Light armour cables for submarine deep water power application

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ABSTRACT

The submarine cable industry is in constant development and trying to reach all market demands. New projects are going to deep waters and the new cables must be capable to withstand this new level of loads. The tensile armours used in the submarine cable industry are made mainly of steel, which is a consolidated material due its mechanical properties but adds linear weight increasing cable installation tensile load and impacting on vessel tensioners during installation. One way to reach deep waters is to reduce cable linear weight since the metallic armour package typically represents 30-50% the overall cable weight. A possible solution which this paper is based on is to demonstrate the use of lightweight high modulus materials for the armouring reinforcement layers.

KEYWORDS

Submarine cable; deep water; extruded DC; XLPE; installation; testing;

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INTRODUCTION

The submarine power cables are limited to a certain water depth. Each design has an intrinsic sort of characteristics which result in a maximum allowed water depth. Power and voltage usually are the main drivers for the cable design, the cable construction is chosen to meet project requirements like electrical, thermal and mechanical. One of the limitations is the installation, where the cable weight in water is principal parameter to be considered [1]. The current armour design is mainly based on metallic materials, like steel, where the armour package is giving higher axial stiffness to the structure, reducing the cable total elongation. However, this metallic layer is responsible for typically 30-50% of the cable weight. For this reason, many of submarine projects are limited to water depths close to 1500m for HVDC and 800m for HVAC. The threshold of 1000 m depth has been exceeded only in the Mediterranean Sea. Only three cables go beneath this depth: HVDC Italy-Greece (1000 m), Cometa HVDC (1485 m) and SA.PE.I. (1650 m), which is the deepest in the world. The two deepest ones were both produced by Prysmian and are of mass impregnated (MI) paper type [2]. While medium voltage cables, submarine umbilicals, optical cables are already passing the limit of 3000m. This value for high voltage cables is still a challenge and this paper will demonstrate a feasible alternative to reach deep waters when considers a non-metallic armour material, with a favorable ratio between weight and modulus.

Prysmian Research and Development Center investigated how to reduce the cable weight using non-metallic materials to allow deeper installation with equivalent total cable elongation and using equivalent installation equipment. One solution proposed consists in a unit made by high modulus fibers embedded in a polyethylene jacket. Laboratory tests for the characterization of this composite were successfully completed, such as ageing in salt water, tensile tests and jointing techniques.

This paper will present results regarding a full-scale prototype of single core cable, for application HVDC, with aluminum conductor, extruded cross-linked insulation, dry design made in a Prysmian factory to assess the concept and confirm its manufacturability. The prototype was submitted to tensile and bending tests to reproduce equivalent installation loads for 3000m water depth, hydrostatic pressure tests, impact tests with different types of hammers, coiling test and thermal studies/testing. Dedicate accessory for anchoring the armour was also developed and tested to prove the feasibility.

COMPOSITE ARMOUR UNIT

The demand of composite materials is increasing in the last few years. The main reasons are its light weight and the high capability to withstand loads, allowing the installation of the submarine cables also in high depth locations. Steel armour are consolidated in industry as solution for armouring application. Steel armour, despite the mechanical strength with high elastic modulus, has limitations regarding high weight by meter ratio, limited capacity corrosion on sea water, bitumen protection needed, high cable bending stiffness and potential bird caging occurrence when cable is coiled in static tanks. The composite armour unit is very flexible and, like a standard steel armour for manufacturing purposes, allows the current facilities “steel armour ready” become also able to manufacture submarine cables with this new composite unit.

Composite Armour Jointing

During the submarine armouring manufacturing process, it is important to assure that all the components of the cable will withstand the scope of design loads, even if process joints are needed. Based on this concept, the composite armour jointing was evaluated to verify its joint process feasibility, dimensional and performance as per design requirements.

Figure 01 shows a composite armour being tested in a tensile test bench. The unit jointing shows a breaking load higher than the load on an equivalent steel armour wire in the same condition.