Characterization tests on semiconductive PE materials for thermoplastic protective sheath in DC submarine cables

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ABSTRACT

This paper is aimed to verify the electrical performances of semiconductive materials with the purpose to replace traditional metal earthing connections with a semiconductive outer sheath acting as grounding element. The use of semiconductive polymeric earthing connections is an innovative solution especially for cable systems designed to work at high depth, since the manufacture of traditional earthing connections is quite challenging due to the high pressure involved. This way of grounding cable systems has been already adopted in AC connections, not yet for DC connections. Experimental tests on different semiconductive materials have been performed to prove the effectiveness of the solution considering high frequencies as well. The complex impedance of semiconductive samples were investigated as well as their conductivity at high frequencies, to simulate the behaviour of cable systems in case of fast transient voltage application. From this investigation no adverse effects were highlighted, confirming that proper semiconductive materials as equipotential layer are a valid solution also for DC applications..

KEYWORDS

HVDC extruded cable systems, Testing experiences, Earthing Connections, High Depth, Semiconductive PE materials.

INTRODUCTION

Market evolution of high voltage (HV) cable industry, especially in the Mediterranean area [1], is pushing cable manufacturers to investigate technologies and cable designs for increasingly higher water depth installations. For these specific applications, mass impregnated (MI) technology can be as cost-effective as cross-linked polyethylene (XLPE) insulation, as reported in [2]. Furthermore, HVDC MI cable systems like SACOI, ITALY-GREECE, SA.PE.I and MON.ITA established a solid reference for operational high-depth cables, already at the record voltage of 500kV. In the design of HV submarine cables for power transmission, anti-corrosion sheaths have been introduced in order to protect the lead screen. As well-known when the protective sheath is characterized by a dielectric material, to reduce over-voltages due to travelling waves, that could reach breakdown values, the metal sheath of the cable at intermediate points has to be earthed with specific metallic strips in order to create a metallic connection between the metallic sheath and the sea water. Thanks to recent evolution of the submarine cable laying vessels, cables with traditional MI insulation is going to reach new limit of 1800m water depth and beyond. In this contest the manufacture of traditional earthing connections is quite challenging due to the high pressure involved. This paper is aimed to verify the electrical performances of proper semiconductive materials with the purpose to replace traditional metal earthing connections and insulating polyethylene sheath. Such semiconductive outer sheath acts as an equipotential layer between the metallic sheath and the sea water.

The evaluations are performed using two similar semiconductive thermoplastic materials available in the market.

ELECTRICAL RESISTIVITY MEASURES ON SEMICONDUCTIVE STRIPS

Semiconductive strips obtained from moulded plaques, see Figure 1, are tested in DC to measure their electrical resistivity according to [9] (§12.4.7 and Annex D "Method of measuring resistivity of semi-conducting screens"). The electrical resistivity of such stripes is measured at high frequency as well, and in this case, the DC generator is replaced by a function generator able to provide a sinusoidal voltage up to 100 kHz – 20 $V_{pk\text{-}pk}$.

Figure 1 Semicon strip sample obtained from moulded plaque