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Original Paper

Multistage screening process for certification and verification of equipment and system in offshore turret

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Abstract: Offshore turret in floating oil and gas production is a key element and an expensive asset which may cost up to few hundred million dollars. The turret design in floating production storage and offloading (FPSO) or floating storage and offloading (FSO) unit is integrated into a vessel, which is permanently moored to the seabed, and allows weathervaning capability. It takes hydrocarbon through subsea risers and transfers hydrocarbon liquids and gases through swivels to topside process facilities. Traditionally, in offshore projects, it has been a challenge to design, deliver, and install various key equipment, systems, and components on time due to many complicated and different rules and regulations, company's unique specifications, various design codes and standards in which manufacturers and shipyards might not have sufficient experiences. This causes additional costs in procurement, engineering, manufacturing, installation, and commissioning, which may affect the overall project delivery schedule. In this paper, the strategy, challenges, and lessons learned from project management for the certification and verification of the internal turret project in the recent FSO unit are discussed to enhance the effectiveness of project handling in large-scale offshore projects. The proposed multistage screening process is a simple but effective method to achieve project requirements and goals, and it allows early identification of the potential issues and problems during the project planning and execution. This methodology and the lessons learned may be applied to other mega offshore projects to ensure the right certification and verification scheme for the equipment, systems, and components.

Keywords: Certification, Verification, Multistage screening process, FSO turret, Inspection

1. Introduction

The Culzean field project development is an ultra-high pressure, high-temperature gas condensate development located approximately 145 miles off the coast of Aberdeen in the UK sector of the central North Sea. The floating storage and offloading (FSO) unit is located in the Culzean field and has the capacity of receiving 25,000 barrels of condensate per day and a storage capacity of 350,000 barrels through the internal turret system for FSO **[1][2]**.

This FSO unit is located in UK water, and thus, must comply with the UK offshore regulations. The verification of the UK offshore regulations and project requirements has been performed by the nominated contractor's verification agent (CVA). The verification scope of work consists of the UK offshore regulation requirements, company specifications (Maersk Oil specifications), performance standards for the project, EU registrations and directives (such as ATEX **[3]**, PED **[4]**, MD **[5]**, LD **[6]**, LVD **[7]**, EMC **[8]**, MED **[9]**, and RED **[10]**), recognized industrial codes and standards, and turret design specifications of the designer.

In general, FSO and floating production storage and offloading (FPSO) newbuilding projects take at least 2–3 years (from contract to delivery). Compared with conventional cargo ship and tanker projects, newbuilding and conversion FSO and FPSO projects require more complicated designs and project requirements as per field regulatory requirements, environmental design conditions, operator's additional safety features and design requirements. Additionally, topside and turret interfaces are key design features. To achieve the project requirements, many steps should be carefully controlled and considered during the conceptual design, frontend engineering design, contract, procurement, design, fabrication, and commissioning of the FSO or FPSO unit. The design starts with the concept technical specifications, followed by front-end

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engineering, contract technical specifications, and detail engineering. Once the detail engineering is completed (and sometimes before it is completed), contractors (generally shipyard, topside, or turret provider) prepare purchase order (PO) specifications to request for quotations (RFQs), followed by the contract with various vendors located in different countries worldwide. However, in many cases, the equipment and component delivery is delayed owing to design changes, change orders, vendor quality issues, underestimation of the work scope, and—most importantly—misunderstanding of project requirements.

Most offshore projects are mega projects that require tremendous efforts, capital, and resources. Recently G. Locatelli *et al.* **[11]** discussed a method for identifying, in a quantitative and rigorous manner, the characteristics related to project management success in megaprojects. A. Shenhar *et al.* **[12]** introduced that successful megaprojects are distinguished by three major elements: a clear strategic vision, total alignment, and adapting to complexity. I. Kardes *et al.* **[13]** took an exploratory approach to identify key characteristics of global megaprojects factors contributing to disappointing outcomes and proposed a risk management framework and managerial prescriptions for enhancing success. It is concluded that by adopting a successful risk management approach and following best practice, success rate and the productivity of global collaborative projects can be enhanced. Various other studies have been performed to identify the critical success factors for projects **[14]**-**[16]**.

In this study, the inherent project complexity and various certification and verification scopes of a recent FSO project were considered. Some methodology (multistage screening process) and the strategy, which has been applied for the project, have been discussed. In addition, challenges and lessons learned during the overall project period were examined and employed for the development of an effective project handling method for large-scale offshore projects. The methodology and lessons learned can be applied to other mega offshore projects to ensure the right certification and verification scheme for the equipment, systems, and components. The key method for achieving the goal is a simple but so effective “multistage screening process” that allows potential issues and problems to be identified as early as possible and allows missing or overlooked potential risks to be captured before proceeding to the next steps. Finally, the equipment and components can be delivered and shipped in full compliance with project requirements.

2. Certification and verification for equipment and components in turret

The FSO turret and mooring system comprise the following key equipment, systems, and components, which are manufactured in many different countries worldwide.

- Anchors, mooring chains and stoppers, mooring wire ropes, mooring leg accessories
- Electrical system (cables, power distribution equipment, lighting, etc.)
- Instruments and instrument fittings
- Fire and gas detection system s
- Turret main bearing system
- Swivels, swivel stack assembly, and components
- Process piping system
- Water/foam deluge system and fire main system
- Turret structures (lower and upper turrets, swivel access structures, turret shaft)
- Torque arm monitoring system
- Anchor leg monitoring system
- Fluid recovery and fluid buffer system
- Low-voltage electrical slip ring
- Valves and actuators (including emergency shutdown valves)
- Pressure vessels (e.g., pig receiver, drain tank, fluid reservoir tank, air tank)
- Hydraulic power units
- Winches, crane, and pull-in equipment
- Mechanical handling equipment
- Pumps
- Miscellaneous bulk items

Figure 1 illustrates the certification and verification scheme for the FSO turret, which includes the classification rules, technical specifications of the operator, project performance standards, turret design specifications, UK offshore regulations, and applied recognized codes and standards which are quite extensive scopes to comply all of these requirements during the design and manufacturing stage.

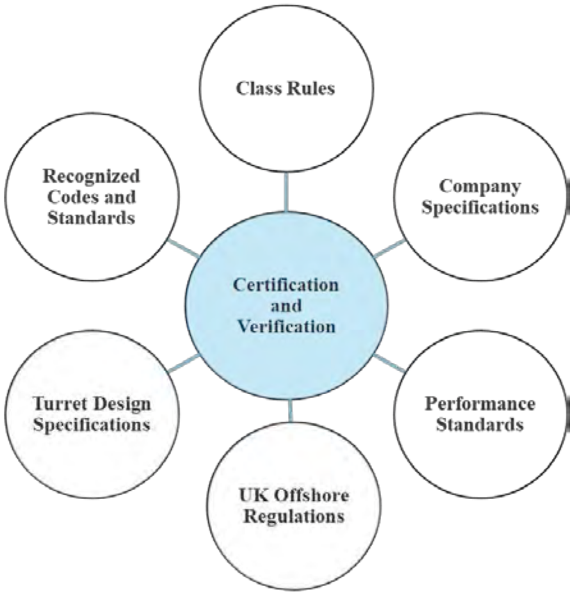

Figure 1: Applied requirements for the FSO turret certification and verification

The project requirements, as a part of the verification and certification, are as follows.

- Classification rules and guidance
- UK offshore regulations
- EU legislations and directives
- Performance standards
- Verification works instruction (VWI) list
- Company's (owner's) specifications and designer's technical specifications
- Selected industry codes and standards

2.1 Certification scope (classification)

The turret designs are fully compliant with relevant classification society rules and recommended practices, as listed below. The compliance is verified through the process of design approvals and manufacturing surveys. Upon completion of surveys, product certificates, relevant material certificates, or survey reports are issued.

- DNVGL-RU-OU-102: Classification of floating production and storage units
- DNVGL-OS-A101: Safety principles and arrangements
- DNVGL-OS-B101: Metallic materials
- DNVGL-OS-C101: Structural design of offshore units (LRFD method)
- DNVGL-OS-C201: Structural design of offshore units (WSD method)
- DNVGL-OS-C102: Structural design of offshore ships
- DNVGL-OS-C301: Stability and watertight integrity
- DNVGL-OS-C401: Fabrication and testing of offshore structures
- DNVGL-OS-D101: Marine and machinery systems and equipment
- DNVGL-OS-D201: Electrical installations
- DNVGL-OS-D202: Instrumentation and telecommunication systems
- DNVGL-OS-D301: Fire protection
- DNVGL-OS-E301: Position mooring
- DNVGL-OS-E302: Offshore mooring chain
- DNV-RP-C201: Buckling strength of plated structures
- DNV-RP-C202: Buckling strength of shells
- DNV-RP-C203: Fatigue analysis of offshore steel structures
- DNV-RP-C205: Environmental conditions and environmental loads
- DNV-RP-C206: Fatigue methodology of offshore ships

2.2 Verification scope

The verification scopes for the FSO or FPSO turret are quite complex and extensive than those for normal commercial ship newbuilding projects, which are simply governed by classification rule requirements, flag administration requirements, and project specifications. The project requires full compliance with technical specifications of the company, EU directives and UK offshore regulations, selected industry codes and standards, technical specifications of the turret designer, and project performance standards through design verification and manufacturing verification. The verification of compliance with UK offshore regulations and EU directives for the equipment and components of the turret is covered by the relevant certificates, a declaration of conformity (DoC) from manufacturers, and a verification statement and a certificate of compliance (CoC) from the CVA.

All equipment packages and the individual components within the equipment packages offered for sale in the European market shall comply with EU legislation, and shall have a written EC declaration of conformity (DoC) drawn up by the manufacturer to demonstrate the fulfilment of the EU requirements. This declaration must cover one or more products manufactured clearly identified by means of product name, product code, or other unambiguous reference, and must be kept by the manufacturer or his/her European authorized representative if the manufacturer is based outside the EU **[17]**.

The followings are the applied EU Directives in the Culzean FSO turret.

- ATEX 2014/34/EU: Explosive Atmospheres Directive
- PED 2014/68/EU: Pressure Equipment Directive
- MD 2006/42/EC: Machinery Directive
- LD 2014/33/EU: Lifts Directive
- LVD 2014/35/EU: Electromagnetic Compatibility Directive
- EMC 2014/30/EU: Electromagnetic Compatibility Directive
- MED 2014/90/EU: Marine Equipment Directive
- RED 2014/53/EC: Radio Equipment Directive

The project performance standards define the applicable UK regulatory requirements for the Culzean FSO turret design, as follows.

- Offshore Installations (Offshore Safety Directive) (Safety Case, etc.) Regulations 2015 (SI 2015/398)
- Offshore Installations (Prevention of Fire and Explosion, and Emergency Response) Regulations 1995 (S.I. 1995/743)
- Lifting Operations and Lifting Equipment Regulations_1998 (UK LOLER, S.I. 1998/2307)
- Stability (UK HSE Research Report 387)
- Floating production system JIP FPS mooring integrity (UK HSE, Research Report 444)
- Technical guidance on the safe use of lifting equipment offshore (UK HSE, HSG221)
- Offshore installation moorings (UK HSE, OIS 4/2013)

Upon completion of the design verification, a design verification report (DVR) is issued, and a verification statement or a relevant material certificate is issued upon completion of a survey at the factory of the manufacturer. Once the DVR and verification statement are issued without outstanding items and project performance standards are verified, a CoC is issued as part of the project-specific requirements, which allows equipment to be shipped and delivered from the factory of the vendor to the shipyard.

3. Organization of verification scheme

Certification of materials and components (CMC), verification of materials and components (VMC) coordination, and project management are integral parts of offshore classification and verification projects. The main purpose of this is to ensure that the applicable equipment, systems, materials, and components are adequately prepared to undergo the appropriate approval, certification, and verification process and to receive the appropriate certificate, verification statement, and a relevant EU directives DoC, and other project required documents, in a timely manner in order to avoid any unforeseen delays of the equipment and components delivery at the shipyard and preventing incorrect certification and verification schemes during the process of design approvals, manufacturing, and factory acceptance tests.

The CVA scope covers the full coordination process and interface with manufacturers, designers, and the turret provider. Additionally, it covers the verification of operator's specifications, turret designer's technical specifications, relevant classification society rules, EU directives and UK HSE requirements, and other project requirements.

Figure 2 shows the overall project structure of the CVA for the Culzean FSO turret, as well as the countries that were involved for certification and verification during the project.

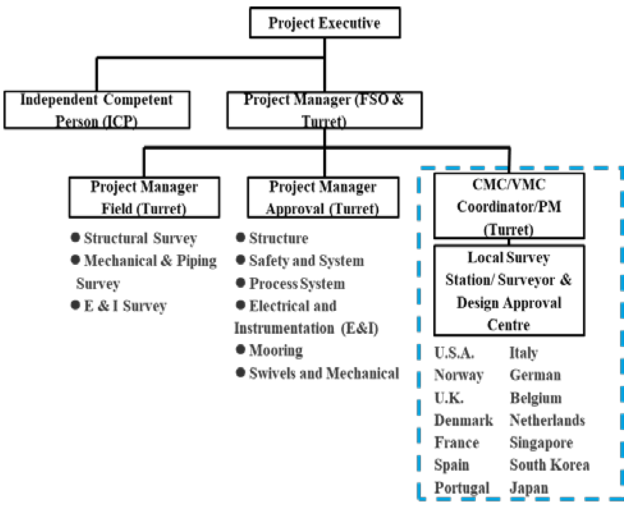

Figure 2: Organization of FSO turret certification and verification

The CMC/VMC project manager (coordinator) is the main point of contact with vendors, designers, and the turret provider to ensure that the relevant equipment, systems, materials, and components comply with project requirements, and obtain the relevant certificates and verification statements which are required for the project and is responsible for the following tasks.

- Review the request for quotation (RFQ and purchase order (PO) specifications to confirm that they comply with project requirements, verification scope, and classification scope.

- Coordinate with vendors and the turret provider to clarify the scope of verification and classification.
- Identify the scope of works and deliverables required for each of the PO packages.
- Report areas of concern and the status to relevant parties.
- Attend a kickoff meeting prior to the fabrication of the product and address project-specific requirements.
- Ensure that the level of involvement of the attending surveyor or inspector is well understood by both the manufacturer and the local station of the surveyor and that a proper inspection test plan (ITP) is generated by the quality-control department of the manufacturer with the agreement of all parties.
- Follow up the design approval status and fabrication status and progress.
- Maintaining all packages and equipment status tracker. This will cover reference equipment tag numbers, PO status, contact points of vendors, approval engineer, local survey stations, design verification status, status of certificates and verification statement, and CoC status.

4. Challenges & methodology

The challenges of the project management and coordination are due to the complexity of the verification and certification scopes that are applied in this project which includes:

- Classification rules and guidance
- UK offshore regulations
- EU legislations and directives **[3]-[10]**
- Performance standards
- Verification works instruction list
- Company specifications
- Selected industry codes and standards

In addition, various geographical areas are involved during the design and manufacturing equipment, system and components that have been manufactured over 14 different countries and over 54 key sub-items for subjected turret design. It has been noticed from various other offshore projects that any of design, quality or delivery issues on equipment and component levels, may lead to significant impact on overall FPSO or FSO project schedule, cost, and consequences.

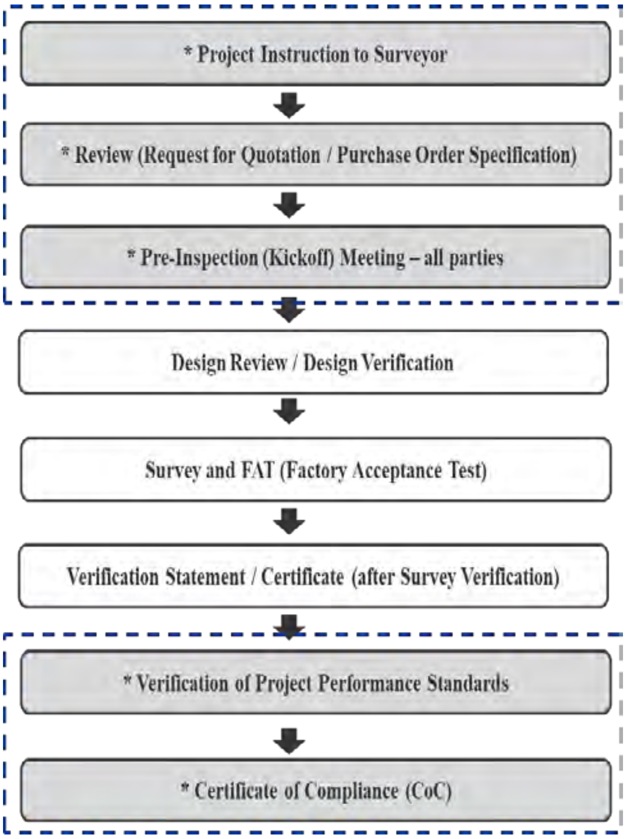

Figure 3: Process of verification and certification

In a typical certification and verification project, the scopes of classification works are design review (verification), followed by survey and factory acceptance tests and issuance of a verification statement or certificate upon completion of the survey. However, for the present project, additional safety layers and verification layers (multistage screening process) were considered and implemented to ensure that all the project requirements and governing rule requirements were fulfilled prior to allowing shipment of the key equipment and items. Consequently, it can be avoided any potential quality issues that could arise during or after installation The steps are presented in **Figure 3**. The screening steps added to those of typical classification or verification projects are indicated by a shaded color.

Project-specific instructions and guidelines were issued to surveyors, which are located in different geographical areas and countries, prior to the involvement of surveyors and inspectors in the manufacturing process. This was done to eliminate the risk of unawareness of project-specific requirements and to avoid mishandling of the verification process by the verification body.

A pre-inspection meeting (PIM) was arranged, which was attended by all relevant parties, e.g., the owner, shipyard, turret provider, manufacturer, and verification body, in order to make sure the awareness of project requirements to manufacturers and to align the parties with regard to their understanding of project requirements. Consequently, an agreed-upon ITP was developed to pursue the manufacturing of the products.

Another key difference from typical certification projects is the verification of project performance standards. The document defines the performance standards for the safety and environmental critical elements (SECEs) developed for the specific project. The performance standards, which are goal setting- and risk-based, are the minimum standards of performance to be achieved by each SECE. The project performance standards document specifies the minimum standards of performance to be achieved by each SECE. Each performance standard lists the key features of the SECEs considering functionality, availability, reliability, survivability, etc. These are verified during the design, fabrication, manufacturing, and installation stages by the CVA as per the project verification work instructions.

A CoC can only be issued after the design and manufacturing are completed. The main difference between the CoC and a verification statement is that the CoC includes the verification of project performance standards, as shown in **Figure 3**. The condition for issuing the CoC is the availability of the final verification statement and certification without any outstanding items, unless there is an agreement with the owner. This ensures that all items have been delivered without any quality issues or carry-over items to shipyard, and the condition of items are guaranteed as per project requirements and project performance standards.

During the project execution, the following lessons were learned, which need to be improved and considered in future projects, are identified:

- Turret provider and manufacturers were not familiar with specific company specifications, which are required as parts of the project requirements.
- Some project requirements were not fully addressed in RFQ and PO. Accordingly, they were not reflected in the initial design and/or fabrication by the manufacturer.
- Owing to the tight delivery schedule, some manufacturers began production prior to completion of the design verification, taking a considerable risk.
- Time and communication management issues due to different geographical locations of the parties (owner, EPC contractor, turret provider, manufacturer, and verification body).
- Equipment and component cannot be shipped without a CoC. Thus, a simple missing documentation can delay the shipment.
- It is challenging for manufacturers to be fully aware of the complex project requirements, including classification rules and guidance, UK offshore regulations, and company-specific technical specifications of the owner.

5. Conclusion

It has been always a challenge to address all specific complex project requirements to manufacturers, turret providers, and shipyards. Owing to the complexity of various project requirements, there is a high possibility of non-conformity and unawareness in requirements. In many cases, there are gaps between the design and actual fabrication and project requirements, which may lead to re-design, repair, and re-fabrication. These not only increase the costs for manufacturers but also cascade to delay the overall project schedule in the shipyard and the oil field.

There are no shortcuts to prevent human error; however, it is possible to reduce risks and non-conformities in the design and products by adopting more safety layers and verification layers (multistage screening process) to ensure that all project requirements and governing rule requirements are fulfilled prior to allowing packing and shipping of key equipment and items.

This process is simple but effective and efficient to control potential quality issues which may deviate from project requirements.

In this study, a simplified and effective multistage screening process was introduced and employed for an actual offshore turret project. Apparently, adopting more screening barriers leads to a successful certification and verification process for the equipment, system, and components. The requirement of the issuance of the CoC from the verification body prior to shipment was the key element for ensuring full compliance with project requirements and is highly recommended as a contractual requirement in marine project execution.

Disclaimer

The opinions expressed herein are solely those of the author and do not represent the views and opinions of the author's employer or any other parties.

Author Contributions

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