Evaluation of Switching Overvoltage Stresses on Cable Sheath Towards the Application of Direct Cross Bonding

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ABSTRACT

The application of direct cross bonding can help reduce the design, installation and maintenance costs of a cable system, by removing the SVLs, the link boxes, the earthing grids and the bonding leads at each cross bonding location. However, the application of the direct cross bonding could have an impact on the performance of the bonding scheme against transient overvoltages. This paper presents the initial results and findings, when studying the impact of the cross bonding scheme (i.e., traditional, hybrid and direct) on the switching overvoltages, as calculated in ATP/EMTP.

KEYWORDS

Direct cross bonding, switching overvoltages, sheath voltage limiters, electromagnetic transients, ATP/EMTP

INTRODUCTION

In general, the common practice as currently being applied by Transmission System Operators (TSOs) considers the sectionalized cross bonding as the standard sheath bonding scheme in High Voltage (HV) and Extra High Voltage (EHV) cable systems with circuit lengths longer than 1 km [1]. A typical sectionalized cross bonding cable system consists of three minor sections, where the sheaths of the minor sections are connected to each other through link boxes that are connected to ground via sheath voltage limiters (further referred as SVL). Due to maintenance reasons, the link boxes have to be reachable and, therefore, they are installed in ground pits. The sheaths at the major section ends are connected to ground via grounding boxes. However, the projection of ground pits in the landscape might be challenging and costly, e.g., due to land access restriction or land acquisition.

In the recent years, developments have been made that allow the transport of longer cable lengths in terms of drum size. Consequently, the typical minor section length of a cross-bonded cable can be increased, resulting in a smaller number of joints required along a cable circuit route. TenneT, the Transmission System Operator in the Netherlands and in Germany, has adjusted the engineering policies towards a standard design for the 110 kV and 150 kV cable systems. The design defines a list of standard cable types and cross sections as well as the maximum allowable minor section lengths per cross section. These lengths are much longer (2 to 5 times), when compared to the typical lengths of the minor sections of cable systems in operation. Such a standard design facilitates the cost reduction when designing and installing a new cable system. As a possible addition to these engineering policies, TenneT is also investigating the feasibility of applying direct cross bonding in the standard 110 kV and 150 kV cable systems. The latter can further reduce the design, installation and maintenance costs, by removing the SVLs, the link boxes, the earthing grids and the bonding leads at each cross bonding location. However, the application of the direct cross bonding could have an impact on the performance of the bonding scheme against transient overvoltages. It is good to mention that in France [2], Belguim [3] and other European utilities, direct cross bonding is already adopted at different voltage levels in both cable connections and mixed connections, i.e., overhead line – underground cable connections.

To that respect, a detailed electromagnetic transient (EMT) study was deemed necessary to analyse and evaluate the overvoltage stresses in the sheath bonding of the cable system, when considering the various SVL configurations within the complete cross bonding cable system, i.e., presence or not of SVLs at the end of a minor section. In this initial study, focus was given on circuits consisting only of cable sections between two substations. This paper presents the initial results and findings, when studying the impact of the cross bonding scheme (i.e., traditional, mixed and direct) on the switching overvoltages, as calculated in ATP/EMTP. Different parameters were considered such as the cable cross section, the total circuit length and the minor section length.

CABLE STANDARDISATION FOR THE DUTCH 110 & 150 KV TRANSMISSION GRIDS

In the Netherlands and in the coming decade, significant and numerous expansion, strengthening and upgrade projects will be realized in the Extra High Voltage (EHV) and High Voltage (HV) grids. These projects are required to meet the high demands for increased transmission capacity due to a) the planned connection of significant amounts of renewable energy sources and b) the load growth. By 2027 it is expected that a total of 3000 km of new (E)HVAC single core underground cables will be installed, with the highest share being at the regional 110 kV and 150 kV grids respectively. Given the challenge of this tight timeline, TenneT worked towards the standardization of all new 110 and 150 kV cable systems that, most importantly, can facilitate the acceleration of the processes related to the cable system design and engineering.

The purpose of the standardization process was twofold, a) to define a list of standard cable system designs able to cover any grid requirements with respect to transport capacities, i.e., MVA ratings, and b) achieve framework agreements with a limited number of qualified suppliers. Approximately 80% of the new underground cable projects can fit the standardization, providing benefits such as: