Continuous monitoring of HVDC Power cables with integrated fibre optic cables

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ABSTRACT

In the past it has been impossible to identify the cause of damage to HVDC power cables from installation or subsequent fishing or anchor incidents as the primary impact may not have caused an immediate failure and subsequent failure, after months or years could not be linked to a timeline when specific events occurred.

The HVDC NEMO interconnector installed between the UK and Belgium consists of two XLPE 400kV cables with integrated fibre optic cables located below the armour layer in all four quadrants of the cable. Utilising these the whole installation process was continuously monitored providing an extra layer of Quality Assurance.

KEYWORDS

Submarine cable, Submarine installation, continuous monitoring, continuous OTDR

INTRODUCTION

Damage and subsequent failure of cable during installation is a historical reality. The higher the voltage of a cable, the higher the electrical stress [1] and the more susceptible the cable core is to failure due to changes in geometry. The increase in stress these produces local electrical fields beyond the operating range of the material.

If damage is not observed during installation, it may be buried and only found during failure commissioning or early operation. Some construction damage survives for more than 10 years before failure [2]. It is however cheaper and prudent that any significant damage is fixed as soon as it is encountered.

Historically external damage could only be noted visually or as a result of significant changes to the primary insulation (TDR, IR). Since the 1990s, fibre optic cables have been laid alongside HVDC power cores or integrated within, primarily for control and protection between the converter stations. However the fibres are used more and more for condition monitoring and fault finding [3]. Continuous monitoring during construction offers distinct advantages as any damage is instantaneously identified and root cause analysis, identification of process or equipment responsible and mitigation measures can then be quickly addressed.

The NEMO HVDC cable laid between UK and Belgium is the world's first 400kV HVDC XLPE project but the incorporation of the fibre optic cable under the armour enabled the supplier to incorporate continuous monitoring of the cable until project takeover.

CABLE CONSTRUCTION

The construction of the 400kV HVDC subsea XLPE cable is shown in Figure 1. Details of the electrical past of the system is provided in other references [3]. 16 Single Mode (SM) fibres were incorporated into the optical fibre units in pairs and some further Multi-Mode (MM) fibres for greater DTS resolution close to shore and on land.

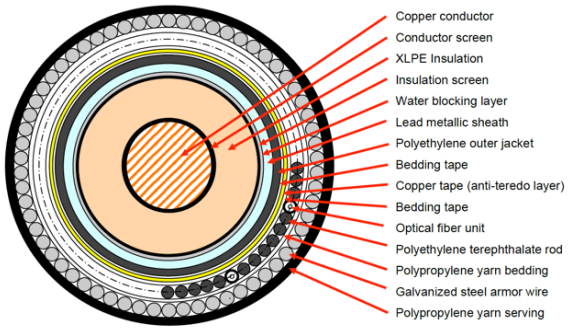

Figure 1 Cable Construction with fiber layer under armour

The coilable cables were transported from Japan on a freighter where they were tran-spooled onto the cable laying vessel.

OTDR MONITORING IN THE PAST

OTDR monitoring has been utilised during installation since fibres (either integrated or bundled) were incorporated into the power projects. The industry standard has been to measure the loss along the available route length at two wavelengths (for SM 1310nm and 1550nm) at one hourly intervals and report the average values and any deviations. Any instantaneous issues where the loss increases over one or two minutes and then returns to the background value (as a result of the cable being pulled by an anchor or trawl board) would not be noticed. Normally at least 10% of the fibres were tested and two test technicians were required to cover 24 hour operation.

PROJECT MONITORING REQUIREMENTS

The diagrammatical representation of the NEMO project is given in Figure 2. The whole route length is 141km however the fibres are longer due to layup factors and extra looping in joint bays. Subsystem 2 and 3 represent the 130km subsea cable length laid in two stages as