INTERNET UPDATE

Designs and reliability of underground cables and systems

By Hilary Marazzato and Ken Barber, Olex Cables

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Summary

The excellent electrical performance of XLPE is the reason it is now used almost exclusively for insulating low voltage, distribution and transmission cables. While XLPE has far better resistance to moisture than paper insulation or PVC, moisture can affect long term performance of XLPE under the influence of high electrical stress. All low voltage and distribution cables can be installed without precautions, but some moisture protection is advisable for medium voltage cables and cables for sub-transmission. The use of metal sheaths for transmission cables is considered essential.

Introduction

There were serious cable failures when XLPE was first introduced in the late 1960s in the USA. This was due to incompatible semi-conductive materials and lack of triple extrusion, but also water ingress and treeing in steam cured XLPE. The cable industry has since made significant developments in XLPE materials, cable design and processing, so that 500kV XLPE cables are now in service and XLPE is the most practical insulation material for the range of cables used by the electricity supply industry worldwide. However, while this material is highly moisture resistant, moisture can still cause electrical failure under the influence of high electrical stress.

Moisture mode of failure

The first XLPE cables were produced on steam cure CV (Continuous Vulcanisation) lines where moisture saturated the insulation due to the temperature and pressure of the steam (~200°C, 200 psi). Many of these early cables are now showing signs of water trees. For more than 10 years, all XLPE insulated cables produced in Australia have been processed in a 'dry cure' manner that ensures water absorption is less than 200 ppm. Very few of these cables have significant water treeing. While water trees may not cause breakdown, in cases where there is a high stress point or a space charge developed during DC testing, such trees may develop into electrical trees which subsequently cause premature breakdown.

Protection/prevention modes

- Radial protection – using a metal sheath on the cable to provide an impervious barrier to entry.
- Longitudinal protection – using solid fillers to fill all voids where water may enter or use of water swellable tapes, which fill the spaces only when the water is present and thereby prevent the longitudinal progress of any further water.
- Moisture resistant insulation material – such as Tree Retardant XLPE - TR-XLPE.

Solutions

<u>Low voltage cables</u>

Cables designed to function at voltage levels up to 1,000V have insulation thicknesses well above those required for purely electrical requirements. The voltage stresses in the insulation are therefore small and inadequate to promote the growth of water trees that lead to electrical failure of the cable. Thus, no protection is required from the effects of water or moisture.

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Distribution cables

Various forms of distribution cable protection and their respective cable life expectancies are outlined below:

Circumstance	Cable life expectancy
Cable without protection and affected by water/moisture	>15-25 years
Use of water swellable tapes	>20-30 years
Use of insulation materials i.e. TR-XLPE	>30-35 years
TR-XLPE plus water swellable tapes	>35-40 years
Metal moisture barrier (i.e. lead sheath)	60 years

Sub-transmission and transmission cables

A metal moisture barrier such as an extruded lead sheath or a welded corrosion resistant sheath is the most secure design option for transmission cable and will ensure a life expectancy of 50-60 years.

Other factors reducing cable life

- Life expectancy is reduced when insulation is subjected to “over voltage” in the form of surges and impulses.
- Changes in the environment, for example, depth of cover, adjacent services and micro-biological effects in the soil, can increase operating temperatures and reduce cable lifetime (cables are designed for a maximum operating temperature of 90°C with limited overload periods as defined in the relevant standard).
- Poor supervision/management and adverse installation conditions may cause cable damage.

Conclusion

Olex believes technology has greatly improved since the early XLPE insulated cables, and the problems these early cables began to exhibit after 20 years or more in service have been addressed. New designs will not experience such problems. Olex confidently predicts cable lifetimes of at least 40 years for any modern XLPE insulated cable and suggests that 60 years is not an unreasonable expectation if the cables are correctly designed, installed and operated. This is particularly so for those cable designs utilising water blocking measures or where there is a welded or extruded corrosion resistant moisture barrier. Condition monitoring by DTS and the adoption of other condition monitoring technologies as they become available, is recommended to help achieve maximum lifetime. It is important to note that when optical fibres are to be included in cables a metal sheath can improve the life of the fibre.

Copies of this article in its entirety and more information is available from Olex Engineering and International Sales on +61 3 9281 4444 or email Ken Barber at kbarber@olex.com.au or Hilary Marazzato at hmarazza@olex.com.au