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66 kV Cable arrays for Offshore Wind Farms

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Introduction

Among the technology developments enabling levelized cost energy (LCE) reduction, several independent studies have shown that use of array cables operating at 66 kV instead of 33 kV presents considerable advantages on typical offshore wind farm systems.

The main cost reduction drivers for using 66 kV, instead of 33 kV whilst maintaining the same overall output power, are:

- Two times more power can be transported over a single array cable,
- Lesser number of cables are entering the offshore substation
- Larger turbines unit power to reduce the number of turbines and array circuits

Prysmian carried out a comparison between three 66 kV composite submarine cables with aluminum conductor of 800 mm2 cross section in order to have an initial comparison of the different designs that could be used for this market. Electrical parameters for each design were calculated under the same ambient conditions:

Design	Weight (kg/m)	Overall diameter (mm)	Transmission power (MVA)
Dry	57,9	183	90
Semi-wet	39,4	175	90
Wet	36,2	163	90

Where

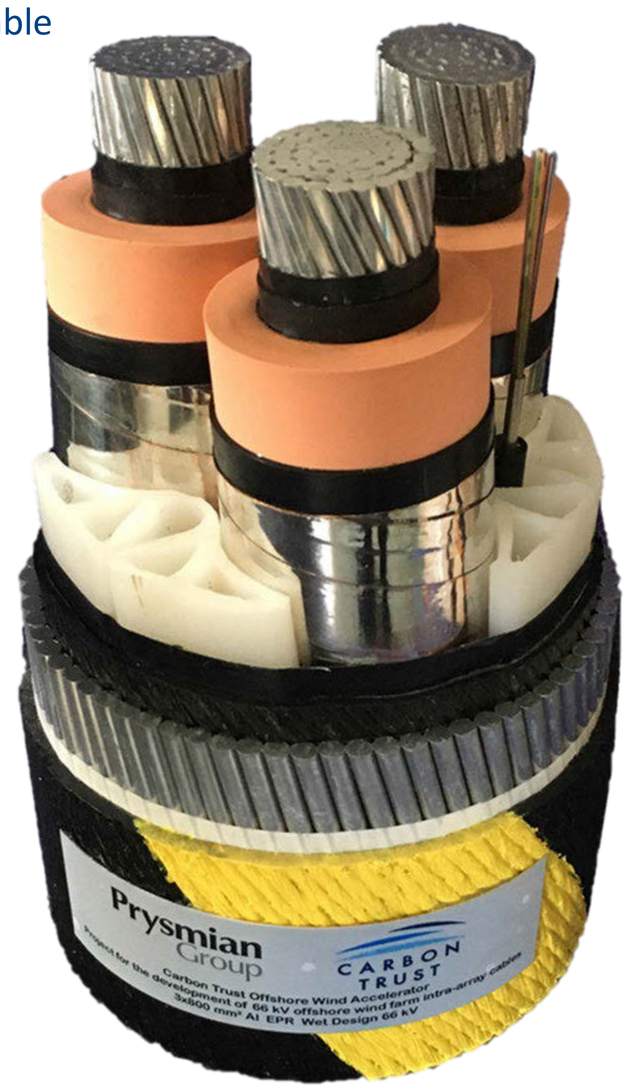
- Dry design is a cable with a lead metallic sheath
- Semi-wet/Semi-dry design is a cable with a PE sheath over the metallic screen
- Wet design is a cable without any kind of PE sheath over the metallic screen.

Insulation material of 66 kV cables operates at higher electric stress than 33 kV cables, requiring rigorous cable design and insulation material selection.

Therefore, Prysmian's 66 kV cable design is based on EPR insulated submarine cables, with 50 years successful operational experience up to 72.5 kV, and it is considered as a reliable and cost effective solution for offshore cable systems. The technical features of these cables are outstanding, with no equal among any other cable insulation types at this voltage level.

Prysmian 66 kV cable systems

66 kV array cables can be manufactured with cross section in the 120 to 800 mm^2 range. Both copper and aluminum conductors are available

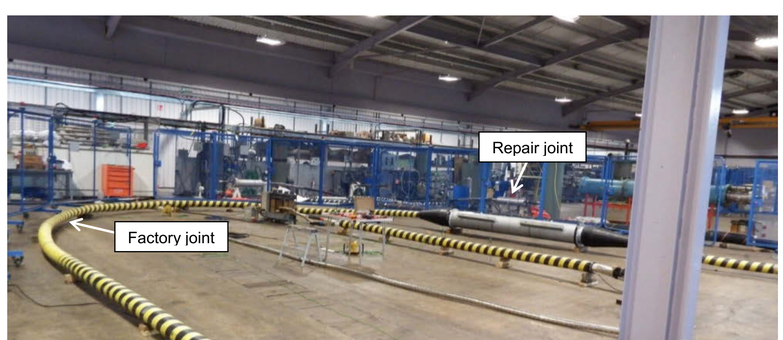


Example of 66 kV wet-design array cable with 800 mm^2 Al conductor and EPR insulation

Qualification

Prysmian Group has successfully type tested its 66 kV cable system in accordance with CIGRE and IEC test protocols, as part of the Carbon Trust's Offshore Wind Accelerator (OWA) program.

The type tested has been carried out on a 3-core, 66 kV EPR insulated "wet-design" cable system with 800 mm^2 aluminum conductors and integrated optical element. The solution includes factory, field joints and plug-in terminations (using proprietary Click-FitTM technology) and combines the use of state-of-the-art EPR insulation - a material with excellent performance in direct contact with water, with the cost effectiveness of a lighter and lead-free design.



66 kV Type Test Loop according to CIGRE TB 490

EPR insulated cables

EPR insulated cables are covered by the IEC standards and by many National Standards worldwide and are operating in several countries at voltages up to 150 kV.

Nowadays the use of EPR insulated cables is preferred for applications requiring superior mechanical and thermal performances including industrial, oil and gas, nuclear, submarine, and renewables systems.

Most premoulded type accessories for EHVAC and HVDC cable systems are also made of EPR.

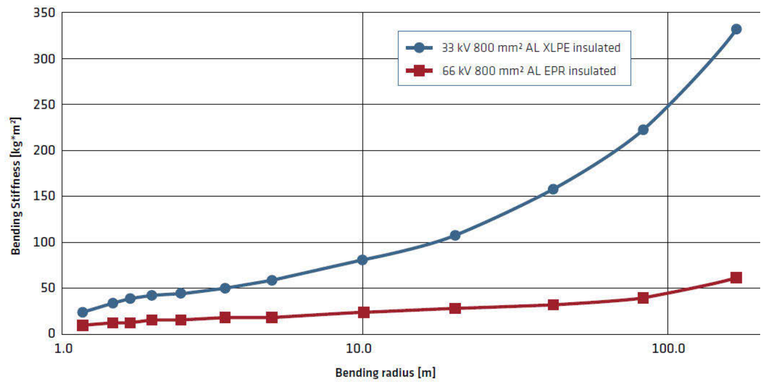
During their history, EPR insulated cables have been mainly characterized by their relatively immunity to the water treeing phenomenon , providing reliable service for more than 40 years in a broad range of applications.

The most widely used testing protocols for accelerated aging in water are the following:

- Accelerated Water Treeing Test (AWTT) according to NEMA USA standards
- Two years Long Term Test for Resistance to Water and Electrochemical Treeing according to European CENELEC standards
- Accelerated 3000 Hours long term test in water at 500 Hz frequency according to European CENELEC standards

EPR insulated cables are recognized to exhibit very good performance in all the above testing protocols conditions.

In addition EPR has an elastic modulus lower than XLPE which makes it easier to install, particularly if the operation has to be undertaken in restricted spaces or into internal switchgear.s



Bending stiffness vs. bending radius

References

1. L.COLLA, A.E. REIG PÉREZ, E. ZACCONE"EPR insulated cables for modern offshore systems", *Jicable 2015*
2. CIGRE Technical Brochure 490 "Recommendations for Testing of Long AC Submarine Cables with Extruded Insulation for System Voltage above 30 (36) to 500 (550) kV ", February 2012
3. CENELEC HD 605 "Electric cables - Additional test methods" section 5.4.15.3