

# A FIBRE OPTIC CABLE END MODULE

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**Abstract:** This paper describes the concept of a Cable End Module (CEM), enabling quick and reliable connection between a Fibre Optic (FO) cable and auxiliary sub-sea equipment. The CEM comprises a FO cable mechanical termination, a cable joint, up to three FO ROV operable wet mateable connectors and ROV operable FO jumper cables.

## 1 INTRODUCTION

Increasing demand for communication, control and monitoring of offshore oil and gas fields has called for fibre optic links connecting to stationary surface plants, to land or intra-field. The applications taking advantage of such high capacity connections include permanent seismic monitoring, measurement of down-hole parameters and sub-sea production equipment.

In the oil and gas industry, sub-sea FO installations are often realized by including one or more FO cable elements in an umbilical, whose main function is to transfer electrical power, hydraulic fluids and chemicals. Typically, the FO connectors are integrated in the umbilical termination head (UTH). The FO connections are made up in a separate ROV operation, in which the ROV connects jumper cables between the UTH and the permanent sub-sea equipment.

New applications, as well as retrofit and maintenance and repair of existing installations call for the use of dedicated FO cables. This paper describes the functions, design and qualification of the termination equipment required, enabling quick and reliable connection between the FO cable and the permanent sub-sea equipment. For the purpose of this document, the termination equipment is denoted "CEM" (Cable End Module). See Figure 1.

## 2 FUNCTIONAL DESCRIPTION

The CEM shall have the following main functions:

- It shall form a fixed structure for an armoured FO cable,
- Its weight and mechanical stability shall be compatible with forces arising from cable laying, currents and installation.
- It shall contain ROV operable wet mateable FO plugs.

- It shall contain up to three connectorized jumper cables. Their storage shall enable an ROV to detach and mate connectors with permanent sub-sea equipment.

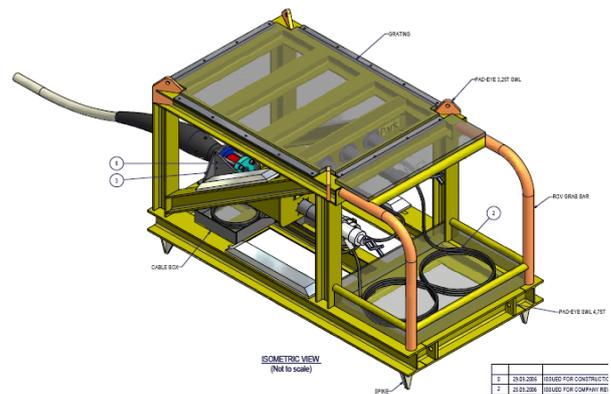


Figure 1. CEM main structure.

## 3 ENVIRONMENT SPECIFICATION

- Maximum depth: 3000 m
- Operating temp.e range: -5 °C to +45 °C (Limited by connectors)
- Dropped object protection: 20kJ impact energy
- Corrosion protection: Sacrificial anodes

## 4 MODULARITY

CEM can be adapted to various soil conditions, from rock fillings to soft mud.

CEM may accommodate various FO cable designs, including aramide and triple steel armoured cables. The unit can also accommodate a variety of wet mateable FO subsea connectors, who may be diver or ROV operable.

## 5 SEA BED INSTALLATION

CEM is deployed using a vessel crane. The deployment requires close monitoring of the FO cable centenary, in order to avoid interference with lifting wire. See Figure 2. Once positioned on the sea-bed, the lifting wire is detached by means of detachable ROV hooks.

The CEM sea bed installation facilitates both first-end and last-end FO cable laying procedure.

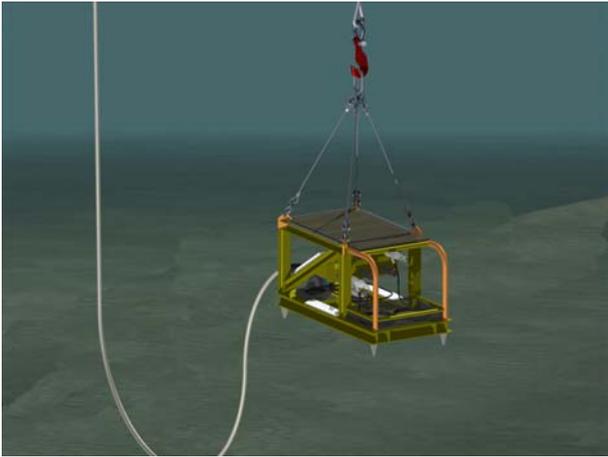


Figure 2. CEM deployment.

## 6 ROV INTERVENTION

CEM accommodates up to three connectorized jumper cables, each of typically 10 m length. Typically, one connector of each jumper cable is pre-mated in a receptacle, while the opposite connector is inserted in a “parking place” whose function is to facilitate ROV handling of the connector. See Figure 3. The “parking place” may be replaced with a fibre loop-back receptacle for continuous cable quality monitoring in the cable laying process.

CEM is supplied with ROV “grab-bars”.

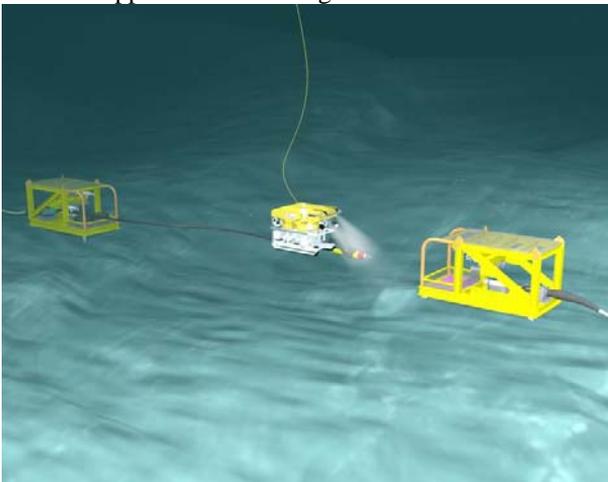


Figure 3. ROV in the process of optically mating two CEM's

## 7 FIBRE OPTIC TERMINATION UNIT (FOTU)

All Nexans Norway FO sub sea cables include one or more steel tubes, in turn comprising the optical fibres. The design offers the best chemical and mechanical protection of the fibres, and also implies that the fibres reside in an environment close to atmospheric pressure. On the other hand, wet mateable FO connectors are generally designed for a limited differential pressure between their mating optical surfaces and the fibre inlets. This motivated the development of a Fibre Optic Termination Unit (FOTU), whose function is to form a pressure tight interface between up to three wet mateable fibre optic connectors and up to three FO elements. See Figure 4 and Figure 5.

FOTU consists of two oil filled chambers separated by pressure tight fibre penetrators. One chamber is pressure equalized while the second chamber is atmospheric.

FOTU can be adapted to a wide range of FO cables and FO connectors.



Figure 4. Fibre Optic Termination Unit (FOTU)



Figure 5. FOTU (top) with two jumper cables (one blinded) and one wet mate-able connector.

FOTU is integrated in the CEM, thus enabling connection of one fibre optic cable to up to three wet mate-able connectors.

**FOTU Specifications:**

Operational depth, max.	3000 m
Temperature range	-10 °C to +35 °C
Weight, approximate	6 kg
Dimensions	Length: 535mm OD: 95mm
Main structure	Superduplex
Estimated min. lifetime	25 Years
No. of fibres, max.	48
Total optical attenuation, maximum	0.2 dB at 1550 nm
Mechanical vibration	Three axis, 5 g, 5 Hz – 150 Hz and random vibration 20 Hz – 2000 Hz.
Mechanical shock	Both directions in each of three axis, half sine, 30g, 11 ms duration
Pressure cycling, external pressure	Four cycles between 1 bar and 330 bar
Pressure, long term test, external pressure	14 days, 330 bar
Pressure/temperature cycling	Pressure cycling 1 bar - 330 bar in temperature range -10 °C - +70 °C
Reverse pressure	Fours cycles between 1 bar and 25 bar
FO element fixation	Short term: 300 N up to 45° from axis. Long term: 100 N up to 45° from axis

**8 CONCLUSION**

Nexans Norway AS has developed a Cable End Module which enables quick and reliable connection between a Fibre Optic cable and permanent sub sea equipment. The sea bed installation of the involved components may be take place at widely separated times, which may be required for operational reasons.

A Fibre Optic Termination Unit (FOTU) has been developed and qualified; enabling the connection of up to three pressure compensated wet mate-able FO connectors to on FO cable.