Practical experience and modelling of the corrosion behaviour of the Aluminium metallic cable sheath

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ABSTRACT

Because of the high groundwater level in the Netherlands, a watertight (in longitudinal and axial direction) metallic cable sheath is recommended in UGC to prevent internal failure mechanisms during its lifetime. More than 10 years ago, the Dutch TSO TenneT started using aluminium instead of lead for the metallic sheath. In order to learn not only from theory TenneT TSO together with the cable manufacturer Prysmian Delft and the Belgium research institute Laborelec conducted a long term theoretical and practical research on the behaviour of an aluminium metallic sheath on the corrosion topic.

KEYWORDS

Aluminium metallic sheath, underground corrosion, condition assessment, condition-based maintenance, on-line monitoring, sheath current, underground cable.

INTRODUCTION

The cross-border grid operator TenneT owns about 1800 km of 110 kV and 150 kV cable and 80 km of 220 kV and 380 kV cable circuit in the on-land power grid of the Netherlands. In the coming years the cable length will continue to grow. The forecast tracé grid expansion is about 3000 km.

Due to the high-water level in the Netherlands, underground cables are equipped with a water barrier in order to prevent early aging of the polymer insulation. A radial water barrier made of metal has shown to be a good option. Besides to ensure waterproofness, the metallic sheath conducts the single-phase short circuit in case of a single phase to ground fault. The use of lead inner sheaths is widely known, but about 10 years ago TenneT changed over to a sheath of aluminium. Compared to lead, aluminium offers the following advantages: (i) less density, which reduces the weight of the whole cable, allowing longer cable lengths and reducing the risk of cable sinking in low density soils; (ii) higher conductivity, allowing higher short circuit currents; (iii) much higher mechanical strength; (iv) lower environmental impact.

However, aluminium is more vulnerable than lead to corrosion [1]. In case of damage of the outer polyethylene jacket (due to for instance excavation campaigns around the power cables or aging of the plastic material), the aluminium sheath may be directly exposed to soil. Although there is a general good understanding on aluminium corrosion, the specific corrosion behaviour in soil of a aluminium welded metallic sheathed cable (referred to as "AluWeld") has received little attention in literature. Even if no case of aluminium sheath degradation has been reported until now in the Netherlands, it is desirable to get more insight on the AluWeld corrosion risk and corrosion kinetics because of (if) the large installed assets base, (ii) the required work force to install and to maintain all the future forecast cable projects.

The aim of this study is to investigate the aging mechanisms, degradation process of the sheath AluWeld in function of (i) the soil composition, (ii) the type of outer jacket damage and (iii) the induced voltage on the sheath. This will allow the grid operator to define an effective maintenance strategy and to determine the maximum allowed time for repair actions following the detection of a sheath damage.

DESCRIPTION OF THE CABLE SYSTEM IN THE POWER GRID

The design of a typical "AluWeld" HV cable is presented in Figure 1. The smooth welded aluminium sheath consists of an aluminium sheet (alloy type 1050A)), longitudinally applied over the cable core, shaped around it, and welded in longitudinal direction. An outer polyethylene sheath (also referred to as "jacket") is firmly bonded to the aluminium sheath resulting in a cable with a impervious water barrier and resistance to fatigue strain. The jacket provides mechanical protection to the metallic sheath as well as protection of direct contact with the metallic sheath, which is important from a safety point of view. In addition, the adhesive part of the waterproof layers ensures that moisture which may have penetrated the protective covering does not spread along the surface of the sheath, extending the areas of corrosion.

The cables are mostly directly buried in the ground. A backfill around the cables is applied when required for the transport capacity.

A cable system includes typically sheath cross-bonding to minimise the currents through the metallic sheaths. he typical cross-bonding system considered in the present study consists of major section(s) that are subdivided in 3 minor section lengths, ideally of equal length and laying configuration. The cable orientation is flat or trefoil arrangement with typical minor section lengths of about 1000-1500 m (depending on the cable cross section, ranging between 2000 and 3500 mm^2). The aim is to reduce the number of joints, which argues for longer sectional lengths (obeying safety).