Measurements of losses on three core submarine power cables

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Submarine power cables are designed with an armour to protect the cable during storage and laying operation but also from external hazards like anchors or trawling gear. The armour is composed of wires, generally steel wires, helically wound around the three-core cables. Such metallic and magnetic armouring provides additional losses when alternating current flows in the cores and thus reduces the cable ampacity.

IEC 60287-1-1 gives formulae in order to estimate the armour losses but recent studies highlight that the use of this formulae yield substantial overestimation. The proposed formulae in IEC standards comes from the model developed by Carter in 1928 for three-core cables in a metallic non-magnetic tube and was experimentally extrapolated by Arnolds in 1939 to cover the magnetic behaviour of the armouring. IEC formulae consider that both the core and the armour are laid parallel to each other and doesn't take into account the cancellation effect provided by the twisting of the components with different lay length.

The overestimation of armour losses during the design process leads to the use of larger cables. Thus the development of an accurate formula can lead to a reduction of conductor size and consequently cable size and price. Measurements have been performed in EDF Lab "Les Renardières" on three-core submarine power cables the last two years in order to address armour losses overestimation, to give comparison data for future implementation in Finite Element Model(s) and to give good measurement protocol to assess armour losses.

Two different three-core submarine cables (150kV, 1200 mm²) with copper conductors and a single-layer armour were considered: the first armour was composed of steel wires and the second armour was made with a mix of PE and steel wires. Measurements were achieved with different currents (close to the rating current) and using various screen connections (single point bounded, grounded at both ends with different impedances).

The paper presents the set-up used in order to measure the armour losses and an analysis of the results obtained on the two cable designs. It addresses also the influence of sea water on armour losses by immersing the cable in salt water. Finally results are compared to those given by the application of IEC formulae.