



Exploration & Production

GENERAL SPECIFICATION

ELECTRICAL

GS ELE 765

Subsea cables

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Contents

1. Scope	4
2. Reference documents.....	4
3. Environmental conditions	5
4. Construction requirements	5
4.1 Rated voltages.....	5
4.2 Conductors	5
4.3 Insulation	6
4.4 Colour of main conductor insulation	6
4.5 Conductor screen.....	6
4.6 Insulation screen.....	6
4.7 Metallic screen.....	6
4.8 Lead sheath	6
4.9 Teredo protection.....	6
4.10 Optical fibres.....	7
4.11 Assembly, inner coverings and fillers	7
4.12 Metallic armour	7
4.13 Oversheath	8
4.14 Cable marking.....	8
5. Mechanical design requirements.....	8
5.1 General.....	8
5.2 Service conditions.....	8
5.3 Mechanical design	8
6. Cable termination.....	10
7. Loading/Installation	10
7.1 General.....	10
7.2 Installation.....	10
8. Inspection and testing	11
8.1 General.....	11
8.2 Inspection	11



8.3	Factory acceptance tests	11
8.4	Electrical tests on site before laying	13
8.5	Electrical tests after installation	13
8.6	Test reports.....	13
9.	Cable repair	13

1. Scope

This specification defines the minimum requirements for the design, manufacture, testing and supply of the composite electrical power and fiber optic cable, for use in a submarine environment. It also covers the minimum requirements for the design, manufacture, supply and testing of cable accessories, connectors, terminators and supports.

The installation shall be carried out by the CONTRACTOR, but SUPPLIER shall provide data/information/services related to cable installation as required in this specification.

2. Reference documents

The reference documents listed below form an integral part of this General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the EFFECTIVE DATE of the CONTRACT.

Standards

Cables shall conform in design, material and performances with the appropriate sections of the latest editions (with amendments) of the IEC standards.

Reference	Title
IEC 60183	Guide to the selection of high-voltage cables
IEC 60228	Conductors of insulated cables
IEC 60287	Electric cables - Calculations of current rating
IEC 60.502-1-2-4	Power cables with extruded insulation and their accessories for rated voltages from 1 kV up to 30 kV
IEC 60811-1-2-3-4-5	Common test methods for insulating and sheathing materials of electric cables (formerly 540)
IEC 60885-3	Electrical test methods for electric cables Part 3: Test methods for partial discharge measurements on lengths of extruded cables
IEC 60793	Optical fibres
IEC 60794	Optical fibres cables
IEC 60874	Connectors for optical fibres and cables

Professional Documents

Reference	Title
Not applicable	

Regulations

Reference	Title
Not applicable	

Codes

Reference	Title
ITU-T	Recommendations G652

Other documents

Reference	Title
Not applicable	

Total General Specifications

Reference	Title
Not applicable	

3. Environmental conditions

The environmental conditions, such as installation depth and water temperature, used to design the cable, are defined in the PROJECT particular specification, and or the data sheet.

4. Construction requirements

4.1 Rated voltages

The voltage designations shall be U_0/U (U_m) as defined in the IEC 60502-1 and 2 § 4.1.

The Category A of systems shall be considered to select the rated voltage of the cable for the operating conditions under single phase to earth fault.

Supply voltage may vary by $\pm 10\%$ (rated frequency = 50 Hz or 60 Hz $\pm 2\%$)

System Voltage	Rated Voltage U_0/U (U_m)
≤ 6.6 kV	6/10 (12) kV
11 kV	8.7/15 (17.5) kV
20 or 22 kV	12/20 (24) kV
33 kV	18/30 (36) kV

4.2 Conductors

Conductors shall be class 2, manufactured from high conductivity annealed stranded copper wire in accordance with IEC 60228.

Conductors shall have watertight cross-sections and construction to prevent transmission of water ingress in the event of external damage.



The longitudinal water-tightness shall be designed with a test pressure calculated with the formula:

$$P = \frac{D}{10} \text{ (P pressure in bar; D depth in meter).}$$

In every cases the maximum test pressure shall be 30 bars which corresponds to the pressure at 300 m depth.

Conductor cores shall be manufactured with the minimum number of joints required. Minimum cross-section shall be 25 mm².

4.3 Insulation

The insulation material shall be XLPE (cross-linked polyethylene) or EPR (Ethylene Propylene Rubber).

4.4 Colour of main conductor insulation

The main voltage cores shall be colour tape coded Yellow, Blue, Red for three phase wire cable.

4.5 Conductor screen

An extruded semi-conducting screen shall be applied to the conductors.

4.6 Insulation screen

The insulation screen shall consist of an extruded semi-conducting layer. In addition a semi-conducting tape may be layed over the extruded semi-conducting layer.

4.7 Metallic screen

A metallic layer of high conductivity annealed copper tape shall be applied to the power cores over the insulation semi-conducting screen.

The metallic screen cross-section shall be sized in accordance with the earth fault current.

Metallic layer of each phase shall be in electrical contact.

4.8 Lead sheath

If necessary for cable stability reason, a lead sheath of sufficient cross-sectional area or lead filling to withstand the earth fault current shall be designed and applied over the insulation outer semi-conducting screen.

This lead sheath shall be manufactured according to standards, including also considerations regarding mechanical protection (during and after cable installation).

No lead sheath for radial watertightness is required ("dry" design) unless specified in the Project particular specification, and/or the data sheet.

4.9 Teredo protection

When cables are installed in Arabian Persian Gulf, an anti teredo bronze or copper screen shall be provided, or similar protection.

4.10 Optical fibres

The optical fibres will be located in one of the interstices of the power cables.

Fibres shall be single mode communication grade optical fibre meeting the requirements of [ITU-T G652](#). However, the attenuation of the fibres shall not exceed 0.45 db/km at 1300 nm wavelength and 0.25 db/km at 1500 nm wavelength.

Fibres shall be produced as one continuous length.

Fibres shall be laid inside a stainless steel tube with an overall covering of Polyethylene.

The stainless steel tube shall be filled with jelly.

Fibres shall be strain tested by performing an elongation test on the complete cable. The force applied to the complete cable shall be defined in accordance with CIGRE recommendations published in ELECTRA No.171.

Optical units shall be designed to take account of the following effects:

- Anticipated strain during installation
- Free hydrogen
- Contact with sea water at the depth indicated
- Temperature effects
- Bending during and after installation
- Radiation effects for platform cable.

The design shall be such that the maximum degradation over the operating life of the optical fibres (25 years) does not exceed the maximum attenuation indicated across the total length of either cable.

Fibres shall be identifiable throughout the length by colour coding or other means proposed by the SUPPLIER.

4.11 Assembly, inner coverings and fillers

The assembly of three core cables with the optical fibres shall be arranged to form a round shape. The inner coverings may be extruded or lapped. Materials used shall be suitable for the operating temperature of the cable.

4.12 Metallic armour

The metallic armour shall consist of a single galvanized steel wire of minimum 5 mm diameter and shall comply with all relevant clauses of [IEC 60502](#) publication.

An appropriate bedding shall be provided under the armour.

Where cable is installed in deep water (more than 200 m depth) a double galvanised steel wire contra-wound for torsional balance of the cable is required.

Where cable is installed on rocky seabed, a triple type steelwire armour shall be provided.

4.13 Oversheath

An overall protective covering shall be applied to secure and protect the armouring during transit and laying. The cover shall be bitumen impregnated polypropylene or black Polyethylene (PE).

The SUPPLIER shall state the minimum allowable bending radius of the composite cable:

- During installation
- During storage with cable torsion
- During storage without torsion, cable on a drum.

4.14 Cable marking

Cable shall have length marking by tape at every 1000 meters except 200 meters from either end of cable where the marking should be at 10 meter intervals to facilitate laying.

5. Mechanical design requirements

5.1 General

This section outlines the design requirements for the mechanical design of the composite cable, which shall be implemented during cable design.

5.2 Service conditions

The SUPPLIER's design interpretation of the specification shall take due account of all temporary and service conditions likely to be experienced throughout the subsea cable's service life:

- **Temporary condition:** All conditions experienced during the fabrication, mechanical completion, installation and testing of the composite cable including the environmental and safety conditions
- **System commissioning:** Including testing of electrical and fibre-optic lines
- **Service conditions:** All conditions during the service life, including accidental service conditions such as specified maximum short circuit, environmental, safety conditions and other service conditions as specified in the design basis.

5.3 Mechanical design

5.3.1 In-place stability

In-place stability shall be analyzed in accordance with the applicable Codes and Regulations, based upon the design data contained in the Contract documents.

The cable shall have sufficient negative buoyancy to prevent any instability on the sea bed. The SUPPLIER shall state the specific gravity of the cable in sea water and shall perform his own calculations based of COMPANY's on provided information.

The lateral stability analysis includes all environmental forces such as drag, lift and inertia as well as frictional resistance. After determination of the appropriate wave theory in combination with wind and tidal velocities, the hydrodynamic loads due to drag, lift and inertia shall be determined.

The design loads to be taken into account are the following:

- Functional loads:
 - Weight
 - External pressure
 - Residual loads
 - Installation loads.

The environmental loads applied to the cable are principally those arising from:

- Environmental loads:
 - Hydrodynamic loads resulting from waves, wind and tidal currents
 - Platform displacements.

Hydrodynamic loads arise from the relative motions between cable and sea water. They consist of drag, lift and inertia forces. The hydrodynamic coefficients used shall be justified.

Wind, wave and tidal induced velocities shall be added vectorially with respect to the direction perpendicular to the cable.

The wave induced water particle velocities and accelerations shall be determinate using the appropriate wave theory for the design wave height, period and water depth. Design environmental parameters shall be extracted from the Project environmental specification included in the Contract documents.

5.3.2 Strength analysis

The composite cable system shall have sufficient strength to resist the loads and load combinations in all service phases of its design life, including installation.

The design of the core arrangement/layout shall be the responsibility of the SUPPLIER and shall ensure that the design outside diameter allows safe installation of the cable. The SUPPLIER shall provide drawings showing the design layout of the cable cross-section.

The SUPPLIER shall perform his own calculations based on review and acceptance of COMPANY's J-tube design for size bending radii and orientation, covering also location of anchoring and termination box and routing of cable to termination box.

The SUPPLIER shall also carry out analysis to ensure that the cable can withstand dynamic bending cycles occurring during an interruption of lay operations, and at mid-water arch location during pull-in operations.

The SUPPLIER shall submit to COMPANY at tender stage a preliminary study justifying the cable mechanical design (stability, etc.).

5.3.3 Allowable spans

The SUPPLIER shall perform allowable span calculations for the cable at the J-tube bellmouth and along its length, based on COMPANY's provided information.

The analysis shall take account of environmental and functional loads.

These allowable spans shall be used to determine the requirements for sweeping along the route before installation or remedial works after installation.

6. Cable termination

The SUPPLIER shall provide all the necessary accessories to terminate the cable. The SUPPLIER shall provide composite armour hang off arrangement with suitable flanges which will be fixed on top of the J-tube. The SUPPLIER shall provide drawings/details of the matching flange for the J-tube.

The cable with inner sheath, after passing through the hang off shall be enclosed in a heat shrinkable sleeve. The cable then shall be passed through a splitting box (breakout unit) to separate the power cores and the fibre optic steel tube; separation shall be made using a quadrifurcation glove.

The individual cores shall be enclosed in heat shrinkable sleeve.

The power cores shall then enter a power cable termination box through cable glands.

The power cores shall be terminated using suitable termination kits.

The optic fibber tube shall enter a separate optical termination unit (OTU) through cable glands. This OTU shall have bulkhead type connectors with pigtails.

The optical fibber splices shall be of fusion type having an average loss of 0.1 dB, and not exceeding 0.2 dB.

The maximum loss of any connector shall be 0.25 dB. Test reports from MANUFACTURER of connector shall be submitted to indicate the guaranteed attenuation value.

Note: Location of splitting boxes, power termination boxes, optical termination boxes, etc., may require certified Zone 1 or Zone 2 equipment.

7. Loading/Installation

7.1 General

The SUPPLIER shall specify guidelines to define the specific technical instructions applicable to the transportation, laying, installation and acceptance of the subsea cable.

Based on these guidelines, the particular specification for the installation issued by the CONTRACTOR shall be approved by the SUPPLIER.

A cable SUPPLIER representative shall be present during the laying of the cable.

7.2 Installation

The complete cable shall be loaded on a drum or a suitable cable laying ship/barge which shall have access alongside the cable MANUFACTURER plant.

The cable shall be stored on the ship/barge in a suitable manner.

The "open" end of the cable shall be fitted with a "bull-nose" to allow the cable pulling equipment to be fitted to facilitate the pulling of the cable through a J-tube.

Two "bull-nose" fittings shall be provided and factory fitted for each length of cable by the SUPPLIER.

Dimension of the "bull-nose" shall be suitable for J-tube inner diameter. Bull-noses shall be designed to allow test of the cable at delivery and during installation.

The SUPPLIER shall develop the procedures and design calculations for pulling the cable through the J-tubes. These calculations shall prove that the stresses imposed on the cable are well within the cable design characteristics. The procedures shall include details of the method of attaching the winch wire to the cable, and any precautions proposed. They shall also highlight any special requirements for the structure, such as support points for winching.

The SUPPLIER shall detail and specify any additional type of extra reinforcement which may be required to the cable where it exits from the base of the J-tube. Details shall be furnished giving full details on how the reinforcement shall be fitted.

The construction of the cable shall be such as to allow a flexible configuration to facilitate installation.

In case of long cable lengths for which junction boxes are unavoidable, the installation of the junction boxes shall be supervised by the SUPPLIER. The required junction boxes with accessories shall be supplied by the cable MANUFACTURER.

8. Inspection and testing

8.1 General

The SUPPLIER shall maintain comprehensive records of all tests undertaken and the results.

The COMPANY reserves the right to witness any or all the tests.

The SUPPLIER shall provide written confirmation of all the tests a minimum of fourteen (14) days in advance of the test date, so that arrangements can be made to witness the events.

The SUPPLIER shall indicate the details of all test equipment proposed to be used for both factory and offshore testing of the cable. The SUPPLIER shall provide a list of all test equipment required on the platform for offshore testing, to allow space and transportation requirements to be allocated.

The type test approval certificates conducted for similar design cable shall be furnished to indicate the results of following tests:

- Bending and tension test
- Heating cycle test plus partial discharge test
- Impulse withstand followed by partial discharge test
- Elongation test (CIGRE).

8.2 Inspection

The SUPPLIER shall apply his normal procedures and standards to control the quality of goods during all stages of preparation, unless modified and replaced by the COMPANY's written requirements.

8.3 Factory acceptance tests

8.3.1 Sequential tests

The following tests shall be carried out on samples or the whole length of the manufactured cable prior to load out. Testing shall be as per [IEC 60502](#) and as listed in the following section.

8.3.2 Test schedule

8.3.2.1 Routine tests on insulated cores before laying-up

	$U_m \leq 3.6 \text{ kV}$	$3.6 \text{ kV} < U_m \leq 36 \text{ kV}$
Partial discharge test	Not required	IEC 60502-2/16.3
High voltage AC test	IEC 60502-1/15.3	IEC 60502-2/16.4

8.3.2.2 Routine tests on delivered cable

Conductor resistance measurement	IEC 60502/15.2	IEC 60502-2/16.2
DC insulation measurement		
High voltage AC test	IEC 60502-1/15.3	IEC 60502-2/16.4
Capacitance test		
Time Domain Reflectometer (TDR)/Echometer test		

8.3.2.3 Special tests on 1 sample

Conductor examination	IEC 60502-1/16.4	IEC 60502-2/17.4
Dimensional control	IEC 60502-1/16.5/16.6/16.7	IEC 60502-2/17.5/17.6/17.7
High voltage AC test (4 hours)	Not required	IEC 60502-2/17.9
Hot test for XLPE insulation	IEC 60502-1/16.9	IEC 60502-2/17.10
Tan delta	Not required	for $U > 6/10$ (12 kV)

8.3.3 Optical tests

Each fibre used in the optical unit shall have an associated manufacturing test/QA record document. The SUPPLIER shall, as part of its response to this document, provide a copy of the test/QA procedures used for the fibre manufacture. The test shall cover as a minimum all parameters of the fibre.

Prior to laying up of the fibres in the optical unit, the fibres will be tested using an Optical Time Domain Reflectometer (OTDR) to measure loss against distance in the operating window specified ends of the fibre. The SUPPLIER shall produce a schedule of the tests including results limits to be agreed with the COMPANY prior to testing. The test results shall be recorded in a manner which allows easy comparison with later tests.

The test shall be conducted as per ITU-T G652 and G650 recommendation.

8.4 Electrical tests on site before laying

Upon the cable arrival at destination and before laying, following tests shall be carried out by the SUPPLIER in presence of the CONTRACTOR (interface):

- Electrical resistance measurement
- Measurement of insulation resistance
- OTDR test of optical fibres.

8.5 Electrical tests after installation

8.5.1 Power cores

	Um ≤ 3.6 kV	3.6 kV < Um ≤ 36 kV
Electrical resistance of the cores		
Measurement of insulation resistance	IEC 60502-1/19	IEC 6002-2/20
High voltage test		

8.5.2 Optical fibre cores

OTDR Optical Time Domain Reflectometer/Echometer test and others tests recommended by the SUPPLIER shall be carried out.

8.6 Test reports

A pro-forma of test reports shall be presented to the COMPANY for approval before placing the order.

The test reports shall detail as a minimum:

- The expected theoretical values
- The tolerances
- The results of the measurements carried out, including any intermediate values, which lead to a temporary non-acceptance, if any.

The test reports shall be included in the contractual technical documents, and shall be considered as an integral part of them.

9. Cable repair

The **SUPPLIER** shall design a method of cable repair and will issue the appropriate procedures. This will encompass the recovery method of the damaged cable, method of repair of power conductors and optical unit, and the manner of reinstallation. The **SUPPLIER** shall design and supply the necessary junction boxes and accessories.

The repair joint will be such that the integrity of the cable shall be maintained and that the design life degradation is not affected.

An additional length of cable shall be supplied for retention to effect repairs on a separate steel drum. The cable ends shall be properly sealed for outdoor storage for a long duration.