Condition assessment of cross-bonded HV cable system

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ABSTRACT

The paper describes the phenomena's and the concerns with cross-bonding systems of high voltage cable connections that could arise when the bonding scheme has improper functionality. In the scope of work the basic principles of XB with (intermittent) faults, impact on the current rating, on-line monitoring of sheath currents and simulations are part of the research. The research has been done on a real existing problem with a double 150 kV cable circuit.

KEYWORDS

Cross bonding, bonding scheme, functionality, oversheath faults, current rating, , monitoring, modelling.

INTRODUCTION

For a transmission system owner preservation, maintainability and loading capabilities are key for operating the (extra) high voltage (HV) cable system grid successfully and control remaining life time aspects from asset management point of view.

For the earth bonding scheme in HV cable systems special bonding methods such as cross-bonding (XB) and single point bonding have been extensively used. These bonding methods are mainly used to effectively reduce or even eliminate the circulating currents. This enables the reduction of the sheath losses and heat produced inside the cable leading to improvement of the current carrying capacity through the conductors of the cable system.

Nevertheless, it is clear that the integrity of the outer sheath of the power cables, the bonding cables or the sheath voltage limiters are important for the proper functionality of such bonding arrangements. Failure of these elements may result in considerable sheath currents and losses, which in turn may lead to overheating of the cable system. Moreover, exposure of the metal sheath to the outer environment may result in corrosion with further undesired effects on the operation of the cable system. Therefore, consideration should be given to the maintenance and monitoring of specially bonded systems.

Next to this, the actual impact on the current rating of the cable system due to a fault in the sheath insulation is often not clear. This hinters the evaluation of the risks associated with the fault and consists an obstacle for taking a risk-based decision by the Asset Manager or the Maintenance responsible for the repair of the cable connection.

In order to improve and optimize the maintenance of HV cable systems, TenneT has initiated a pilot project with respect to the functionality of XB systems.

AIM OF THE PROJECT

The aim of this project is twofold:

- To develop an on-line diagnostic technique for the detection of outer sheath faults and eventual oil-leakages. This can help to detect, already at an early stage, and prevent potentially serious problems in the cable system.
- To develop a method for determining how severe a sheath fault is without disconnecting the cable system. With this information TenneT can evaluate the risks and decide about the priority of the maintenance activities to repair the sheath fault.

By continuously monitoring the magnitude of the sheath currents we can detect failures in the outer sheath in a timely manner. An additional benefit is that we can monitor the behavior of the failure over time.

Next to this, the measurements will be analyzed and compared with results from simulation software to assess the impact of the sheath faults, on the current rating of the cable system. This enables the evaluation of the risks associated with the sheath fault and helps the Asset Manager or the Maintenance responsible with taking a risk-based decision for the repair of the cable.

WHY SPECIAL BONDING SYSTEMS?

In land underground transmission systems most often single-core HV cables are utilized [1] [2]. For the earth bonding scheme of such HV cable systems, special bonding methods such as cross-bonding and single point bonding have been extensively used [3]. These methods are developed to limit the magnitude of the induced voltages in the sheath and effectively reduce or even eliminate circulating currents. This enables the reduction of the operational losses and heat produced inside the cable leading to improvement of the current carrying capacity of the cable system. [4]

SCREEN CURRENTS IN HEALTHY SYSTEMS

For the bonding of the metal sheaths three installations principles can be used, i.e. solid bonded (SB), single point bonded (SPB) or cross-bonded (XB).

In a SB system the circulating currents in the cable sheath increase linearly with load currents. In SPB the heath circulating currents are eliminated by leaving one end of the system unearthed. In XB system the basic principle that the induced voltages in the three phase cable sheaths are displaced vectorially by 120° (as per the conductor currents), therefore by cross connecting three