132kV XLPE Cable Sheath Fault Locating and Repairing: Techniques and Challenges

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Abstract: ***High voltage cable sheath fault locating techniques have developed drastically during the past few years. With all available technologies, Engineers are able to pre-locate sheath faults initially and then pinpoint (locate) the exact spot using equipment that work by pulse injection method, where the voltage drop detects the fault location wherever leakage current is detected. At the fault location, the voltage pulses discharge into the surrounding ground due to the fault resistance and form voltage gradient on the earth surface, which can be detected by suitable equipment. However, with all the advanced equipment and technologies, there are still some challenges that require further studies and developments including cases where faults are under asphalt roads and clear signals are difficult to obtain for exact location detection. In this paper, we aim to go through the currently applied methods for 132 kV Transmission cable sheath fault locating as experienced in Dubai Electricity and Water Authority (DEWA), and the repair techniques given the various cases that could be faced at site, and also the challenges associated in terms of limitations and special cases.***

Keywords: cable sheath fault, pinpoint, pulse, voltage drop

1. Introduction

132kV XLPE cable sheath tests are performed as part of the preventive maintenance plan in order to verify the healthiness of the cable sheath (outer jacket) layer. These tests are regularly performed over both feeder and transformer cables by the frequency specified in DEWA's Reliability Centered Maintenance (RCM) methodology. The Reliability Centered Maintenance identifies the frequency of tests that will result in ensuring the continuous reliability of the system. For transmission Cables, the frequency for performing the sheath test is determined based on the utility's experience and manufacturer's recommendations. The main objective of the cable sheath test is to ensure the healthiness of the cable sheath layer (the lead sheath and outer jacket). The healthiness of this layer is an indication that the cable is not damaged from an external source. The test is performed by injecting 5 kV DC for 1 minute over the sheath layer, and the criteria is to confirm whether the cable will withstand this 5kV voltage or not. Sheath Faults in 132kV Transmission cables are diagnosed often and declared based on sheath test results (not withstanding 5 kV DC for 1 minute). Identification of those faults is a must as cable sheath rectification is essential in order to sustain the required ampacity of the circuit and operate with the highest standard of reliability. Any damage over the sheath will permit water penetration, and water penetration will cause corrosion and corrosion will gradually deteriorate the cable causing the risk of flashover. Prior to rectification, cable sheath faults need to be located given that the cables are buried under ground and it is impossible to excavate and locate without a clear technique.

The technique to locate 132KV cable sheath faults consists of two major steps:

1) ***Pre-locating:*** *in this step we determine approximately fault distance from the test point to cut down the time required for determining the exact location of the fault.*
2) ***Pin pointing:*** *to determine the exact location of the fault.*

2. Cable Sheath Fault Locating

1) Cable Sheath Fault Pre-Location

To avoid long time duration for the pinpoint location procedure, especially on long length cables, cables installed under asphalt, tiles, solid surfaces etc. it is always recommended to perform pre-location. Without pre-location, the time taken to pinpoint fault location would be quite long, thus also extending the thermal load on the cables at the fault location. A common method for sheath fault pre-location is the bridge method. The detection principle of the bridge method is also called the Murray loop bridge as shown in figure 1. In this method, a faulty phase and a healthy phase are connected as shown. The cable resistance is equivalent to ri, rz, Ri and Rz in the bridge, and the resistance to the ground of the fault point is equivalent to Rp. When the bridge balance is achieved, sheath fault location will be determined. The device uses the formula l_x

$= \frac{\alpha}{100}\ 2l$ in order to calculate the approximate distance to the fault location. Internally, the device translates the resistance value to length.

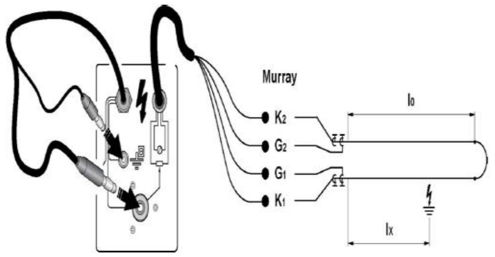

Figure 1: Murray connection method for fault locating

However, this measurement is affected by various external factors like installation conditions, fault nature, surrounding material etc. that's why this method is called pre-location and exact fault location will be confirmed by pin pointing method.

2) Cable Sheath Fault Pin-Pointing

Sheath fault pin-pointing will be determined by the principle of the step voltage method. It is applied by using a step voltage reflecting machine to send out voltage signals. As the outer sheath at the point of the fault is damaged, the cable will directly connect with the ground. The galvanometer on the step voltage receiver measures the potential of the circuit, and the pointer will point to the middle position when the galvanometer is just above the fault point, whereas when the galvanometer is located to the left of the fault, the pointer will deflect rightwards, and when the galvanometer is to the right of the fault, the pointer will deflect left-wards. In theory, the larger the angle of deflection is, the further the distance is from the fault. This method requires no reading or calculation, and it is very simple to use and the result is of high accuracy.

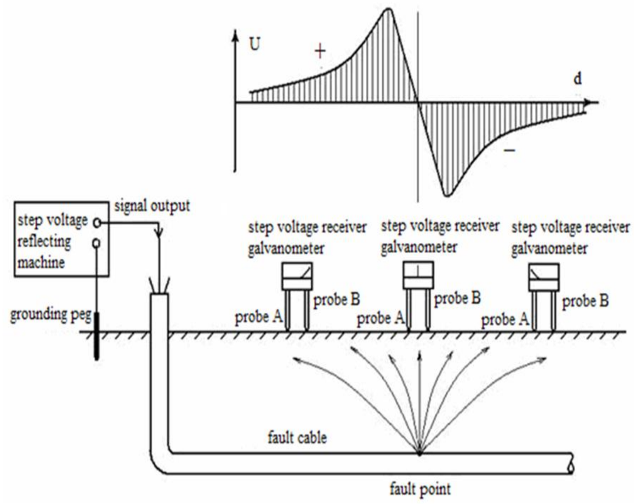

Figure 2: Fault pin-pointing concept

3) Challenges Associated with Cable Sheath Fault Locating

Despite the advancements and simplicity of the above-mentioned methods, there are still quite a few challenging cases in which faults are difficult to locate. Those challenging cases include:

- Sheath faults in all the phases
- Sheath faults in cables under asphalt / solid surfaces (100 mm asphalt layer)
- Sheath faults in cables inside road crossing ducts

4) Sheath Faults in all Phases

In this case we cannot determine pre-location as we do not have any healthy cable for reference so we have to proceed directly with pinpointing. To avoid a long duration of pinpointing, the circuit is sectionalized and a sectional sheath test is performed to determine the faulty section. The Majority of the cases having all phases faulty were found at the cable joints. Once the faulty section has been determined, the pinpointing is started at the joints in that section. A few examples of the sheath faults at the joint bays are shown in figure (4).

Figure 3: Sample of fault over joint

5) Sheath Faults in Cables Under Asphalt/ Solid Surfaces

In the case where pre location indicates the fault falls under asphalt, it is advisable to carry out the pre-location from both ends of the cable. Once the pre-location is completed and found that the fault falls under asphalt / solid surface, pin-pointing has to be carried out by alternative ways as it is difficult to fix the earth rods in such surfaces. Once the fault is pinpointed, necessary approvals to expose the fault will be taken to repair it.

Figure 4: Fault pin-pointing for fault under asphalt

*B. **Sheath Faults in Cables Inside Road Crossing Ducts***

In the case where pre-location shows that the fault falls inside duct, it is advisable to carry out the pin-pointing from both ends of the duct entries. Based on the confirmation from the pin-pointing that the fault is within the duct, necessary approvals will be taken to expose the area. The sheath fault inside the duct can be repaired as per the utility requirement.

Figure 5: Fault inside road crossing duct rectification

3. Conclusion

In conclusion, the techniques DEWA follows in order to maintain 132 kV cables are without doubt, the reason behind the spectacular record it holds with no major reported power supply loss for many years ahead. DEWA has adopted best practices and latest technologies that serve the reliability requirement it seeks as a globally leading utility. Today, as a result of a well-established baseline of proper maintenance planning and executing, adopting the most advanced standards and utilizing the latest market technologies, DEWA leads globally amongst the most prestigious power utilities in the world. The methodology of 132kV cable maintenance plays a major role in those achievements as today, DEWA is following the process of applying Reliability Centred Maintenance Methodology, which serves as a clear cycle of maintaining cables through testing and rectification to ensure achieving zero power interruption at all time.

References

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