Cable Construction

Caledonian medium voltage cables are manufactured using the monosil process. Caledonian provides the highly specialized plant, state-of-the-art research facilities and meticulous quality control procedures that is required for the manufacturing of XLPE/EPR insulated cables for use at voltages up to 46 KV. The materials are all kept in cleanliness-controlled conditions throughout the production process in order to ensure the absolute homogeneity of the finished insulation materials.

Depending on the cable's application, the medium voltage cable may have metallic shielding, armour or sheath and an overall jacket. Such cables can be directly buried, pulled into underground ducts, submerged under water or hung from an overhead messenger wire. They are robust, easy to install and readily available in most conductor sizes and voltages from 5 to 46 kV.

Triple Extrusion

The XLPE, TR-XLPE or EPR insulated cables are produced under clean room, using the triple extrusion process in which the conductor screen, insulation and insulation screen are extruded through a single extrusion head. The surface of the insulation is never exposed to the atmosphere or to any other material other than the adjacent semi-conductive screens, ensuring the interfaces between the materials are free of air voids or contaminations.

A thin layer of semi-conducting cross-linked polyolefin is extruded over the conductor, followed by the XLPE/TR-XLPE/EPR insulation and then a strippable semi-conducting cross-linked polyolefin (XLPO) insulation shield. All three layers are extruded through a single true triple crosshead on a dry cure catenary continuous vulcanization (CCV) line.

Conductor

Conductors may be either aluminum or copper in accordance with ASTM B 8, ICEA S-66-524. They are usually compress stranded or compact stranded, but sizes 2/0 AWG and smaller are often supplied as solid.

Conductor Shield

Conductor shield is an extruded semi-conducting material that lies somewhere between a conductor and an insulator. It smoothes out the conductor to make it look like it has a solid smooth surface. The conductor shield provides for a smooth, radial electric field within the insulation. The materials used to form the conductor shield consists of a polymer with a high carbon black content which change the polymer from insulating to semi-conducting. When this material is extruded over the conductor, it electrically reshapes the conductor to hide or fill any rough spots, burrs, strand high points and air voids between the strand interstices. The reduction of interface irregularities leaves a smooth round conductor surface with no sites to concentrate electrical stress. Reducing the electrical stress at the conductor / insulation interface allows for a thinner insulation than would otherwise be required. Lower electrical stress also increases cable life. No conductor or insulation shields are required for cables rated up to 2 kV. At 2kV and above a conductor shield is required by standards such as U.L., C.S.A., and I.C.E.A.

Insulation

There are three types of insulation, namely the XLPE, TR-XLPE and EPR. XLPE insulation possess very good electrical, mechanical and thermal characteristics in medium voltage cable. XLPE is chemical resistant and cold resistant.

Usually, the XLPE insulated cables are designed with longitudinally waterproof. In comparison with PVC or paper insulated cables, XLPE insulated cables are possessing a very low dielectric factor. Tree-retardant cross-linked polyethylene (TR-XLPE) compound contains an additive that slows the growth of water trees. These additives tend to reduce the electrical properties of XLPE, slightly increase dielectric loss, and slightly lowers the initial insulation strength (but with much better insulation strength if aged).

Water tree is the main cause of deterioration for XLPE cables of 60KV or less. TR-XLPE is characterized by longer service life and lower electrical losses. EPR is characterized by better flexibility, less expansion during heating and better properties at high temperature.

Insulation Level

Insulation level applies to what's referred to as shielded cables or cables with an insulation shield. Generally cables rated at 5 kV and higher are shielded but some at 5 kV, depending on their construction, may be unshielded.

Insulation level comes from ICEA standards S-95-658 and relates to the fault tolerant time for the system on which the cable is used.

There are two types of insulation levels with medium voltage cable. These are 100% and 133%. 100% level is used where a system fault is cleared in one minute of less. This insulation level is applicable to the great majority of cable installations which are on grounded neutral systems, where voltage rise during system faults is minimal. 133% level is used where a system fault is cleared within 1 hour. 133% is often specified when greater insulation strength (higher reliability), extra protection against surges, lighting, or water treeing is desired. This insulation level is applicable to high resistance grounded system or for ungrounded system, where the voltage rise can reach the full phase to phase voltage These insulation levels are chosen to handle increased voltage levels that may be seen in systems when faults occur. Higher insulation levels on a cable generally means it has a thicker insulation. However the only exception to 100% vs 133% is the 5KV cables. In this case, most North American standards specify the same for both insulation levels.

Medium voltage cables with same insulation thickness could have dual rating. For example, 5KV cable, 133% insulation level (ungrounded systems) could be rated for 8KV, 100% insulation level (grounded systems).

Generally 100% insulation level cable is used on grounded wye or star systems and 133% is used on delta systems. This is because generally a fault is cleared very quickly on a wye (ie: within a few cycles) but could persist for longer periods on a delta system.

Insulation Shield

The insulation shield, like the conductor shield, is required in medium voltage cables rated at 2KV or above. The conductor shield provides for a smooth, radial electric field within the insulation. Industry specifications require a resistivity of below 500 Ohm-meter to adequately carry current to the metallic shield.

The semi-conducting component of an insulation shield, like the conductor shield, is an extrusion of semi-conducting material over the outer surface of the insulation. This shield controls the electrical stress within the insulation and prevents objects from disturbing the stress at the insulation's outer surface. An insulation shield is always made up of two components, an extruded semi-conducting layer over the insulation and a metallic shield over that.

The insulation shield, when correctly grounded, will confine the electric field within the cable, equalize voltage stress within insulation, minimize any surface discharge, protect the cable from induced potential, limit electromagnetic and electrostatic interference on the adjacent systems, and lastly reduce any shock hazard in the vicinity of the cables.

When a power cable is referred to as shielded it means that it has an insulation shield.One very important aspect of the insulation shield is its degree of strippability. The insulation shield must be easily removable in order to be terminated and spliced. The extruded semi-conducting material used for insulation shields is slightly different than that used for conductor shielding.

Conductor shields bond to the insulation and are inseparable, where the insulation shield is co-extruded with the insulation and crosslinked to its surface. Most insulation shield are based on EVA polymers that have high enough polarity that even though crosslinked to the insulation, do not mix with and bond permanently to it.

Basically the metallic component of an insulation shield is there to bridge or lower the resistance of the semi-conducting layer. The metallic shield provides a path for the flow of charging current and a path for the flow of fault current. If the metallic shield is of sufficient size and conductivity, it can provide a path for the return current and thereby acts as a system neutral. There are a number of designs of metallic shields including the round wire, flat strip, copper tape helically applied with overlap or longitudinally applied corrugated copper tape. Some of which are detailed below.

Metallic Shield

Concentric Neutral - helically applied

The concentric neutral conductors of medium to high voltage cables are formed as wire or tape braids wrapped helically over the semi-conductive insulation shield of such cable. These wires act as the metallic component of the shield and the neutral, at the same time. The neutral conductors are intended to provide a return circuit for load currents and to maintain the shield at ground potential to prevent injury to persons coming in contact with the cable. The concentric neutral wires may be either bare or tinned copper (from#6 to #9AWG) helically applied. For single-phase systems, the conductance of the neutral is equivalent to that of the phase conductor. For three-phase systems, it is typically 1/3 but can be made with 1/6, 1/12, etc. neutrals.

Copper Tape – helically wrapped

Helically wrapped copper tape have bee a medium voltage standard for years. Wrapping design can improve performance. For electrostatic shielding of the underlying cable core, one or more 5 mil copper tapes are applied helically with gapes or overlap over the extruded insulation shield. The overlap of the tape windings is a key design feature in helical tape construction. Although the ICEA recommends a minimum tape overlap of 10%, an overlap of 25% deliver better performance. Extra overlap delivers increased short circuit capacity and better mechanical reliability. Tape shields may not always have sufficient fault current capability for protective relaying purposes. The cable is characterized by low short circuit capacity, providing good electrostatic shield. If grounded both ends, conductor current derating is small.

Wire Shield- helically applied

The wire shield deliver the same performance as copper tape. This is characterized by same short circuit and ampacity derating as copper tape. The wire shield may be either bare or tinned copper (from#22 to #18AWG) helically applied.

L.C. Shield

A transversely corrugated copper tape is longitudinally applied with a small overlap along the axis of the cable. A bridging tape is applied at the overlap. This design offers greater short circuit capability than helically applied tapes and reduced shield loss when compared to the concentric neutral construction. The sealed overlap of the shield is effective in impeding moisture ingress into the insulation system. This cable type is used on large single conductor sized utility and industrial cables.

This cable type provides good electrostatic shield, a moisture barrier when longitudinal overlap is sealed, and accommodates the expansion and contraction of the cable during thermal cycling. The short circuit level and conductor current derating of this cable type lies between copper tape shield and concentric neutral cables. Due to the 100% core coverage and superior heat dissipation characteristics, the entire LC shield offers the most effective means of providing fault current a low resistance path to ground during fault conditions, By contrast, the concentric neutral shield usually takes the fault to ground by using some of the wires around the cable circumference. Most of the other wires remain unused.

Metal Sheaths

The metal sheath is an interlocked metal tape made of lead or aluminium, a corrugated metal tube or a smooth metal tube. A metal moisture barrier such as an extruded lead sheath or a welded corrosion resistant sheath is the most secure design for the medium voltage cables and will ensure a life expectancy of 60 years as compared to other cable design.

This cable type provides good electrostatic shield, a moisture barrier when longitudinal overlap is sealed. The short circuit level and conductor current derating of this cable type is high if grounded at both ends as compared to other shielding types. The only drawback of this cable design is the difficulty to splice or terminate for this cable type.

Jacket

Jackets are available in a number of different compounds for specific requirements. Jacket type include Polyvinyl chloride (PVC), Polyethylene (LLDPE, MDPE, HDPE), Polypropylene (PP), Neoprene, Hypalon, thermoplastic chlorinated polyethylene (CPE), FRPVC and LSZH. The PVC jacket is mechanically rugged and has excellent resistance to oil, acids and most chemicals. The standard jacket on concentric neutral cables is low-density polyethylene (LLDPE). It prevents longitudinal ingress of water between the concentric neutral wires if the jacket is damaged. The jacket also provides mechanical protection during installation and inhibits corrosion of the concentric neutral wires or metallic shield. If fire is a concern, a FRPVC or LSZH jacket should be used. It is not quite as tough as polyethylene, but has superior flame retardance. Where required for identification of power cables in shared underground systems, three extruded red stripes can be provided on the cable jacket.