

## Qualification, installation and commissioning of world's first DC 400kV XLPE cable system

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### ABSTRACT

DC400kV XLPE cable system was introduced to the NEMO Link project for the first time in the world. Nemo Link is also the first electricity interconnector between UK and Belgium. The overall length of the interconnector is approx. 141 km including a submarine section of 130 km long. The cables were manufactured in accordance with strict quality control plans and various testing plans in Japan, and those were installed and buried in 2017 and 2018. After final commissioning tests, NEMO Link has been in operation since 31st of January, 2019 as scheduled.

### KEYWORDS

DC XLPE cable system, type test, volume resistivity, space charge accumulation, cable loadout, cable installation, commissioning test

### INTRODUCTION

For the application of long-distance power transmission, HVDC power transmission lines are widely applied around the world such as interconnectors between countries and offshore wind power generation.

Mass impregnated (MI) cable and fluid-filled (FF) cable have been applied to DC transmission cable lines for long time, however cross-linked polyethylene (XLPE) insulated cables, which is widely used for AC power transmission cable line, as XLPE cable is more friendly environmentally than MI or FF cable, has been introduced for DC application.

However, it is well known that AC XLPE insulation has a problem when used for DC application, because of prominent accumulation of space charge in AC XLPE insulation.

We have started development of DC XLPE material since 1980's, and developed a DC XLPE insulation material which has excellent DC characteristics even at high temperature.

After several tests for development including polarity reversal condition of DC 250 kV and DC 500 kV XLPE cables, DC 250 kV XLPE cable was applied for the Hokkaido-Honshu DC link with LCC converters first time in the world and put into operation in December 2012.<sup>[1][2]</sup>

Then after completion of DC400kV XLPE cable system PQ test according to CIGRE TB 496 including polarity reversal condition and at 90 deg-C conductor temperature, DC 400 kV XLPE cable was applied for NEMO link project. The cable system was put into operation on 31st of January, 2019. NEMO link project is the first interconnector between UK and Belgium.<sup>[3]</sup>

This paper describes successful results of type test which were demonstrated for 400kV project, manufacturing, installation and commissioning tests for the DC400kV XLPE cable system.

### NEMO LINK, THE WORLD FIRST 400KV DC-XLPE CABLE SYSTEM

NEMO link consists of 1050 MW of symmetrical monopole 400 kV HVDC converter and DC 400 kV XLPE cable system with submarine and land cables and their accessories. This HVDC converter does not require polarity reversal operation and cable conductor temperature was designed to operate continuously at 90 deg-C. There is no threat of lightning strike from overhead line. In order to demonstrate the higher cable performance than the system requirement, additional LCC conditions were adopted for type test, and even higher temperature was adopted for additional load cycle test.

The main components of the cable system for NEMO link are submarine cable, land cable, factory joint of submarine cable, submarine joint, land joint, transition joint and air insulated termination. The features of the cable system are as follow:

- XLPE insulation cable system in accordance with CIGRE TB496 and relevant IEC/CIGRE standard/recommendations
- Transmission capacity of 1050 MW at the rated voltage of DC 400kV
- Maximum operating temperature of 90 deg-C. (Higher than 55 deg-C of MI cable, and 70 deg-C of other kind of DC XLPE cable)
- Symmetrical monopole with VSC converter
- Design life of 40 years

### Route profile

NEMO link is the first interconnector between UK and Belgium. Fig. 1 shows the location of the NEMO HVDC link. The VSC converters are located at Richborough in UK and Zeebrugge in Belgium. The cable route length is 141 km including 130 km of submarine section and 2 km in UK and 9 km in Belgium land section.

Subsea section profile is shown in Fig. 2. The water depth of the most area is 20 m to 40 m and the deepest portion is 55 m near UK area. There is a big amount of sand wave accumulation in some area and the highest is estimated 12 m. The cable transmission capacity was calculated considering this sand wave accumulation. The DC XLPE cable with 90 deg-C maximum allowable temperature of conductor is suitable for this circumstance.

The required depth of cable burial was 0.8 m to 3 m according to the area. The seabed condition is rather