Special Offshore Cables
Nexans Norway AS designs and manufactures a wide range of special purpose cables and umbilicals through its product divisions, either as individual products or composite structures taking advantage of all highly specialised technologies available within the company in order to offer the customers optimum solutions.

The special telecom cables are directed to serve application areas in need for highly dedicated cable or umbilical designs, serving multiple functions like:

- communication
- signal transmission for control and data
- electrical power transmission to remote equipment
- air or fluid power supply through plastic flow lines

The main products and areas of applications are:

- fibre optic submarine cables
- fibre elements into composite power and fibre optic cables to enable communication of voice, data, video, broadcast over long distances (>300 km)
- electrical umbilical cables with signal and power elements for connecting oil platforms to subsea templates over long distances (>100 km) and down to water depth > 1,600 m.
- dynamic umbilicals for operation of Remotely Operated Vehicles (ROV) containing signal elements (pairs/quads, RG coax or fibre optic elements) together with electrical power elements feeding remote equipment with more than 1 Mwatt.
- Air-gun umbilicals and lead-ins for towed systems, and bottom laid cables for 4-D seismic acquisition
- submarine cables for permanent underwater installations for monitoring and control purposes (oceanographic, telemetry of ship activity, defence systems etc.)
- topside cables (fibre optic or coax) for interplatform wiring of communications systems having fire resistant or mud resistant characteristics
- Optical Ground Wire (OPGW) cables, providing normal electrical functions and large transmission capacity for data and communication requirements

In order to respond fully to customer needs, many of the cable or umbilical products are supplied with accessories, comprising terminations, cable joints for repair or maintenance purposes, weak links, hang-off for oil platform terminations and flexible riser systems for use from sea bed to floating structures.

In addition special purpose telecom elements can be incorporated into large combination umbilicals together with steel tubes or high voltage conductors.

We also offer design engineering services to fully undertake turnkey responsibility for cable and umbilical systems including installation, which can be offered in addition to our contracting activity.
Some of the specific capabilities are represented by the ability to manufacture long lengths of unspliced cables or umbilicals. To make up “infinite” cable lengths technology has been developed to join long unspliced segments to very long final lengths (100 - 300 km).

Further, with a highly trained engineering staff, cables or umbilicals can be designed and manufactured to meet customer specifications.

This is reflected in a supply record of more than 100 different umbilical designs for ROVs, many supplied for highly specific projects, with its dedicated tools and instrumentation package requiring a varied combination of umbilical elements. Further, as operational range of ROVs are extended, new requirements to armour and outer diameter call for constant improvements and new designs.

The same applies in almost every area, because new special demands requires new special solutions.

Through development of new technologies qualified through extensive test programs Nexans Norway AS aims at being in the forefront capable of serving the customers with new solutions to either improve existing applications or to enable new areas to be served reliably by cost efficient designs.

We would like to work closely with our customers to take full advantage of common skills, as we believe special demands requiring special designs and solutions are best served with both sides fully understanding needs and technical alternatives available.

Our capabilities are shaped by your special needs.
Nexans Norway AS supplies umbilicals to the majority of the standard ROVs such as Solo, Scorpio, Sprint, Voyager, Seaowl, Seahawk, Seatwin, Trojan, Examiner, Triton, Triton XI, Demon, MRV, Recon, Boxer, Hercules, SCV, Innovator, Magnum, Millennium and others.

We also supply umbilicals for special underwater vehicles like the Capjet, Flexjet, Gater, Marlin, Mako, PL2, ST200 and other trenching machines and plows.

**Tethers**

are neutral buoyant cables connecting the ROV to the TMS. These cables typically include a three-phase power supply (100 – 150 HP), instrumentation conductors, and a laser welded steel tube containing optical fibers which are encased in a jelly giving internal protection and support, also referred to as FIMT (Fibre In Metal Tube), for monitoring and video transmission. The tether is armoured with aramid yarns and has a TPR (Thermoplastic Rubber) outer sheath. Typical outer diameter is 30-45 mm.

Steel Armoured Umbilicals are umbilicals designed for vehicles applied for tasks such as trenching, maintenance, drill support etc. Typically the cable has a two or three layer torque balanced steel wire armouring, and includes elements for three-phase power supply (100-150 HP), instrumentation conductors and a laser welded steel tube (FIMT), for monitoring and video transmission. Typical depth ratings are 2000 to 4000 m.

**DW Umbilical**

is an umbilical developed for deepwater applications rated to 6000 m. This is a lightweight aramid armoured cable with an outer diameter of 39 mm. The cable includes elements for three-phase power supply (typical 100 HP), two instrumentation conductors and a laser welded steel tube (FIMT), for signalling. Results of prototype testing show that the cable is well suited for dynamic deep-water applications. The mechanical termination strength is higher than 350 kN.

**Improved technology**

Nexans Norway’s continuous efforts in product development and improvements with respect to materials and processing, have resulted in extended operational conditions and increased lifetime of ROV cables. Loose optical fibres in a laser welded metal tube (FIMT) have proven both in laboratory testing and field use to provide reliable communication with the vehicle. The metal tube ensures a robust protection of the optical fibres, and the stranded configuration introduces sufficient strain relief for the optical fibres so as to avoid fatigue failures.

The umbilical cable designs of Nexans Norway feature cable core compactness, efficient element lay-up and emphasises overall dimension. Steel wire armoured umbilical cables are available for water depths down to 5000 m. For deeper waters aramid yarn armoured solutions are applicable.

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**Platform/Umbilical Cables**

**Electric and electro-hydraulic control umbilical**

For cost efficiency and optimum utilisation of hydrocarbon reservoirs, present techniques for oil and gas production require underwater installations, producing to existing platforms. Subsea umbilicals provide the electric and/or hydraulic power and controls necessary to operate subsea installations remotely from offshore platforms or onshore facilities.

The umbilicals are used to monitor position and functions of such equipment as wellhead valves to signal the operations for opening or closing, and to provide power for operation.

The applicable subsea control and operational systems determine the characteristics of the umbilical, such as size, number of elements and the required standards.

Power cores, signal and fibre optic elements, steel tubes and/or thermoplastic hoses/composite materials, are elements which may be used in various combinations determined by the service requirements. The umbilicals may be delivered with or without armouring according to the customer’s needs.

The following umbilicals comprise electrical and/or optical elements:

- Conoco - Heidrun
- Statoil - Norne
- Shell - Mars

**Mensa**

Nexans Norway supplied the electrical umbilical to Shell’s Mensa project in the Gulf of Mexico. At a depth of 1647 m and a distance of 102 km between the platform and the three gas wells, this umbilical represented a milestone when installed in 1997. The umbilical contains one signal quad and two power triads.

**Statfjord Satellite**

Separate electrical umbilicals have been installed in the Statfjord Satellite field. The umbilical is made up of 7 unshielded quads with a polyethylene inner sheath together with cross-armoured steel wires for mechanical protection and torque balance.

The umbilical core is filled with petroleum jelly to prevent longitudinal water migration.

**Interplatform - composite cables**

Fixed production platforms have usually been self-contained with respect to power generating facilities. Cables can be installed between old and new installations in an offshore field thus eliminating the need to
install power-generating facilities on all installations.

Some factors making interplatform, or shore to platform, power and signal cable solutions increasingly more attractive are:

- Installation weight/size.
- Power generating equipment weight/size.
- Manning levels.
- CO₂ emission levels.
- Remote control of the installation.

The high priority given to continuous operation favours a power cable network between installations. Such a network ensures reliability of power from other sources in case of shutdown or breakdown at one platform.

The remote control of unmanned installations is another application for submarine composite cables. Most subsea power cables installed offshore have a fibre optic element containing 8 – 48 optical fibres for signal transmission. The advantages of combining signal and power capabilities in one cable are:

- communication will not be influenced by weather or surface traffic as in radio
- greater bandwidth compared to radio and satellite
- stable and improved signal quality

Interplatform cables have been supplied by Nexans Norway to:

- Phillips Ekofisk 2/4 A
- Saudi Aramco - Saudi Arabia
- Elf Aquitaine - North East Frigg
- Elf Aquitaine - Frigg-Frøy
- Statoil - Gullfaks A-B
- Statoil - Sleipner West
- BP - Atlantis
- BP - Thunder Horse
- Scarab - Saffron
- Saga petroleum - Benin
- Shell Sarawak - Malaysia
- Shell - Troll Phase 1
- Shell - Nakika

Shore to platform cables
Supplying power to offshore installations from energy sources onshore makes for smaller and lighter installations. Lower manning requirements, and lower CO₂ emission levels. With this solution any number of installations can be linked and provided with power from an onshore power grid. The power supply cable system can be expanded to form a network between offshore fields, providing flexible and safe power utilisation for the oil industry.

The first offshore development where this concept is taken into use is the Troll field off Bergen. The 18 MW platform power requirements was supplied by Nexans Norway through a 67 km long, 52 kV XLPE-insulated combined power and signal cable.

The fibre optic element was manufactured at our factory plant in Rognan in the north of Norway. The composite cable including the power cores was manufactured at our Halden factory in the south of Norway. C/S Skagerrak laid the cable and Capjet 500 performed the protection.

Fire and mud resistant fibre optic topside cables
Nexans Norway has delivered fibre optic topside cable to several offshore installations in the North Sea region. The topside cable is halogen free and flame retardant in accordance with IEC 331/ IEC 332-III which includes testing at 1000°C. The cable has a rugged design with a serving of steel armour for mechanical protection. Both single mode and multimode fibres can be supplied in numbers up to 48 per cable.
Nexans Norway supplies the following products for seismic acquisition:

- Lead-in cables
- Gun cables
- Bottom laid cables for 4-D seismic acquisition

**Lead-in cables** are towing the steamer arrays. Lead-ins are exposed to abrasion, crush and impact. Thus mechanical strength and protection is important. Our lead-ins are heavily armoured, with either steel wires or aramid yarns. The lead-in cores comprise combinations of power conductors, signal pairs and fibre optic elements. On request, fairing for drag and strumming reduction can also be provided. Typical cable outer diameter is 27-40 mm.

**Air-gun umbilicals** are used for both towed and bottom laid systems. Typically an air-gun cable is composed of a central pneumatic hose with stranded power and signal elements. Steel strengthened copper conductors can be supplied, and fibre optic elements can be integrated as well. A torque balanced armouring, consisting of two layers of sheathed high strength steel wires, provides the specified strength. Typical cable outer diameter is 67-81 mm.

**Ocean Bottom Cables** are available for both permanent and retrievable systems. Permanent systems are, unlike conventional retrievable systems, installed and buried under the seabed. Sensor houses with hydrophones and geophones are integrated into the system. The sensor array is connected to the surface through a riser cable.
Cables for oceanography
Nexans Norway has specialised in supplying cable infrastructure for challenging monitoring systems. The cables are deployed permanently and are connected to various types of underwater sensors such as oceanographic (salinity, temperature, pollution, current), geophysical (hydrophones and geophones) and specific sensors monitoring radiation from space or from nuclear bomb trials subsea.

Nexans is in the forefront in the development and execution of cable based systems for deep waters.

Nexans Norway has recently designed and supplied a cable for defence monitoring purposes. In addition, a challenging reference project for monitoring of neutrino particles from space down to 2000 m depth, was implemented in 2001, off the coast of Sicily.
CableSense – a versatile cable monitoring system

Nexans Norway AS is proud to offer CableSense
CableSense is a new feature enabling our customers to perform continuous monitoring of for instance internal temperature of a cable. This is of vital importance in cases where ROV operations are taking place with many layers of umbilical on the winch.

Technical Description of the CableSense System
The CableSense system is based on the Fibre Bragg Grating technology. A Fibre Bragg grating (FBG) is a periodic variation of the index of refraction along the core of an optical fibre. When light with a large spectral width is coupled into the fibre, the FBG will reflect one spectral component. The remaining components will be transmitted. This principle is shown in Figure 1.

The central wavelength of the reflected component satisfies the Bragg relation:
\[ \lambda_{\text{eff}} = 2 n \Lambda, \]
where \( n \) is the index of refraction and \( \Lambda \) is the period of the index of refraction variation of the FBG. Due to the temperature dependence of the parameters \( n \) and \( \Lambda \), the wavelength of the reflected component will also change as function of temperature. This dependency is well known what allows determining the temperature from the reflected FBG wavelength.

The CableSense system allows monitoring up to 10 discrete sensing points using only one optical fibre. This is achieved by putting different FBGs with different wavelengths in a series configuration, see Figure 2.

The wavelength responses of the different FBGs are recorded using a special designed fibre optic measurement system, operating in the C-band (1530 nm – 1570 nm). The working principle is shown in Figure 3. The system consists of a broadband light source that couples the light through a 2 by 2 coupler into the CableSense fibre. This same coupler guides the reflected light, coming from the different FBGs, into an Optical Spectrum Analyser (OSA) module where the different peak wavelengths are calculated. If more than one CableSense fibre is used, an additional optical switch is needed to make the interrogation of the different fibres possible. The control of the measurement system as well as the wavelength to temperature conversion is established using a graphical user interface that can be run from a laptop or desktop PC.
CableSense

Output
Wavelength
Intensity

Input
Wavelength
Intensity

Bragg grating
\[ \lambda_g = 2n \cdot \Lambda \]

\[ \frac{d\lambda}{dT} \sim 12 \text{ pm/K} \]
\[ \frac{d\lambda}{(dL/L)} \sim 1.2 \text{ pm/\mu m} \]
\[ \frac{d\lambda}{dP} \sim -6 \text{ pm/MPa} \]

Multiplexing of several fibre Bragg grating sensors

Figure 1: Principle fibre Bragg Grating response.

Figure 2: Series configuration principle of CableSense cable.

Figure 3: Working principle of the fibre optic measurement system.
Fibre optic submarine cables are attractive due to the large communication capacity of optical fibres over extremely long distances without need for intermediate repeaters (i.e. underwater regenerators or amplifiers).


Today, fibre optic repeaterless systems have almost unlimited capacity, and new cable design systems can be implemented quickly offering highways for services like telephony, data, video or broadcasting. With modern synchronous digital hierarchy (SDH) equipment highly flexible network structures can be established linking e.g. oil platforms to mainland offering redundancy through self-healing network structures in case of cable break or equipment failure. By use of intelligent add-drop multiplexers ring and branching, networks can be achieved substituting traditional point-to-point solutions offering no redundancy except when duplicating terminal equipment.

The URC-1 cable family has been designed specifically for unrepeated systems and is characterised by optimal mechanical properties, dimensions and weights, simplifying installation and hence contributing to cost effective system solutions. The cable design is based on a laser welded steel tube containing the optical fibres which are embedded in jelly such that all fibres are stress free, ensuring a long life time. For mechanical protection the cables can have a large variety of outer steel armourour protections, with heaviest armour type with breaking strength of more than 60 tonnes.

The galvanised steel armouring wires have additional corrosion protection through embedding the wires in bitumen with either polypropylene yarn serving or polyethylene sheath.

The cable can have any number of fibres from 2 up to 384, and various fibre types can be used according to international standards ITU G652, G654 and G655.

The steel tube offers mechanical and hydrostatic protection as well as a hermetic barrier from hydrogen for the optical fibres. Furthermore, the tube technology makes it easier to keep the hermeticity for joints and terminations.

We have over 70 references with over 11000 km of cable installed worldwide.
Fibre Optic River and Lake Cables

In the last few years rivers and lakes (R&L) have increasingly been used as rights of way (RoW). The main feature of R&L as a RoW is that it provides a quick and inexpensive means of cable deployment for new operators. R&L thus provide an opportunity to reduce significantly the time to market for high capacity fibre optic cables. To meet the demand for RoW, Nexans has introduced a complete concept for installing cable in R&L.

For such R&L projects Nexans can supply:

- Cable-only
- Cable system (with installation and accessories)

Nexans regards R&L as a symbiosis of submarine and terrestrial technology, and the total solution takes parts from each area. Each project is different from the previous, and thus each one must be engineered individually.

Nexans previous experience with R&L and related technology is extensive in two countries:

**Norway**
- 1,500 km in rivers and lakes
- Submarine type cable
- Cable laid on river and lakebed

**Switzerland**
- 250 km in lakes
- Marinised terrestrial cable
- Cable laid on lakebed

Nexans has available solutions for any R&L application, and is prepared to carry out such projects anywhere in the world.
Pull-in/hang-off head
To fix or hang off a dynamic or static cable on the deck of a platform, mechanical termination units are developed. The pull-in/hang-off head is fastened to the armour layers by use of cones, pressed together in the armour block. The armour termination is mounted in a fixture to fit the hang-off arrangement at the top of the tubes leading onto the platform deck.

Subsea umbilical termination and bend stiffeners
The cable is secured by fastening the armour wires into an armour block. In the back of the armour block, the housing is bolted up together with the bend stiffener.

The bend stiffener and housing can be slid backwards onto the umbilical to ease the assembly of the electrical chamber and penetrator. The electrical chamber will be pressure compensated and filled with petroleum jelly.

Weak link
To protect the platform against severe damage if the cable is grabbed by e.g. a trawler, a special unit has been developed, which is mechanically much weaker than the cable itself. This is installed close to the platform, and the purpose is to ensure that the weak link will break before the cable it is connected to, and thus not pull the platform itself.

Repair jointing
For electrical cables/cable elements a joint type is developed both for splicing in the factory (if necessary) and for field repairs. This joint has been used for umbilical applications in the North Sea (East Frigg, TOGI).

The joint consists of a rigid outer tube with an armour termination in each end. Inside the tube the conductors are spliced individually, and the insulation is reinstated. The volume inside the splice is filled with a material compatible with the filling material of the cable.

The cable termination is terminated between especially hardened threaded cones, which are secured with a portable hydraulic tool. The armour termination is capable of sustaining more than 90% of the cable armour straight tensile strength.

A dedicated joint box for fibre optic cables is also developed. This joint box can hold up to 384 fibre splices and has a tensile strength adapted to a 400 kN cable. The joint is small compared to other joint boxes. A joint can be performed with very little equipment, the only special tool being a hand held press. The Nexans fibre optic cable is also qualified for use with the Universal Quick Joint. A bend restrictor can be applied to ease the passing of the joint through the cable machinery on the ship.

Training for doing the joints takes only a few days.

Buoyancy elements
To absorb movements in a dynamic cable between a floating platform and the seabed, excess length is introduced by clamping buoyancy elements to generate e.g. a “lazy S” or a “Steep Wave” configuration. Tools both to
design this configuration and the buoyancy elements are available.

**Beach Joint**
All cable types can be terminated by means of standard land splice closures like Raychem and Tycoflex. Beach joints are also available with up to 48 tap couplers, enabling feedback of a fraction of the optical signal. Such feedback is normally required for safety reasons in high optical power transmission links.

**Branching unit**
Fibre optic cables can be provided with branching units to allow one cable to split into two.

**Remote Optical Pump Amplifier**
**RAH (Remote Amplifier Housing), qualified up to 24 fibres.** The URC-1-Q1 cable joints may be incorporated into the WDM R3 concept and thereby named Remote Amplifier Housing (RAH). The RAH consist of a repeater house with armoured bend parts (armadillos) coupled to the URC-1 cable on either side by the use of URC-1-Q1 JB embedded into anchor part for protection. Bend relief is incorporated to adjust cable bending during installation and laying. The internal unit containing the passive optical components and the external pressure resistant housing comprising the pressure resistant sea case and bulkheads that are designed to withstand sea depths of 8000 m. The URC-1-Q1 joint boxes within the RAH will withstand 3000 m. All system RAHs are terminated in the factory and are usually loaded in line with the cable. Spare RAHs are delivered to the ship either in protective packing cases or fitted with line with the cable. Spare RAHs are delivered to the ship either in protective packing cases or fitted with armadillos, terminations and cable tails. In both cases they will be fitted with impact recorders. The length of the complete RAH is 4168 mm and diameter is approximately 266 mm.

**RAB (Remote Amplifier Box), qualified up to 48 fibres.** The Remote Amplifier Box (RAB) serves to amplify the optical signal in submarine fibre cables. The technology relies on passive optical components, which are optically pumped from a land station. The amplification typically corresponds to 75 km additional transmission system length, and is available with up to 96 transmission channels. RAB is designed and tested to 3000 m sea depth, also implying long term protection from hydrogen and moisture ingress. Likewise, the optical cable overall axial strength and electrical properties are maintained. RAB permits easy adaptation to all Nexans’ fibre optic sea cables and is deployed with standard installation procedures and techniques.
Over the years expertise and experience in testing the variety of special cables has been developed. The test methods and equipment are selected to meet both customer and internal demands. The tests are performed as standard (e.g. IEC, ETSI, Electra) tests or on special request according to customer specifications, and can be defined in five main categories:

**Optical tests**
- Fibre Attenuation
  - OTDR Measurements
  - Cut – Back
  - Spectral attenuation
- Cut – Off Wavelength
- Chromatic Dispersion
- PMD

**THERMAL TESTS**
- Temperature Stability
- Ageing
- Corrosion Studies
- Compatibility Studies
- Hydrogen studies

**Mechanical tests**
- Tensile Performance
- Fatigue
- Torsional Stability
- Impact
- Crush
- Hydrostatic Pressure
- Repeated Bending

**Fire characteristics**
- Flame Retardance
- Fire Resistance

**Electrical tests**
- Resistance
- Insulation Resistance
- High Voltage
- Impedance/AC measurements
  - Capacitance
  - Inductance
  - Attenuation
  - Conductance
- Cross Talk
- Time Domain Reflectometry
- Environmental Management System

**Flexig**
Management System Certificates

Certificates for Telecom, Nexans Norway AS, Telecom and Building Cables Division, previous “Communications Cable Division”, held a Quality System Certificate according to NS-EN ISO 9001, since 11th of November 1991, latest issue 17th of December 2002.

The Division also held an Environmental System Certificate according to NS-ISO 14001, since 23rd of October 2000, latest issue 17th of December 2002.
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