INSTALLING SUBSEA STRUCTURES – A SUCCESSFUL CABLE END MODULE CASE STUDY

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Abstract: There is a growing trend towards the installation of Cable End Modules (CEMs), which allow subsea rather than on-platform termination of fibre optic cables. However, installing these subsea structures is not without its challenges. This paper addresses the potential issues an installer may face and additionally demonstrates how a CEM in practice may be installed through a case study example from a recent North Sea installation.

1. INTRODUCTION

A Cable End Module (CEM) increases flexibility for offshore oil and gas platforms by delivering the potential to quickly connect fibre optic cables and subsea equipment without having to cut cables, thus offering a 'plug and play' concept. CEMs can operate as deep as 3,000 metres and provide an operating life of circa 25 years. A typical CEM measures 4 metres x 4 metres in plan and 1.5 metres height with a weight of 15 tonnes (in air).

2. PLANNING SUBSEA MARINE OPERATIONS

Project Engineering and planning is the key to the successful installation of subsea structures such as CEMs, and all projects of this type start with the same planning process. The basic principles consist of:

- Design brief, regulations, standards and specifications,
- Scope of Work,
- Object particulars
- High level procedure (vessel/asset selection & limitations),
- Detailed design basis,
- Review against capabilities

In addition a DTS (desk top study) will be undertaken to establish the correct cable route from the CEM to the end resting place of the cable spur on the seabed. This study forms the foundation for the FEED (front end engineering design) study. To facilitate this process, geographical information system software is leveraged to help manage and analyse geographically referenced data, giving quick access to millions of kilometres of as-laid cable data, along with the locations of pipelines, subsea structures, fishing grounds and even must-avoid locations such as munitions dumps. One of the key areas for review is consultation with the operator to ensure the planned installation location and operations do not interfere with existing or planned infrastructure within the field.

The Project Engineer utilises the DTS where the proposed route is then subject to a dedicated marine hydrographic survey, and permitting procedures. The cable is then laid along with any other plant such as branching units and CEMs.

3. CABLE END MODULES

The CEM consists typically of a top assembly, and a mud-mat foundation. The top assembly houses the cable termination, fibre optic termination unit (FOTU), jumper storage barrels and fibre optic jumpers including connectors and associated parking positions.

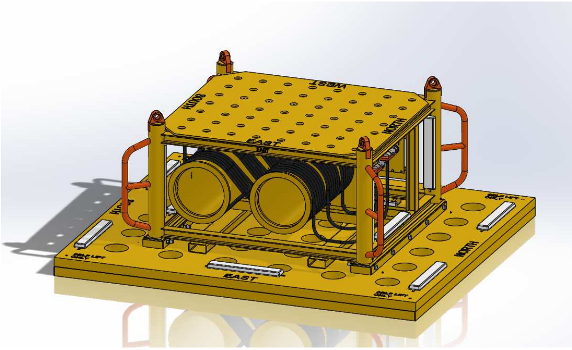

Illustration 1. Typical Cable End Module

The fibre optic jumpers are then connected subsea to an adjacent structure with either divers or ROV (dependant on water depth).

Illustration 2. Typical Fibre Optic Jumper Connectors

The idea of fibre optic cable that could be connected underwater originally arose from military requirements (vessel detection systems); however, the technology fulfilled a real need in the offshore industry. For the design premise, CEMs had to be stable on the seabed, operable at extreme depths and capable of branching out a 24-fibre submarine cable in groups of four, six or eight fibres.

Today's CEMs achieve all these objectives and can even accommodate diverse cable designs and connectors. The FOTU has been developed which provides a pressure-tight interface for up to three connectors and fibre optic elements.

4. CEM SOLUTION

A recent success story is the T&I (transportation and installation) of a CEM in the North Sea, which was not without its challenges. Here, Project Engineers were tasked with demands that included pre-planning, interfacing with project stakeholders, design engineering and precision installation.

When the contract was awarded, the initial concept design for the CEM was very different to what was finally deployed. Indeed, the early involvement of Project Engineers in the design phase was a key part of this platform-to-platform fibre optic communications project.

The design changes requested by the Project Engineers were important to allow successful installation given the tight parameters set by the client. Essentially, the CEM had to be installed within a set distance of a pre-installed SSIV (subsea isolation valve) to allow jumper cables to be connected by divers at a later date. Additionally, the operation was to be performed in close proximity to surrounding structures, which added further complications to the offshore execution.

Interfacing with a multitude of stakeholders is always an important element in any project but particularly when different companies are responsible for design, fabrication, installation and hook-up. Throughout the design process, the Project Engineers were involved in review meetings with all parties, including the field owner, and visited the fabrication yard to ensure the changes incorporated were satisfactory.

The team was also able to offer its expertise to design the installation rigging, which allowed the methodology for subsea release to be developed. When engineering the rigging for subsea deployment, it is important to have a contingency for subsea release in the event that the primary system does not work. For this project, a primary, secondary and tertiary method for releasing the CEM rigging was engineered, although the primary method, using ROV hooks, worked successfully as planned.

5. CEM LIFTING

Subsea lifting is complex and it involves technology, working procedures, weather evaluations, competence, organisation and management. Present rules, regulations and standards for offshore lifting appliances are based mainly on the risks associated with cranes of moderate capacity and lifting operations to and from supply vessels.

Recommended Practice DNV-RP-H201[1] – Lifting Appliances used in Subsea Operations released in November 2014 is a joint industry project, established to develop common ground covering design, manufacturing, maintenance and operational aspects associated with lifting appliances intended for subsea lifting operations. In the context of this Recommended Practice a subsea lifting operation means installation or removal of objects underwater. An object will normally be lifted through the splash zone, lowered to and landed on the seabed, or vice versa. Often the removal of the subsea structure is an element of the process whereby little time is spent typically but this should be addressed as part of the design process from an early stage.

Subsea lifting is typically divided into deployment and recovery. Every subsea lifting operation should be broken down into discrete, well defined steps. A step is typically a checkpoint or an important step carried out by a competent person before progressing to the next step. The phases for deployment are described below (these can be typically reversed for recovery):

1. Pre-lift
2. Lift-off
3. Overboard
4. Splash zone
5. Lowering
6. Landing

Pre-lift, lift-off from deck and over-boarding – The challenge during this phase is to maintain sufficient control over the horizontal motion of the object e.g. avoid uncontrolled swinging and limit the vessel motions. In general before lift-off the list below should be checked as a precaution:

- Function test any subsea release systems.
- Any ROV markings on the asset should be checked for suitable location, orientation and visibility for subsea application.
- Operational limits shall clearly be defined for all subsea operations.
- Requirements for weather forecasting.
- Crane AHC should be checked and tested.

[1] Recommended Practice DNV-RP-H201 - Lifting appliances used in subsea operations November 2014

- Any cutting of seafastenings should be such that no/limited vertical restraint on lift-off.
- Height under hook including remaining seafastenings and rigging.
- Loose items removed.
- Trial lift / inshore typically as part of the mobilisation.
- Positioning devices, transponders calibrated and verified for use.
- Relevant areas restricted before commencing lifting operations.
- Tag lines/tugger lines attached to prevent horizontal movement.
- Landing area should be inspected by ROV.
- Rigging design should have taken into account accidental or disconnection of the load during lifting.

Lifting through the splash zone – The challenge during this phase is to ensure slack slings is reduced to a minimum with a shift in the centre of buoyancy. In general the following items should be considered:

- Slamming loads in splash zone
- Shift/tilt of object
- Time needed for equalisation
- Visual observations
- Tag lines/tugger lines release

Lowering through the water column – The challenge during this phase is to ensure a controlled deployment to the seabed maintaining heading and position. In general the following items should be considered:

- Lowering at defined speed
- Snagging of lines to be avoided
- The load lifting appliance increase due to depth
- Monitoring with ROV
- Lowered to safe height above seabed before set down
- Dynamic forces on rigging
- For deep sea deployment, resonance should be considered

Landing – The challenges during this phase is not only to ensure accurate placement but also contingency methods for release of the rigging from the subsea structure in the event of primary failure. In general the following items should be considered:

- Inspect by ROV for positioning and tolerances
- Landing to be performed with defined allowable speed
- Orientate structure with correct heading
- Installation subject to client sign-off
- Suction loads
- A point of no return and contingency measures for release
- Lift rigging release
- For potential vessel run-off a quick release function for the rigging

Non-engineered lifts or “routine” lifts are considered “everyday” lifts without specific supporting documentation. For non-engineered lifts, a simplified approach by applying a conservative dynamic factor to compensate the lack of detailed engineering may be sufficient.

DNV’s Standard for Certification No.2.22 Lifting Appliances [2] suggests applying a minimum design dynamic factor of 1.7 for significant wave heights up to Hs=2.0m, however, this approach may be

[2] DNV’s Standard for Certification No.2.22 Lifting Appliances – October 2011

insufficient, and an engineered lift approach shall be applied.

The engineered lifts as was the case for the CEM deployment; these are well planned and prepared operations. For lifting appliances subjected to engineered lifts, de-rating of the lifting capacity shall normally be provided and the actual static and dynamic loads shall not exceed the de-rated capacity for the specific sea condition.

Of course, each lift has its own installation factors to consider, especially if subsea structures are involved. Here, crane lifting capacities, water depths and motion compensation systems, come into play. In addition, dynamics, inertia, added mass, buoyancy, drag, rigging weight and seabed suction must also be considered.

6. CEM POSITIONING

A further important aspect of installing subsea structures is positioning on the seabed. On this particular project, tolerances of ±2.5m for position and ±2.5° for heading.

To correctly position the CEM on the seabed the project used a combination of accurate surface and sub-surface positioning systems. Surface positioning used two independent C-NAV DGPS receivers and a Cyscan laser positioning system, backed up by a taut-wire.

DP (Dynamic Positioning) capability of a Vessel is an important aspect of subsea lifting operations in particular when the installation vessel is alongside platform structures and directly above an existing subsea network as was the case with the CEM deployment.

Image 3. Subsea Installation in Close Proximity to Offshore Platforms

The primary method used for subsea positioning was using a Sonardyne Ranger 2 wideband USBL (ultra-short baseline) System. The system was used to track transponders attached to each corner of the CEM while template tracking software EIVA Navipac was used to ensure precise placement and was checked with the ROV taking fixes on the corners to verify the position.

Image 4. Typical Transponder on a Subsea Structure

Of course, contingency plans are also a pre-requisite when it comes to positioning subsea structures, and on this project the secondary method in place was a second USBL system, while a third strategy was the deployment of pre-installed sandbags to box-in the target area for landing the CEM.

The CEM was installed successfully in April 2015, with installation tolerances of 0.2m. Positioning this subsea structure accurately was a crucial part in the overall delivery of the project, and relied heavily on sound project engineering both in the planning phase and subsequently during offshore installation operations.

7. NODE INSTALLATION

Similar subsea structure installation projects include the T&I of subsea nodes for research purposes at a subsea laboratory that provides live data to the ocean research community off the coast of British Columbia, Canada. A DTS was first completed to identify the optimum location for node and sensor positioning, which was followed by system installation.

The first phase involved the deployment of 40km of cable and two node bases in offshore waters. At the ocean observatory site, the second phase was completed with the installation of nodes at three previously identified sites, located 95 metres, 175 metres and 300 metres water depth respectively.

The success of the project relied on the provision of an end-to-end solution, from initial surveys through to the installation of the fibre optic cable system. The process included DTS, route engineering, shore end installation, main lay operations and post-project reporting.

An increase in demand for extensive monitoring networks and subsea observatories for scientific research to help governments make informed decisions about the future has led to a further demand by the University of Victoria, Ocean Networks Canada is to install further subsea nodes off the West Coast of Canada. In May 2016 the University are planning to install four cables in total which will each feature a mud-mat at each end that helps secure the cable in-place. Each node will weigh approximately 2 tonnes each and will be required to be positioned in water depths close to 2,500m.

Image 5. Subsea Node used in VENUS system

8. CONCLUSION

Subsea structure installation projects demand sound planning, a flexible approach and need to fully engineer solutions, including contingency throughout the operational process.

It is considered essential that marine operations and in particular subsea activities, including all support activities are planned in consultation with the DNV standards in relation to Practices for Lifting Appliances and Standards for Certification. As well as adhering to these standards, it is also recommended that the plans are thoroughly risk assessed at conceptual design stages through to detailed design and offshore operations. The objective of DNV-RP-H101 – 'Risk Management in Marine and Subsea Operations' [3] aim is zero accidents, incidents or losses through promoting safe, robust and efficient operations, and through application of the principles of ALARP (as low as reasonably practical).

This standard promotes a systematic approach to manage risk from when a concept for a marine operation is realised, through the project period, until the operation is completed. DNV recommends a basic step process for management of risks within marine operations:

- Establish Process Plan
- Establish Acceptance Criteria
- Overall Assessment and Categorisation
- Risk Identification Activities
- Risk Reducing Activities

Following this DNV standard for subsea operations allows a detailed planning, cohesive approach, linking with all necessary stakeholders and ensuring project delivery and execution are completed safely, on time and to budget.

[3] DNV-RP-H101 – 'Risk Management in Marine and Subsea Operations' January 2003