Rectification of Sheath Faults Observed in Power Cables and Accessories in EHV Cable Circuits

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Abstract: ***This study addresses the occurrence and rectification of sheath faults in EHV XLPE cables; Primarily focusing on external interference leading to cable outer jacket damage. Various corrective actions are explored based on fault location, with detailed processes outlined for rectifying sheath faults over power cables, including fault isolation and layer reinstatement. While not imposing a direct threat to the functionality of the power cable; sheath faults can directly affect the cables current carrying capacity and can lead to the deterioration of subsequent cable layers in case it was not rectified. This comprehensive examination highlights the importance of fault identification and rectification for ensuring the reliability of EHV XLPE Cables in power transmission systems.***

Keywords: Sheath Fault, D.C. Oversheath Test, Power Cable, Bonding Cable, Cable Joint

1. Introduction

EHV XLPE Cables are theoretically maintenance free and relatively easy to install with a lengthy life expectancy making them a very popular method of power transmission. However, that is only accurate assuming ideal cases. Faults are quite common and can occur during production, installation, or due to any external reasons while in service.
Production faults are detected during Routine tests and Sample tests as per relevant international standards. [1] These tests are done before dispatching to the client. Tests such as High Voltage Alternating Current Test (HVAC), DC Over - Sheath Test, and Partial Discharge test (PD) to ensure that the assets being implemented are defect free. Prior to commissioning similar testing is repeated (HVAC & PD tests) ensuring that no damage was done to the equipment during transportation and installation.

Cable Oversheath faults however lie in a grey area. As per IEC Standard 60229:2007 D.C. Voltage test’s passing criteria is “No breakdown of the oversheath shall occur during the test”.[2] While testing, leakage current is a parameter that is measured, however it does not affect the test result. High Leakage current indicates that there might be some weakness in the outer insulation.

Cable sheath faults in High Voltage (HV) cables are of paramount significance within the cable system, primarily due to their potential to compromise the integrity and reliability of the entire power transmission network. HV cables play a critical role in transmitting large quantities of electrical power over long distances. A sheath fault refers to damage or degradation of the cable's outer protective layer, compromising its insulation and exposing the conductors to external factors [3]. Such faults can lead to a cascade of adverse effects, including the risk of electrical breakdown, increased losses, and a heightened probability of catastrophic failures. The sheath serves as a crucial barrier, safeguarding the cable against environmental influences, moisture ingress, and mechanical stress. Therefore, any compromise in the sheath's integrity poses a direct threat to the cable's insulation, potentially leading to insulation breakdowns and posing safety hazards.

The increased over sheath insulation deterioration, and mechanical stress on the cable further accentuates the need for a robust monitoring and maintenance strategy. Addressing cable sheath faults in HV cables is crucial for sustaining the reliability and longevity of the power transmission infrastructure, ensuring continuous and secure electricity supply to end-users.

We can ensure that the cable to be installed is free of defects up until the point of cable pulling by carrying out a D.C. Test on the drum at site. However, Oversheath faults occur most commonly during activities after the drum test, such as during cable pulling and laying, instating bonding cables, and jointing. With this in mind, Sheath Faults occur in three locations; The Power Cable, Bonding Cable, or Cable Joint.
Sheath faults can occur on the Cable’s outer jacket naturally due to ageing, or due to external interference. This external interference is generally any kind of physical damage that occurs to the cable’s outer sheath which in turn weakens the insulation to the point of breakdown. This can come in the form of excavation by heavy machinery, directional drilling,

manual excavation using sharp tools, or naturally from the settlement of soil.

2. Corrective Action

Once the fault is located using step voltage pinpointing, it shall be determined whether the fault is in the cable, cable joint or bonding cable / accessories. The appropriate rectification method will be applied based on where the fault is found.

2.1 Power Cable Oversheath Fault

For faults that develop on the outer jacket of the power cable, as seen in figure 1, the power cable rectification method is a process in which the fault is isolated and different layers are instated to replace different components that were damaged by the fault.

Figure 1: Power Cable Oversheath Fault

The Power Cable sheath fault rectification procedure, as illustrated in figure 3, is as follows:
1) The fault is located and confirmed visually.
2) The fault is isolated by removing the semi conductive layer atop the cable's outer sheath.
3) A D.C. sheath test is carried out to ensure that the fault was isolated. If the fault was isolated, then it would not have a path to ground. The D.C. sheath test isolation criteria is summarised in figure 2.

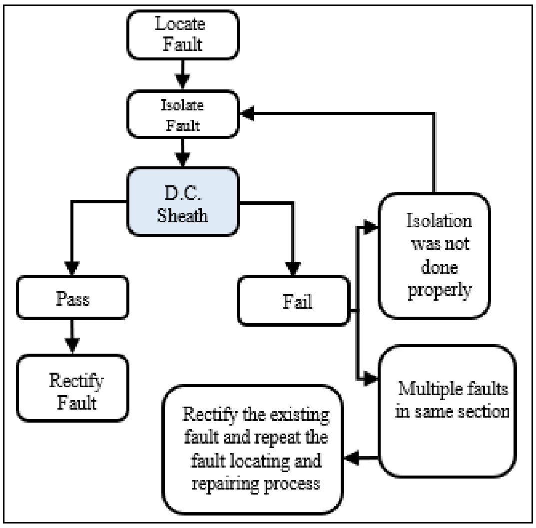

Figure 2: D.C. Sheath Test After Isolation

1) Putty material is used to fill-in any crevices that might have formed due to the breakdown of insulation. Then a full wrap around the cable's circumference is done using this putty material to create a unified smooth layer.
2) A series of PVC and HV Tapes follows to reinstate the damaged insulation layers.
3) A heat shrink tube is added to ensure that the newly instated layers are secured.
4) A semi conductive layer is applied at the top for continuity purposes during cable sheath testing.

Figure 3: Sheath Fault Rectification

However, if the oversheath fault is located inside a duct, repairing the cable will not be performed without cutting the cable in order to pull back the cable for repairing. This will require installing an additional joint in the circuit.

2.2 Bonding Cable & Accessories Oversheath Fault

Other possible forms of a sheath fault occurring in the power cable circuits can be from issues with the bonding cable/accessories. Bonding cables are terminated into a link box; There are many factors in this enclosure that can lead to the development of a sheath fault such as bonding cable defect, Sheath Voltage Limiter (SVL) Defect, Water ingress, etc.

In these cases, the defected parts can simply be replaced or repaired. For the bonding cable defect/damage on the oversheath only, as shown in Figure 4, the repairing can be done by cleaning the damaged area on the oversheath, applying insulating tapes, self-bonding tapes and heat shrinkable tube on the damaged portion. The final repaired bonding cable can be seen in Figure 5.

Figure 4: Bonding Cable Sheath Fault

Figure 5: Rectified Bonding Cable Fault

As for the water ingress, the cleaning of the link box shall take place and to re-install proper mechanical sealants at the location of bonding cable entry.

The sheath fault examples listed above can affect the bonding arrangement. A defective bonding cable can cause the unwanted connection of two phases together. This means that the induced voltage in the sheath can rise higher than intended, which in turn can lead to speeding up the ageing process of the insulation hence creating a sheath fault. This is critical as it may increase the circulating current that leads to the reduction of current carrying capacity of the cable.

SVL defects can also cause a similar issue by creating an unwanted connection to ground. This connection creates a double point bonding system in which circulating currents flow in the metallic sheath. These circulating currents can fasten the ageing process and cause sheath faults to develop. The simple correction action can be taken for this case is that the defected parts such a SVL can be replaced.

2.3 Sheath fault in Power Cable Joint

Sheath faults located in the power cable joint most commonly occur in layers instated above the metallic housing. The process of rectification of a sheath fault in the joint is done by reinstating the layers that were effected during the joint fault investigation process.

A common example in joint sheath faults is due to the improper instatement of the filling compound. Different joint makes have different compound requirements; Some joints use a hot compound such as bitumen that hardens as it cools, while others use a resin compound that hardens when mixed with an activator.

During the jointing process the compound must be completely set, however due to improper curing and mixing of compounds it has been found that the inner compound in some cases is still in liquid form. The improper instatement of the compound makes it lose its electrical properties, hence contributing to the development of a sheath fault. In figure 6 we can observe signs of electrical treeing on the joint's protection box due to improper compound mixing and filling.

Figure 6: Sheath Fault in Cable Joint

Different site conditions such as temperature, humidity, and precipitation also affect the instatement of the inner compound, hence a proactive jointer must be able to identify these uncontrollable factors and counteract them appropriately. The rectification method that is implemented is to remove these components up to the metallic tube/casing of the joint. A detailed physical inspection occurs to ensure that there are no traces of carbonisation to ensure that the result of sheath fault is because of the coffin box, gasket or filling compound. Reinstatement of the required layers of PVC HV tapes, heath shrink tubes, coffin box, gasket and filling compound take place to clear the sheath fault.

3. Conclusion

In conclusion, Cable Outer Sheath faults can occur in different places / components within the cable system network. While not imposing a direct threat to the functionality of the power cable; sheath faults can directly affect the cables current carrying capacity and if left unattended can lead to the deterioration of subsequent cable layers. To ensure the reliability of the system cable oversheath faults must be located and rectified in an appropriate and timely manner.

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