DESIGN OF FIBER OPTIC CABLES AND NETWORKS FOR OFFSHORE APPLICATIONS

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Abstract: The growth in utilizing fiber optics in offshore infrastructure introduces some additional requirements and needs for special engineering, compared to traditional telecommunication subsea deployments.

Concerning the network planning and network connections there are several possibilities, platforms and subsea wells will require redundancy in capacity. A cable break should never mean that the connection is lost, as this will be taken care of by rerouting of the telecom/control traffic management systems.

To tie in a platform, one can use simple J-tube pull-in solutions, more advanced dynamic risers for deep water applications, and of course the use of wet mate able connectors and branching units are all means to have robust and durable connections between offshore and onshore locations.

In particular, the dynamic cable section with associated components relevant for floating platform installations call for extended engineering, analysis and qualification testing. The reliability requirements are high, due to the cost and risk related to replacement campaigns.

In design of the cable it is necessary to be able to predict global loads on the cable during installation and service. The local stress on the various materials and elements in the design shall ensure that fatigue issues are avoided. In addition to structural analysis of the cable construction, dynamic analysis based on configuration of dynamic cable, meteorology data and platform movements, as well as fatigue analysis are basics of the development phase and should be performed in close cooperation with development of components such as bend stiffener for topside interface, buoyancy modules and seabed anchoring.

Likewise, on-bottom stability is important in congested areas on the sea-bed, in which other subsea components like umbilicals, pipelines, structures and cables are required to be stationary in individual designated corridors. The paper describes the various stages of development, manufacturing and installation of different cable types and with various solutions.

1 INTRODUCTION

Demand for bandwidth is increasing all over the world, and the offshore industry is definitely no exception.

Now, with increased competition in the tele- and data communication market and mature technology readily available, regional offshore networks are developing and becoming more robust.

Cable Installation to platform with C/S Skagerrak

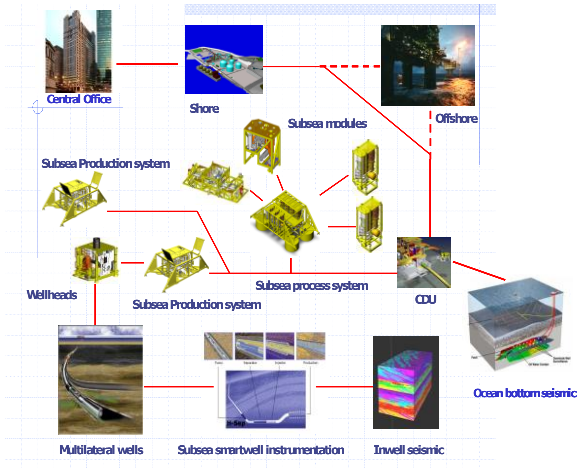
It is a fact that some of these networks have not been easy to construct, however, experience has led to the development of new components, solutions and improved protection philosophy.

Other studies with a completely different perspective have shown that there are substantial opportunities in platform cost savings, safety and security through the provision of fibre optical cable based services.

The optical networks enable operations to be performed remotely from the onshore facilities. Thus, reducing the number of people to be transferred to the offshore plants, reduce number of helicopter transfers, etc. Hence, not only reduced OPEX, but also reduced risk (HSE) and reduced pollution.

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..

The bandwidth required by the different applications varies from a few kbit/s (for commands/signalling), up to several Gbit/s (for permanent sea bed seismic arrays).



Offshore Nework

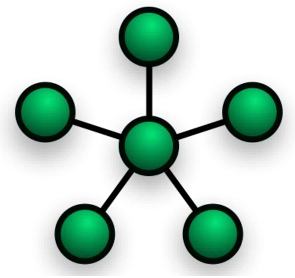
The potential savings of making effective offshore networks are estimated to billions of USD for the offshore industry. Furthermore, for remote subsea developments, without platforms, optical networks are the only solution for communications.

Up to now, only a relatively small number of telecommunication cable links connecting platforms have been installed. Instead the most common way to deploy optical fibers for the offshore industry is to integrate them in power or control umbilicals, whose main function is to transfer electrical power, hydraulic fluids and chemicals. FO connectors are typically 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.

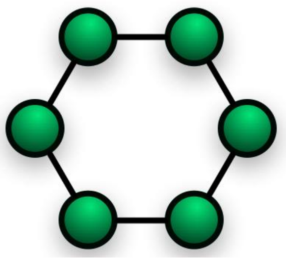
As bandwidth requirements increase, not only for traditional communication needs, but also due to more advanced subsea systems and sensor and monitoring systems, the interest in separate fiber optic cables is growing.

The requirement to always be connected, un-interrupted, is crucial, more and more of the network design is now for backup, redundancy and other means to stay connected.

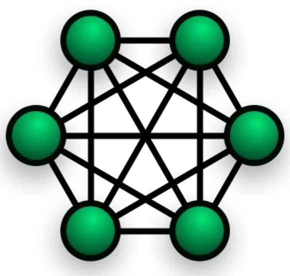
Star network configurations are vulnerable, redundancy cables are expensive, wherever you can design a ring configuration or a meshed network; that should be the goal.



Star Configuration



Ring Configuration



Meshed Ring Configuration

A wide range of components supporting these network configurations are developed. Some key elements for building up such structures subsea are branching units and cable end modules, with wet-mate-able connectors, for connection and looping of fibres as desired. This can be very flexible if the planning is done properly. Cables have to be protected by all means, and risk analysis is an important part of cable placement and design.

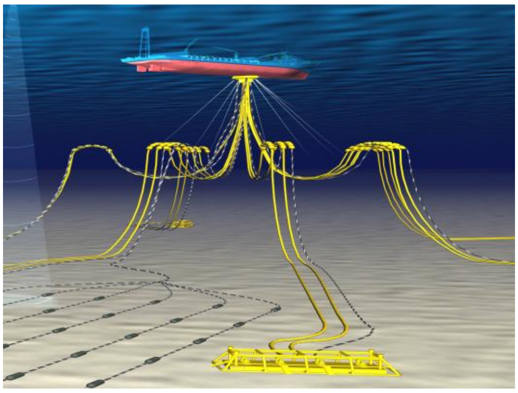
2 DYNAMIC VERSUS STATIC APPLICATION

In general, the mechanical performance of traditional submarine fibre optic cables for seabed deployment is determined by dimensioning the axial strength for loads associated by the installation and for allowing a repair situation without degradation or significant reduction in lifetime and reliability. The tensile performance is typically specified by the parameters NPTS (Nominal Permanent Tensile Strength), NOTS (Nominal Operating Tensile Strength), NTTS (Nominal Transient Tensile Strength) in addition to the breaking loads. The above characteristics are defined in international standards [1], as well as methods for testing and verification [2]. Except for the NPTS, which reflects allowed residual tension on the cable after installation, the definitions and test methods are focused on high loads and a relatively low number of load cycles.

For dynamic cables the load scenario is somewhat different. Throughout its entire operational lifetime, the cable will be exposed to tensile and bend loads which depend on actual weather conditions and sea state. This results in a large number of cyclic loads in terms of tensile and bending, and consequently effort in avoiding long term fatigue is a key issue.

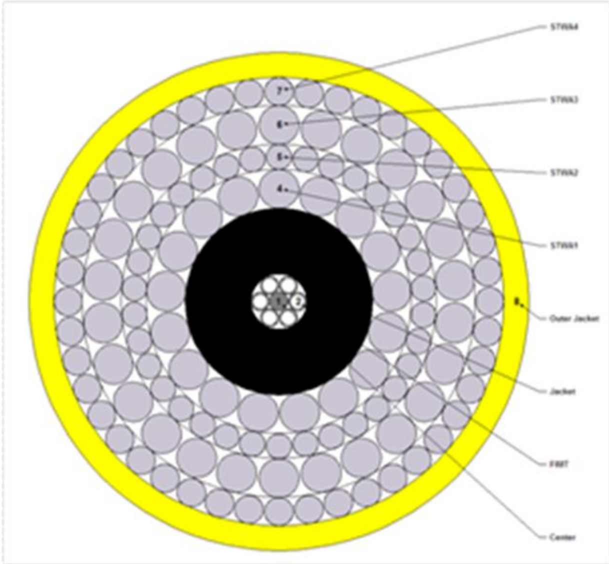
The loads to be handled by the cable and associated components making up the complete riser cable system are strongly dependent on where the system is going to be installed. In fact, establishing the full global load scenario is a major part of the required engineering. This scenario includes both loads on the cable during installation and throughout the service life.

Most of the dynamic riser cables that are installed are custom made umbilicals, made up of power conductors and hydraulic tubes or hoses according to client specifications. Clients, in this case are normally oil companies or subsea equipment providers. It follows that there are few standardized products, and apart from one ISO standard [3] and its equivalent API standard [4] dedicated to cables, it is generally referred to company "best practice documents" and generic specifications and standards for offshore structures.

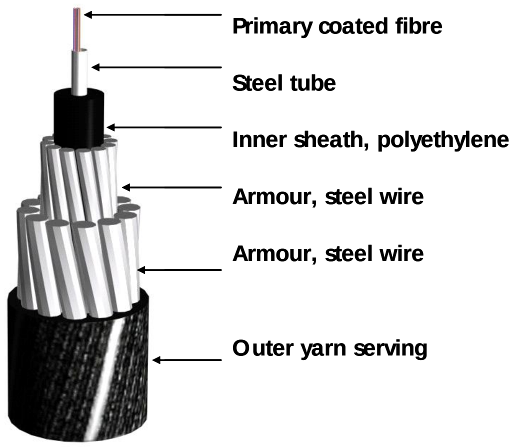


Dynamic Installation

The lack of experience with fibre optic dynamic cables and the lack of detailed international standards combined with the variety of parameters influencing the design and strong requirements on long term reliability are major reasons for the need for detailed engineering for every deployment case.



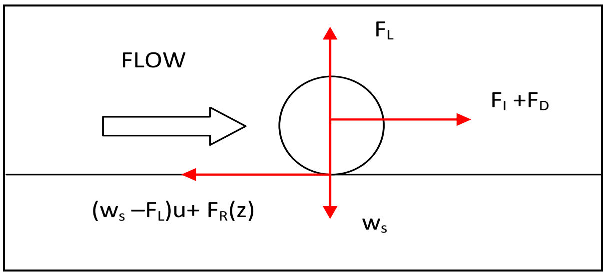
Typical Dynamic FO Cable Design



Typical Static FO Cable Design

3 SEABED STABILITY

It is normally required that the subsea cables shall lay stable on the seabed in order not to conflict with other cables, umbilicals and pipelines.



Seabed driving and resisting forces on subsea cables.

Seabed stability is normally calculated in accordance with DNV-RP-F109 [5].

The submerged weight to outer diameter ratio (Sub.w/OD) is the governing parameter of a cables's on-bottom stability at certain weather conditions.

The weather and seabed conditions vary greatly with respect to geographical location, hence the minimum required Subm.W/OD ratio for a cable design will be dependent on the location of where it is to be installed.

Since FO cables are normally much smaller and lighter(i.e low submerged weight to diameter ratio) compared to power cables, umbilicals and pipelines, on-bottom stability is often difficult to achieve for FO cables.

Hence, a pragmatic approach is normally necessary in the on-bottom stability assessment of FO submarine cables. The best solution is burial into the seabed, and should be used where possible.

4 SUBSEA DISTRIBUTION UNIT

The offshore FO networks are normally established through various cables and umbilicals which are connected to subsea structures, and is not straight forward to recover the umbilicals/cables for repair and maintenance. Thus, the FO optics are normally connected to Subsea Distribution Units (SDU).

The overall function of the SDU is to enable quick and reliable connection between subsea cables and auxiliary sub-sea equipment. A typical SDU comprises a cable mechanical termination with bend stiffener, cable joint(s), up to 6 FO wet-mate connectors. All connectors are ROV operable.

The SDU enables the sub sea cable and auxiliary equipment to be physically installed in separate operations. Its sea-bed installation and final connection to the auxiliary equipment is carried out using a conventional ROV.

The SDU is designed to protect its instrumentation from falling objects and impacts during installation and ROV interventions. Likewise, the design offers bending protection of the sub-sea cable. Sacrificial anodes offer long term corrosion protection. Its foundation can be adapted to the local sea bed soil conditions. Likewise, the SDU can be adapted to a all relevant subsea cable armouring designs, materials and dimensions.

Sea-bed installation of the SDU is carried out in a single-vessel operation, as part of a first-end or last-end cable laying procedure. Its lifting equipment is designed for ROV operated hooks.

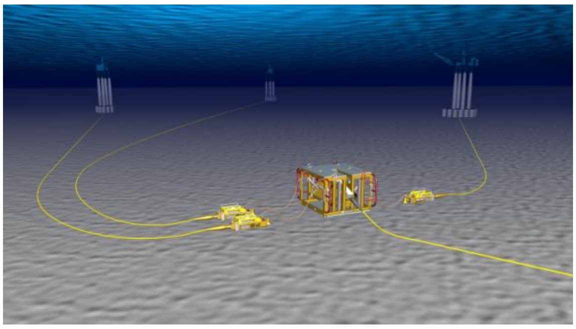
If necessary the SDU/CEM units can be protected by lids, mattresses or other means on the seabed.

Subsea Distribution Unit

5 CABLE END MODULE

The subsea cables must be terminated to a Cable End Module (CEM) with wet mate connectors and flying leads in order to connect to the SDU.

FO cable with CEM with wet mate connector.



Connection principles – offshore FO networks.

6 CONCLUSION

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 investments are significant and especially the installation and protection of the fibre optic infrastructure have proved to become costly, but economical and necessary.

Design of offshore FO systems are more complex than traditional FO systems.

7 REFERENCES

[1] ITU-T G.972, "Definition of terms relevant to optical fibre submarine systems"

[2] ITU-T G.976, "Test methods applicable to optical fibre submarine cable systems"

[3] ISO 13628-5, "Petroleum and natural gas industries – Design and Operation of subsea production systems – Part 5: Subsea Umbilicals"

[4] API Specification 17E, Third Edition, July 2003

[5] Recommend practice DNV-RP-F109, On Bottom Stability Design of Submarine Pipelines, October 2007