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THE NORNED HVDC LINK – CABLE DESIGN AND PERFORMANCE

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ABSTRACT

The NorNed link is the longest submarine power cable system ever with a distance of 580 km. The bipolar HVDC system with ± 450 kV dc represents the state-of-the-art of "classic" HVDC technology while modern production and installation technology helped to push forward the limit of HVDC power transmission. This paper describes some of the characteristics of the power cables in the NorNed link.

KEYWORDS

NorNed, HVDC, mass-impregnated cable, submarine cable.

INTRODUCTION

The cables for NorNed were supplied by two manufacturers. Technical data given in this paper relate to the cables supplied from one manufacturer for approx. 70% of the cable route.

NORNED HVDC CABLE LINK

The NorNed link connects the Dutch to the Norwegian national power grid. Since these grids belong to different power frequency control areas in Europe (UCPTE and Nordel, resp.) they are asynchronous. For this reason, but mainly due to the extreme length of the link, an HVDC connection is the only feasible technology for the task. The HVDC converter stations are situated in Feda (Norway) and Eemshaven (Netherlands) within a few kilometres from shore. The cable route between the converters is approx. 580 km.

The link has a bipolar configuration with a 12-pulse converter in each converter station [1]. The valve stack is mid-point grounded and feeds two cables at ± 450 kV. The arrangement is a very attractive solution for a single converter block scheme for extremely long cable trans-missions. The transmission voltage is effectively 900 kV giving fairly low cable current and low losses. The total losses are 3.7 % at nominal 600 MW operation. The DC link is further designed to operate continuously at 700 MW with all converter cooling equipment in operation.
The converter midpoint ground in Eemshaven constitutes the zero DC Voltage potential reference for the DC side. This is accomplished by a midpoint reactor which also blocks 6-pulse harmonic currents otherwise injected into the DC cables. The midpoint in Feda is isolated from ground with an arrester to protect the midpoint from over-voltages. The bipole configuration is shown in Figure 1 [1].

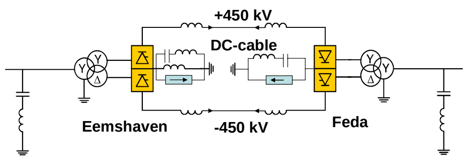

Figure 1. NorNed main circuit configuration

CABLE ROUTE

The challenging cable route includes the following components:

- o Trenched land cable in the Netherlands
- o Submarine cable in the tidal flats off the Netherlands, with strict environmental installation requirements, and risks of moving sands changing the thermal cable ambient
- o Long portions of flat sea bottom with boulder fields with water depth <100 m
- o The Norwegian trench with up to 400 m of water
- o Steep tunnels in Norway

Thermal conditions

A comprehensive assessment of the thermal conditions of the cable ambient is crucial for a successful cable design. Given the extreme length of the cable route, even a very small change in conductor size would imply enormous cost changes for the project.

A sufficient conductor area must be provided to keep ohmic losses low enough so that the conductor temperature limit (50ºC) will not be exceeded. As the thermal conditions vary along the cable route the use of various conductor areas would be a tempting solution. However, using many different conductor cross sections would impair flexibility in production and installation seriously. Experience from other long-haul cable projects [2] shows that a small number (two or three) of different areas is best for logistic considerations and production flexibility.

The thermal soil resitivity in the sea bottom has been assessed from soil samples retrieved during the route survey. As the sea bed is quite similar in structure along the shallow portion of the route the samples are considered representative. Adding a comfortable safety margin, values