Accelerated aluminum corrosion upon water ingress in damaged Low Voltage underground power cables.

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Low Voltage (LV) underground power cables generally have a good reputation in terms of customer-minutes-lost and ageing phenomena. However, in the Netherlands a slow but steady growth in the number of faults is observed. Since the increasing penetration of de-central generation is adding more pressure and given the high costs involved with repairing faults, condition monitoring is under investigation. Due to the low voltage level, often occurring damages don't necessarily lead to a fault directly. Damaged cables with exposed conductors may go undetected for very long time. Many cables nowadays employ aluminum conductors. Inspection after faults in these cables sometimes show the presence of white powder, indicating corrosion.

For corrosion to occur, three elements are required. A metal, potential difference and an electrolyte. When a cable is damaged and water can reach the conductor, these elements are all present. In this situation, aluminum oxide is formed on the surface of the aluminum. Due to the voltage hydroxide concentrates at the surface of the conductor, causing a dissolution of the oxide layer. This process allows corrosion to continue until the cross-section is sufficiently reduced for a fault to occur.

To study this process, a test setup was designed. A cable sample with an artificial damage is placed in a tank filled with water. The water is heated and pumped out periodically to speed up the corrosion process and allow for oxygen to reach the damage spot. The cable ends are sealed and the sample is energized to nominal voltage. The process is recorded by a camera, taking pictures periodically, and current measurements are taken at the same time. Different paths in current flow have been identified, depending on cable damage and type. Initial tests were conducted over up to three weeks of time for a single sample. An example is given in figure 1. Several configurations are tested, and the effect of the water conductivity is studied. The water conductivity used is similar to that of average ground water.

Figure 1: Example of aluminum corrosion in a 6 mm hole.

During the first days, the speed of the process already shows to be significant. A 6 mm in diameter hole, drilled into the conductor, fills up with aluminum oxide within several days. A continuous release of hydrogen gas bubbles is observed. During the testing period, the density of oxide seems to increase and flakes of oxide are released into the water. At a later stage, small holes releasing hydrogen bubbles show that the oxidation continues. Current levels are generally in the order of several milli-amperes, varying over time. Further characterization of the current is currently under investigation.

This work reveals the often found, but hardly understood process as it occurs underground. Corrosion under this mechanism exceeds the rate of regular corrosion if no voltage is applied. The actual rate as a function of the damage size and materials applied are currently under investigation, including a comparison to the behavior of copper conductors.