Submarine Power Cables
Submarine Power Cables

Since decades Nexans’ plant in Hannover is specialised in the design, production and installation of low and medium voltage submarine power cables required for river or lake crossings, power supply to islands and platforms for offshore oil and gas production and offshore wind mill parks.

Numerous successfully completed projects with our cables in Europe and overseas have proven the capability of Nexans’ highly skilled technical staff to cope with submarine cable design, production, transportation and laying problems.

The experience gained by Nexans in the development of extra high voltage cables is further applied in the production of submarine power cables.

The properties of cross-linked polyethylene (XLPE) and ethylene propylene rubber (EPR) insulated cables

Cross linked polyethylene and EPR have proven as excellent cable insulating compounds for submarine power cables. The main reasons are the outstanding electrical and mechanical properties of these materials. Compared to oil filled paper insulated submarine cables, XLPE and EPR insulated cables offer the following advantages:

- XLPE and EPR are solid dielectrics. They are maintenance free, no supervision and control of the oil level in the cable systems is necessary.
- XLPE and EPR insulated submarine power cables are usually supplied without a lead sheath. Their construction is therefore of lighter weight permitting longer continuous delivery lengths and easier handling during transportation and laying. The bending radius is small. The solid dielectric and the heavy steelwire armouring are superior to the paper insulated and lead sheathed cables and are much less sensitive to severe stresses to which submarine cables are subjected during transportation, laying and operation.
- The main electrical and mechanical characteristics of XLPE and EPR insulated medium voltage cables compared with paper-oil-insulated cables, are shown in table 1.

<table>
<thead>
<tr>
<th></th>
<th>Dielectric constant εr</th>
<th>Dielectric loss factor tanδ</th>
<th>Insulation resistance 10¹⁷ Ω cm</th>
<th>Operating temperature</th>
<th>Short circuit temperature</th>
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<tbody>
<tr>
<td>XLPE</td>
<td>2,3</td>
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<td>90°C</td>
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<td>60-70°C</td>
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Testing

Testing at the factory is done according to the specified national or international standards and furthermore in strict accordance to the rules of the Nexans quality assurance recommendations.

Modern testing facilities permit extensive testing of the cables as: routine tests - special tests - type tests.
Transportation, Laying, Field testing

Special manufacturing, storing and loading facilities for submarine power cables in long lengths have been developed at Nexans including the necessary provisions for transportation to seaports and direct transfer to cable laying ships or to special loading platforms. Short lengths are supplied on special cable drums, while longer lengths are normally supplied in coils laid out on platforms or fed directly into the cable laying ship.

For the actual cable laying operation, platforms can be placed by means of a floating crane on barges or supply boats. The cable is then laid directly from the coil into the water through a roller system which is necessary to avoid kinking. For laying the cable into deeper water a special cable laying unit which coordinates the laying speed and braking of the cable is required. Depending on the possible danger of damages by anchors or heavy fishing gear, the cable is either laid directly on the bottom or buried in the seabed using a water jet stream or other trenching methods. On request, Nexans can either provide technical assistance and supervision of the cable laying operation or do the installation on turnkey basis including substations and cable protection equipment.

The machinery and equipment for cable laying as well as cable accessories, such as specially developed splicing kits for submarine joints and cable terminations, can also be provided.

Cable testing after installation and in case of a damage fault location with modern measuring equipment can be performed by Nexans as well.
Nexans supplies different types of submarine power cables depending on specific requirements and conditions at site. The cable constructions are based on the major national or international Standards e.g. VDE, IEC and ICEA or according to customers design and standards.

The Nexans Group has produced submarine power cables up to 525 kV A.C. with paper-oil insulation; our plant in Hannover is specialised in the production of submarine power cables with XLPE and EPR insulation up to 36 kV.

Medium-voltage submarine cable, including fibre optic cable

Typical design of a medium-voltage submarine cable with a maximum voltage up to 36 kV, including fibre optic cable.

**Type: 2XS(FL)2YRAA**

1. Conductor: copper, circular stranded compacted
2. Conductor screening: extruded semi-conductive compound
3. Insulation: XLPE
4. Insulation screening: extruded semi-conductive compound
5. Screen: copper wires and copper helix, swelling powder
6. Laminated sheath: aluminium tape bonded to overlaying PE sheath
7. Fibre optic cable, optional
8. Fillers: polypropylene strings
9. Binder tapes
10. Bedding: polypropylene strings
11. Armour: galvanized round steel wires
12. Serving: bituminous compound, hessian tapes, polypropylene strings with coloured stripe
Medium-voltage submarine cable, XLPE insulated

Typical design of a medium-voltage submarine cable with a maximum voltage up to 36 kV

**Type: 2XS2YRAA**
1. Conductor: copper, circular stranded compacted, longitudinal water-tight by filling with a sealing compound (optional)
2. Conductor screening: extruded semi-conductive compound
3. Insulation: XLPE
4. Insulation screening: extruded semi-conductive compound
5. Screen: copper tapes
6. Separator: plastic foil
7. Sheath: PE
8. Fillers: polypropylene strings
9. Binder tapes
10. Bedding: polypropylene strings
11. Armour: galvanized round steel wires
12. Serving: hessian tapes, bituminous compound, polypropylene strings, lime wash

Medium-voltage submarine cable, EPR insulated

Typical design of a medium-voltage submarine cable with a maximum voltage up to 36 kV

**Type: 3GSERAA**
1. Conductor: copper, circular stranded compacted, longitudinal water-tight by filling with a sealing compound (optional)
2. Conductor screening: extruded semi-conductive compound
3. Insulation: EPR
4. Insulation screening: extruded semi-conductive compound
5. Screen: copper tapes
6. Fillers: polypropylene strings
7. Binder tapes
8. Bedding: polypropylene strings
9. Armour: galvanized round steel wires
10. Serving: hessian tapes, bituminous compound, polypropylene strings, lime wash
These constructional and electrical data are values of typical submarine cables up to 36 kV (Standard IEC), with radial and longitudinal water barrier.

### Legend for tables
- **Constructional Data**: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
- **Electrical Data**: 1, 2, 3, 4, 5, 6, 7, 8

### Constructional Data, Electrical Data

#### 2XS(FL)2YRAA 6/10(12) kV

<table>
<thead>
<tr>
<th>Nominal cross sectional area of conductor</th>
<th>Conductor resistance DC 20°C (Ω/km)</th>
<th>Conductor resistance AC 90°C (Ω/km)</th>
<th>Screen resistance 20°C (Ω/km)</th>
<th>Capacitance (µF/km)</th>
<th>Inductance (µH/km)</th>
<th>Current rating (A)</th>
<th>Losses (W/m)</th>
<th>1s short circuit current after full load at 90°C (kA)</th>
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### Electrical Data

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<th>Nominal cross section area of conductor (mm²)</th>
<th>Conductor resistance DC 20°C (Ω/km)</th>
<th>Conductor resistance AC 90°C (Ω/km)</th>
<th>Capacitance (µF/km)</th>
<th>Inductance (mH/km)</th>
<th>Current rating (A)</th>
<th>Losses (W/m)</th>
<th>1s short circuit current after full load at 90°C conductor temperature (kA)</th>
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</table>
These constructional and electrical data are values of typical submarine cables up to 36 kV (Standard IEC).

1 Conductor
2 Conductor screening
3 XLPE insulation
4 Insulation screening
5 Metal screen and separator
6 Core sheath
7 Fillers / FO cables
8 Bedding
9 Armour
10 Serving

### Legend for tables

**Constructional Data**
- 1, 2, 3, 4, 5, 6, 7, 8: Nominal values
- 9, 10, 11: Approx. values

**Electrical Data**
- 1: Nominal value
- 2: Max. value to IEC 60228
- 3, 4, 5, 6, 9: Approx. values
- 7: Calculated in accordance to IEC publications 60287 and the following assumptions
  - Max. conductor temperature at continuous load 90°C
  - Frequency 50 Hz
  - Max. ambient temperature 20°C
  - Screens bonded at both ends and connected to earth
  - Burial depth of cables 1.0 m
  - Thermal resistivity of surroundings 1.0 K·m/W
  - At current acc. to 7

### Constructional Data, Electrical Data

#### 2XS2YRAA 6/10(12) kV

<table>
<thead>
<tr>
<th>Nominal cross sectional area of conductor (mm²)</th>
<th>Conductor copper round stranded diameter over conductor (mm)</th>
<th>Insulation XLPE wall thickness (mm)</th>
<th>Screen copper wires and counter helix cross sectional area (mm²)</th>
<th>Core sheath PE black wall thickness (mm)</th>
<th>Core sheath galvanized diameter (mm)</th>
<th>Bedding wall thickness (mm)</th>
<th>Armour steel wires round galvanized diameter (mm)</th>
<th>Serving bitumen fib. material and lime wash wall thickness (mm)</th>
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<th>Nominal cross sectional area conductor (mm²)</th>
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### 2XS2YRAA 18/30(36) kV

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### 2XS2YRAA 18/30(36) kV

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These constructional and electrical data are values of typical submarine cables up to 36 kV (Standard IEC).

1 Conductor
2 Conductor screening
3 EPR insulation
4 Insulation screening
5 Metal screen
6 Binder tapes
7 Fillers / FO cables (optional)
8 Bedding
9 Armour
10 Serving

### Legend for tables

**Constructional Data**
- 1, 2, 3, 4, 5, 6 – Nominal values
- 7, 8, 9 – Approx. values

**Electrical Data**
- 1 – Nominal value
- 2 – Max. value to IEC 60228
- 3, 4, 5, 6, 9 – Approx. values
- 7 – Calculated in accordance to IEC publications 60287 and the following assumptions
- Max. conductor temperature at continuous load 90°C
- Frequency 50 Hz
- Max. ambient temperature 20°C
- Screens bonded at both ends and connected to earth
- Burial depth of cables 1.0 m
- Thermal resistivity of surroundings 1.0 K·m/W
- at current acc. to 7

### Constructional Data, Electrical Data

#### 3GSERAA 6/10(12) kV

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### 3GSERA 12/20(24) kV

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</table>

#### Electrical Data

| Nominal cross sectional area of conductor (mm²) | Conductor resistance DC 20℃ (Ω/km) | Conductor resistance AC 90℃ (Ω/km) | Screen resistance 20℃ (Ω/km) | Capacitance (μF/km) | Inductance (mH/km) | Current rating (A) | Losses (W/m) | 1s short circuit current after full load at 90℃ conductor temperature conductor screen (kA) |
|---|---|---|---|---|---|---|---|---|---|
| 35 | 0.524 | 0.67 | 1.05 | 0.19 | 0.41 | 166 | 57 | 5.0 | 3.3 |
| 50 | 0.387 | 0.49 | 1.05 | 0.21 | 0.39 | 197 | 59 | 7.1 | 3.3 |
| 70 | 0.268 | 0.34 | 1.05 | 0.24 | 0.37 | 241 | 62 | 10.0 | 3.3 |
| 95 | 0.193 | 0.25 | 1.05 | 0.26 | 0.35 | 288 | 65 | 13.6 | 3.3 |
| 120 | 0.153 | 0.20 | 1.05 | 0.29 | 0.34 | 327 | 67 | 17.1 | 3.3 |
| 150 | 0.124 | 0.16 | 1.05 | 0.31 | 0.33 | 365 | 69 | 21.4 | 3.3 |
| 185 | 0.0991 | 0.13 | 0.73 | 0.33 | 0.32 | 409 | 71 | 26.5 | 4.3 |
| 240 | 0.0754 | 0.098 | 0.73 | 0.37 | 0.31 | 470 | 74 | 34.3 | 4.3 |

### 3GSERA 18/30(36) kV

#### Constructional Data

<table>
<thead>
<tr>
<th>Nominal cross sectional area of conductor (mm²)</th>
<th>Conductor copper round stranded diameter over conductor (mm)</th>
<th>Insulation EPR wall thickness (mm)</th>
<th>Screen copper toess cross sectional area (mm²)</th>
<th>Bedding wall thickness (mm)</th>
<th>Armour steel wires round galvanized diameter (mm)</th>
<th>Serving bitumen, fib, material and lime wash wall thickness (mm)</th>
<th>Outer diameter of cable (mm)</th>
<th>Cable weight (t/km)</th>
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</tbody>
</table>

#### Electrical Data

| Nominal cross sectional area of conductor (mm²) | Conductor resistance DC 20℃ (Ω/km) | Conductor resistance AC 90℃ (Ω/km) | Screen resistance 20℃ (Ω/km) | Capacitance (μF/km) | Inductance (mH/km) | Current rating (A) | Losses (W/m) | 1s short circuit current after full load at 90℃ conductor temperature conductor screen (kA) |
|---|---|---|---|---|---|---|---|---|---|
| 50 | 0.387 | 0.49 | 1.05 | 0.17 | 0.43 | 196 | 59 | 7.1 | 3.3 |
| 70 | 0.268 | 0.34 | 1.05 | 0.18 | 0.39 | 241 | 62 | 10.0 | 3.3 |
| 95 | 0.193 | 0.25 | 0.73 | 0.20 | 0.37 | 287 | 67 | 13.6 | 4.3 |
| 120 | 0.153 | 0.20 | 0.73 | 0.22 | 0.36 | 325 | 67 | 17.1 | 4.3 |
| 150 | 0.124 | 0.16 | 0.73 | 0.23 | 0.36 | 364 | 69 | 21.4 | 4.3 |
| 185 | 0.0991 | 0.13 | 0.63 | 0.25 | 0.35 | 406 | 72 | 26.5 | 5.4 |
| 240 | 0.0754 | 0.098 | 0.63 | 0.28 | 0.33 | 467 | 75 | 34.3 | 5.4 |
Applications

Offshore production platform in Indonesia, with power supply through a submarine cable

34.5 kV shore substation submarine cable project Mindanao, Philippines

Landing a submarine cable at shore of an Australien Island
Laying of inter turbine cables for Horns Rev offshore windpark, Denmark
Nexans welcomes your inquiries. For elaboration of a proposal most suitable for your individual requirements, detailed informations should be given to the following questions (as far as applicable):

1. **Application**
   
   Attach plan of layout, if possible .................................................................

2. **Transmitted voltage**
   
   Rated system voltage \( (U_o/U) \) ....................................................................................................................
   
   Highest continuous voltage \( (U_m) \) ...........................................................................................................
   
   Operating frequency ..........................................................................................................................

3. **Transmitted power**
   
   Rated transmitted power \( (kVA) \) ............................................................................................................
   
   Short circuit current \( (kA) \) ....................................................................................................................
   
   Short circuit duration \( (s) \) ..................................................................................................................

4. **Type of operation**
   
   Public network (load cycling) ..................................................................................................................
   
   Continuous full load operation ..............................................................................................................
   
   Requirements for control/telecommunication circuits ........................................................................

5. **Grounding conditions**

6. **Conditions of cable route**
   
   Length of cable route \( (route\ plan) \) ........................................................................................................
   
   Water depth ............................................................................................................................................
   
   Water flow conditions/tide ....................................................................................................................
   
   Thermal resistance of the soil ...................................................................................................................
   
   Laying depth ..........................................................................................................................................
   
   Soil temperature ..................................................................................................................................
   
   Conditions of the cable route at the beginning and at the end .................................................................
   
   Cable laying in pipes or in the air ..............................................................................................................
   
   Ambient temperature ............................................................................................................................
   
   On-shore cable protection requirements .................................................................................................

7. **Transport and laying conditions**
   
   Required laying method (laying on bottom, water jet trenching) ............................................................
   
   Will laying be performed by customer or separate subcontractor ............................................................
   
   Are there limitations for handling sizes and weights .............................................................................
   
   Are cable laying barges available ...........................................................................................................
   
   Load carrying capacity of the laying barge .............................................................................................
   
   Dimensions of the loading platform .......................................................................................................
For your notes