Accurate analytical formula for calculation of sheath and armour losses of three core submarine cables

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Several measurements performed by different cable manufactures have shown that the losses in 3-core submarine cables are much lower than predicted by IEC-60287 [1][2][3][4], and Finite Element Analysis and physical concepts have been presented to explain the measurements [1][2]. However, currently no widely accepted model is available, and more work both on the theory and measurements is needed to develop an approach that may eventually replace the loss factor formulas in IEC-60287.

Accurate calculation of the cable losses is crucial to design optimized and cost effective cable connections, which is becoming more and more important for example in offshore windfarm projects. In this paper an analytical model to calculate both the sheath losses and armour losses of 3-core cables is presented, and compared with measurements on three different 3-core cables, at different frequencies, with and without armour.

The model consistently accounts for the relative twisting of the armour with respect to the conductors, which is important to accurately calculate how the armour influences the cable losses, both directly in the armour and indirectly in the cable sheaths. Due to the field dependent permeability and hysteresis of the armour, the cable resistance increases with current [2][3][4], a feature that is incorporated in the formulas. The physical concepts that the formulas builds upon are validated by comparison with Finite Element Models using Comsol Multiphysics.

1 “Power loss and inductance of steel armoured multi-core cables: comparison of IEC values with “2.5D” FEA results and measurements”, Bremnes et. al. Cigré 2010.

2 “Current dpenent armour loss in three-core cables:comparsion of FEA results and measurements”, M.M. Hatlo and J.J. Bremnes, Cigré 2014.

3 “ARMOUR LOSS IN THREE-CORE SUBMARINE XLPE CABLES”, Palmgren et. al., Jicable 11, 2011.

4 “HV submarine cables for renewable offshore energy”, Dell`Anna et. al., Cigré, 2011