Short circuit performance of three-core submarine power cables having screens made of helically applied metallic tapes

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ABSTRACT

This paper deals with single-phase short circuit performance of three-core submarine power cables having screens made of helically applied metallic tapes. A new laboratory validated 3D numerical methodology, combining finite element method and circuit analysis, is presented to calculate metallic tapes screen short circuit capability. Numerical simulations based on this methodology allow an accurate assessment of short circuit performance and, in conjunction with laboratory tests, confirm and overcome the conservatism included in IEC 60949 [4].

KEYWORDS

Submarine cable; Metallic screen; Wet design; EPR; Short circuit; ATP-EMTP; FEM

INTRODUCTION

In recent years, the offshore wind industry has experienced a marked technological development driven by continuously growing installed power generation, increasingly challenging applications and the need for overall system costs reduction to continue fostering the renewables energy transition world-wide.

New designs for 66 kV submarine array cables require not only high reliability but also economical attractiveness. Wet design EPR insulated cables have been mainly characterized by their outstanding electrical performance in wet environment and superior thermo-mechanical characteristics [1] [2], with several systems throughout the world being successfully in operation up to 72.5 kV for more than 40 years.

This ability to operate in wet environment allows to use simple, robust and easy to manufacture metallic screen designs without the need of any radial water barrier. A typical metal screen design used consists of copper tapes helically applied onto each insulated core with a certain overlap. Such screened power cores are then laid-up to form a three-core submarine cable with direct screen-to-screen contact. An armour is then applied on top ot the three power cores. An outer serving is then protecting the overall cable from abrasion.

An example of such cable design is illustrated in Figure 1.

Short circuit performance is a key requirement for power cables with significant impact on cable design. Three-phase short cicuit is almost never of concern with typical cable specifications because it mostly involves conductors with their low ohmic resistance. On the other hand single-phase short circuit, which are also the most frequently expected, involve both the conductor and the metal screens, the latter having typically an higher ohmic resistance.

Fig 1: Typical 66 kV submarine array cable with EPR insulation and metal screen made by helically applied copper tapes

This paper discusses the short circuit capacity of helically applied metal tapes screen design: firstly summarising IEC 60949 [4] methodology and secondly by presenting full-scale measurements performed in laboratory and 3D numerical simulations according to a newly developed methodology.

TRADITIONAL METAL SCREEN SHORT CIRCUIT CAPACITY CALCULATION METHOD

IEC 60949 [4] provides a calculation method for permissible short circuit current in cables. When dealing with screens made of helically applied metal tapes the standard recommends to conservatively assume the current to flow around the helix on the account that inter-turn and inter-tape contacts are not easily predictable. Therefore cable short circuit performance calculated according to IEC 60949 [4] is significantly pessimistic.

This assumption of no current path through overlap areas has been demonstrated [3] to be overly conservative and that measured overall longitudinal screen resistance is in fact lower than the theoretical longitudinal resistance of a pure helix tape [3].
It is therefore interesting, both from technical and economic perspective, to investigate the phenomenon and to develop a calculation methodology as realistic as possible.
Laboratory tests and a validated calculation methodology are presented in the next sections.