation are extruded using triple extrusion technique. The curing process was initially carried out with steam at high temperature and pressure. This resulted in the formation of microvoids within the insulation and restricted the application of steam curing process upto 33KV. To achieve reliable HV cables, it was therefore necessary to employ curing in the absence of steam. For this reason, dry curing methods were developed, where PE was crosslinked under nitrogen pressure in silicone oil, in molten salt and also in long dies. The number of microvoids were drastically reduced. A new curing process has recently appeared namely silane process which is more economical. XLPE has become the most favoured insulant. Germany, Japan, USA and the Scandinavian countries have installed vast quantities of such cables. Japan has developed XLPE cables upto 500KV which is the highest voltage rating of XLPE cables manufactured so far.

0.4 INDIAN INDUSTRY

In India, presently XLPE cables of EHV grade upto 132KV have been commercialized. Presently there are nine major XLPE cable manufacturers in the country. They are:

a) Asian cables Ltd., Thane, Maharashtra.

b) Cable Corporation of India Ltd., Bombay.

c) Finolex Cables Ltd., Pune, Maharashtra.

d) Fort Gloster Industries Ltd., Howrah, West Bengal.

e) Incab Industries Ltd., Jamshedpur, Bihar.

f) Industrial Cables (India) Ltd., Rajpura, Punjab.

g) Nicco Orissa Ltd., Baripada, Orissa.

h) Premier Cable Company Ltd., Ernakulam, Kerala.

i) Universal Cables Ltd., Satna, M.P.

Majority of Indian manufacturers have employed steam curing for the production of XLPE cables upto 33KV. Few manufacturers have employed dry curing also for manufacturing MV as well as HV & EHV XLPE cables as they use the same plant for the production of all voltage range XLPE cables. Few Indian manufacturers have employed silane curing technique for the production of low voltage cables upto 3.3KV.

First XLPE cable was manufactured in 1978. Since then a rapid growth has taken place in this industry. Presently XLPE cables upto 132KV have been commercialized. Production of 275KV and above voltage rating XLPE cable is being contemplated by few Indian manufacturers. All cable manufacturers in the country have foreign collaboration for the production of XLPE cables. The raw materials viz, XLPE compound and semiconducting materials are being imported. Semiconducting material has been indigenously developed, however it is under trials and not yet commercialized. The XLPE cable manufacturing plant are presently imported. No efforts have been made in the country to develop these equipments. Accessories are not available for XLPE cables of voltage rating above 66 KV. Materials for few latest type of cable accessories like slip-on type and others of 33KV class are not available in the country. However some efforts are being made by few Indian accessory manufacturers to indigenise the same. Facilities for testing XLPE cables upto 132KV rating are available in national testing laboratory. Thus there exist considerable technological gap in Indian XLPE cable industry in respect of material, equipment, accessories etc.

0.5 TECHNOLOGY GAPS

- Technology gap exists in respect of material and equipment for manufacture of the same in the country.
- The equipment required for manufacture of XLPE cables is not indigenously available and presently not much efforts are being made to develop them presumably owing to restricted demand in the country.
- Technology gap exists in the field of accessories for XLPE cables of voltage rating 66KV and above as material, design and technology for developing them are not available with Indian accessory manufacturers.
- Technology gap also exists in the production of EHV cables with large size conductors as know-how for production of such cables is not presently available.
- Although expertise for testing and evaluation, design and other relevant aspects has been built in a National Institute like Central Power Research Institute, gap exists in the availability of adequate facilities for evaluation of life and corresponding statistical analysis of EHV cables and their accessories in the country.

6 RECOMMENDATIONS

As stated earlier XLPE cable industry in the country has technological gaps in four major areas viz, material, manufacturing equipment, accessories for cable testing and evaluation. With a view to bridge this gap following recommendations are made:

(i) XLPE compound and semiconducting compounds are not available in the country to the required level of purity and quality. Such high quality raw materials should be indigenously manufactured by material manufacturers like Indian Petrochemicals Corporation Ltd., (IPCL) National Chemical Laboratory (NCL).

(ii) The XLPE cable plant with necessary controls are being imported by all the cable manufactures. Indigenisation of such plants involves R & D efforts and significantly high investments. Organisations like Hindustan Machine Tools (HMT), and Central Machine Tools Institute (CMTI), can explore these possibilities.

(iii) Only few manufacturers have indigenised the design, technique and materials for accessories of XLPE cables upto 33KV. There exists a large gap in accessories for 66KV and above voltage rating. To bridge such gaps, collaboration with leading International accessory manufacturer viz, Pirelli, Italy, Elastimold USA or Rachem, may be considered.

(iv) As know how for the production of EHV cables with large size conductor is not available, import of technology for horizontal curing technique like MDCV may be initially allowed.

(v) National Laboratories like Central Power Research Institute (CPRI) should establish sophisticated facilities for testing EHV rating XLPE cables to develop extensive evaluation and life estimation facilities for EHV cables and strengthen their expertise in this area.

(vi) As the quantity requirements of superior materials for EHV grades are low and less attractive to the manufacturers Indian manufacturers of LDPE/MDPE be given incentives to develop and manufacture these materials for EHV cables.

(vii) Test facilities available in the country for testing XLPE cables and accessories may be upgraded in line with International Institute like CESI, Italy.

(viii) Suitable Indian specifications could be formulated for testing XLPE cable accessories of MV and HV rating so that reference to International specifications are reduced.

(ix) Adoption of Sioplas technique for XLPE cable production upto HV class be examined in the country as the same has been tried by foreign manufacturers upto MV voltage.

(x) Application of water absorbent tape over XLPE insulation be given consideration.