Comparison of losses in an armoured and unarmoured three phase cable

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ABSTRACT

In this article, measurements of a 245 kV 3x1x630 mm^2 armoured and unarmoured cable is presented along with a description of the data processing of the measured quantities. The results of the measurements show that the losses in the armoured cable are larger than the losses in the unarmoured cable. The measurements also show that the equivalent phase resistance of the cable increases as a function of the current.

KEYWORDS

Armoured cable, unarmoured cable, cable losses.

INTRODUCTION

An increasing number of wind farms are placed offshore, the energy harvested from the wind turbines must be brought to shore. This is done by using submarine cables from the offshore collector platform. The platform is collecting the power from the wind turbines, to a suitable onshore substation. For practical and economic reasons it is preferred to use three core submarine power cables. Three core submarine cables are armoured in order to provide mechanical protection of the cable and to achieve the tensile strength needed when the cable is installed. Today the IEC 60287-1-1 standard is used to determine the current rating of armoured three-phase submarine cables. The formulas in the standard are based on work from the 1920's and 1930's [6]. In the cable industry, the method used in IEC 60287-1-1 is known to overestimate the losses of three phase armoured cables [1] [2] [3] [4] [5]. Overestimation of the cable losses can result in core cross-sections too large and thereby a more costly cable installation. Therefore, further research is needed in order to develop new analytical equations capable of a more accurate estimation of the losses in three-phase armoured cables.

This paper presents measurements performed on both an armoured and unarmoured submarine cable of the same type. The losses of both cables are presented and compared. For the armoured cable the equivalent AC resistance, as a function of the phase conductor current, is presented. The induced currents in the lead sheaths of both the armoured and unarmoured cable are also presented and compared. The losses in the armoured cable will further be investigated for different armour connections (e.g. armour short circuited, armour open in both ends). Finally the impedance between the sheaths, through the semi-conducting screens is presented.

THE MEASUREMENT SETUP

The measurements of the two cables have been performed at NEXANS factory in Halden, Norway. The cables were powered from a step down transformer which was powered by a variable transformer. The variable transformer was supplied by the factory grid which was not a clean supply. The step down transformer was connected to the phase conductors in one end of the cable. In the other end of the cable the phase conductors were short circuited as shown in Figure 1. The sheaths in the end near the transformer were short circuited and the armour was connected to the sheaths. In the other end of the cable the sheaths and armour were connected to the phase conductor star point, see Figure 1. The unarmoured cable was configured in a similar manner, see Figure 1.

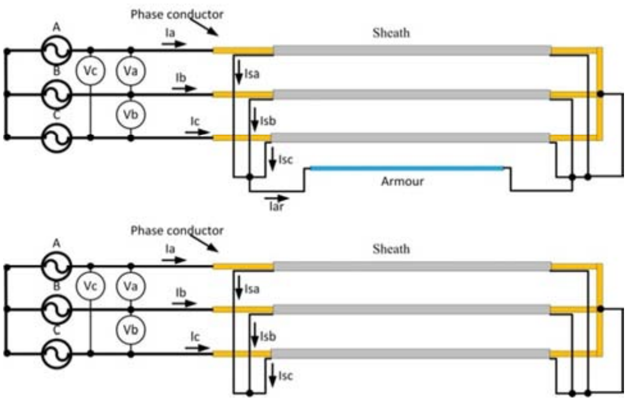

Figure 1 Measurement setup: On top: the measurement setup for the armoured cable. In the bottom: the setup for the unarmoured cable.

The cables were laid on the ground right next to each other, see Figure 2.

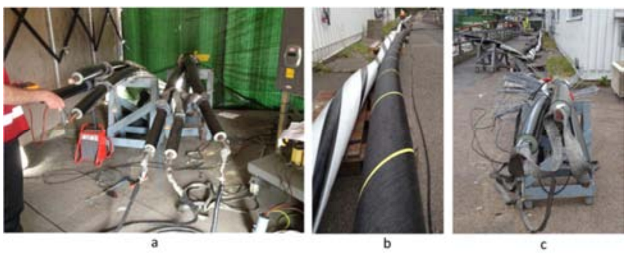

Figure 2 a) The cable ends near the transformer. b) The two cables lying on the ground. c) Cables remote end.

As can be seen in Figure 2(c) the two cables were unequal in length. The armoured cable was 88.2 meters long and at each end of the cable approximately 1.2 meters of the armour were removed. Approximately 50 cm of the semi-conducting layer over the sheaths was also removed in order to make it possible to short circuit the lead sheaths. The unarmoured cable was 79.1 meters long and also this cable had approximately 50 cm of the semi conducting layer over the sheaths removed at each end. The voltages were measured directly on the phase conductor and currents were measured using Rogowski coils.