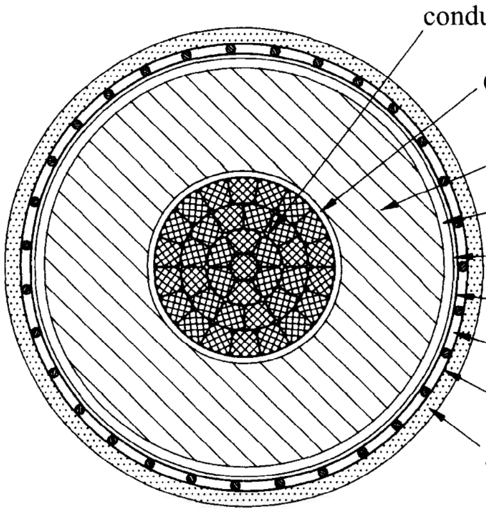
WHY WE MUST PERFORM CABLE SHEATH TEST

Theoretical background

Metallic Shields and Sheaths

The simplest shield construction consists of one or more flat copper tapes wrapped helically around the cable core. Other constructions can be used in order to increase the short-circuit capability of the metallic shield. Concentric copper or aluminum wires applied helically is perhaps the simplest, as illustrated in the following figure. Another consists of a longitudinally folded and corrugated copper tape applied with an overlap under an extruded PVC or polyethylene jacket.



Cross section of solid-dielectric power cable with concentric wire shield

The metallic shield serves two purposes:

1. With the outer metallic shield of the cable grounded, the electric stress distribution within the insulation attains radial symmetry and is confined to the insulation. This is an important safety consideration.
2. In addition to fulfilling this shielding function, it is often used as the essential ground return path to carry the fault current in the event of a line-to-ground fault on the system. Thus, it must be able to carry this current for the time required to operate the overcurrent protective device without overheating and damaging the cable.

The shield constructions described above should only be used on high-voltage polymeric cables installed in locations known to be dry. Such cables must be either installed in a dry environment or protected against moisture ingress by a hermetic sheath.

Various countermeasures can be taken to protect the cable against water tree formation. The most commonly used is a longitudinally folded copper, aluminum, or lead laminate with a sealed overlap and bonded to the polyvinyl chloride (PVC) or polyethylene jacket during extrusion. Where short-circuit requirements dictate, these may be used in combination with concentric copper or aluminum wires. If desired, longitudinal water blocking of the shield area can be achieved by the use of water-swellable powder or semiconductive tapes.

COVERINGS FOR CORROSION PROTECTION

Exposed metallic jackets and armors are subject to deterioration due to corrosion attack resulting from a number of possible causes. For cables buried directly in ground, corrosion may result from the chemical attack caused by weakly acidic or alkaline water, galvanic currents generated between dissimilar moist earths in contact with the metallic sheath or armor, development of a 50-Hz current component between the earth and the cable surface, and any possible stray direct currents. For cables installed directly in ducts, in addition to the above causes, corrosion may take place due to galvanic currents generated between dissimilar metallic surfaces in contact.

To prevent corrosion of the metallic sheaths and armors, the latter must be shielded from the environment by nonmetallic coverings. At the present, a universal covering material that would function well in all corrosive environments is not available. However, by proper selection of any one of the previously described extruded jacketing or sheathing materials, adequate corrosion protection may be achieved.

Corrosion may occur with primary-type distribution cables that have a bare concentric neutral of coated copper wire to ensure proper grounding. Such cables are particularly susceptible in soils having high sulfur content; however, in many instances direct buried copper wires tend to resist corrosion remarkably well, since the copper neutral is cathodic to a large range of other metals. In cases where difficulties may arise, cathodic protection should be considered. In cathodic protection, a battery or a corrosion cell is formed between the cathode (the cable wire ground to be protected) and the anode. The anode may consist of metals high in the electromotive or galvanic series, such as zinc or magnesium. With the anode placed in close proximity to the possible or anticipated corrosion site on the copper grounding wires, a current will be established in the formed electrolytic cell between the anode and the cathode, leading to the gradual corrosion of the anode, thereby providing continued protection of the cathode.

Protective Coverings

For all high-voltage power cables, the metallic shield or sheath is invariably protected by an extruded layer of either PVC or polyethylene (PE). This protective covering or jacket is required for a number of reasons.

In order to provide some degree of mechanical protection to the underlying shield or sheath, the jacket must be tough and resistant to deformation both during and after installation of the cable. For most installations, jackets are black in order to give them good resistance to sunlight.

Metallic shields and sheaths are susceptible to corrosion from a number of possible causes. In order to prevent such corrosion, an extruded covering must be applied. Although very few chemicals normally found in the ground along a cable route will have a significant effect on the jacket, care must be taken in the choice of jacket compound, when the cable is to be installed in a particularly corrosive environment.

Because of its susceptibility to corrosion, protection of the aluminum sheath on a cable is especially important. When the jacket is applied directly over an aluminum sheath, it is desirable to have a thin coating of bitumen or other flooding compound along this interface. If the jacket should be damaged for any reason, localized corrosion of the sheath may then occur. The flooding compound provides secondary protection by limiting penetration of the groundwater beyond the exposed area.

In order to verify the integrity of the jacket, a direct-current (dc) voltage test is normally carried out periodically to check that no damage has occurred. To facilitate application of the test voltage, a coating of colloidal graphite or some other conductive material is applied over the jacket during extrusion.

In a three-phase single-conductor cable system, sheath losses may be significant. They can be reduced by the use of a special bonding system. This involves grounding the cable sheaths at one point only and insulating all other points from earth. In this way, circulating sheath currents are prevented and losses are eliminated. As a result, the individual cables can be spaced further apart to reduce their mutual heating effect, and, thus, to increase their current rating.

Three basic variations of specially bonded systems are normally used: end-point bonding, mid-point bonding, and cross bonding. All such bonding schemes must of necessity be fully insulated. Thus, the cable sheath must be insulated from ground. This is done by having an extruded covering of PVC or PE on the cable sheath. Again, this jacket can be checked for damage by testing it regularly after the cable has been installed. In any of the special bonding arrangements, the jacket must have adequate dielectric strength to withstand not only the induced standing voltage on the sheath but also transient overvoltages arising from lightning or switching surges.

Polyvinyl Chloride

For several decades, PVC has been used as a jacketing material when extruded over the metallic shield or sheath of a cable. Because of its resistance to oils and most chemicals, it has found use in chemical plants and oil refineries.

The PVC compounds can be formulated for a particular application by the proper use of fillers, plasticizers, stabilizers, etc. Thus, there are a wide variety of such compounds. For cables installed in tunnels or on cable trays, flame-retardant compounds are available to limit flame spread. For cable installations in a cold environment, the low-temperature properties of a PVC compound can be enhanced by the incorporation of special plasticizers. Table 2.18 provides a comparison of the physical properties of a typical PVC jacketing compound with those of various polyethylenes.

Polyethylenes

Whereas PVC has been the established jacket compound in the United Kingdom, France, and Japan, polyethylene tends to be preferred in North America. Unlike PVC compounds, the only additions made to polyethylene are an antioxidant and carbon black. Because polyethylene does not suffer from the effects of brittleness at low temperatures, it has a particular advantage for installation in those countries where low temperatures exist for an extended period of time.

Thermoplastic polyethylenes of various densities are available for jacketing purposes. It is important to select one that has good resistance to environmental stress cracking, especially for HDPE, which is particularly notch sensitive.

For most applications, either LDPE or linear low-density polyethylene (LLDPE) is used for underground installations where flame retardancy is not a consideration. When cables are being installed at high ambient temperatures in tropical locations, HDPE is often used to minimize jacket damage during installation. Although greater mechanical protection is afforded by the use of HDPE, this comes with a trade-off in increased cable stiffness.

In those countries such as Australia, Malaysia, and Indonesia where ants and termites pose a threat to the cable, appropriate countermeasures must be taken. At one time, contact insecticides such as aldrin and/or dieldrin could be incorporated into a PVC jacket. While these proved to be very effective, increased concern about the toxicity of such additives precludes their use today.

Instead, very hard jackets such as HDPE are used either alone or in combination with a thin nylon coating. A variation on this design incorporates the nylon skin between an inner and outer HDPE jacket.

Conclusions

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1. ***The jacket of the metallic shield protects the metallic shield from corrosion and deterioration. If the active cross-section of the metallic shield is reduced due to corrosion, then the whole installation may be at risk because the metallic shield will not be able to carry the fault current in case of line-to-ground fault, resulting in a possible malfunction on the operation of the overcurrent protection relay. Even if the deterioration of the metallic shield is minor, a line-to-ground fault may still cause serious damage to the cable due to overheating.***

2. ***The jacket of the metallic shield protects the XLPE cable insulation against water penetration and water tree formation. Water treeing may allow the cable to operate for some time (even to pass the recommended VLF after installation tests), but in case of strong electrical fields it may quickly lead to electrical tree formations and eventually to consecutive cable breakdowns. Water treeing is not reversible. Once water enters the XLPE cable insulation, it can not be dried out. Cable breakdown is then irrelevant to whether the penetration points are located and repaired. A detailed repair of the jacket may only prevent the problem form becoming worse, but it will give no actual guarantee that no insulation breakdown will occur.***

3. ***In case of corrosion and deterioration of the metallic shield a serious safety matter may occur, since the symmetry of the electric stress distribution within the insulation may be altered.***