Challenges and Concept Solutions for 46-inch Diameter Deepwater PLEM – Connector Qualification

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ABSTRACT

The export of gas from deepwater floating or subsea production systems involves a large diameter pipeline with a manifold (PLEM) at the deep end. The PLEM comingles the flow from multiple smaller diameter flowlines or risers, isolates the pipeline and provides a subsea pig launching and receiving facility. Connecting the PLEM to a large diameter gas export line is challenging because of the pipe stiffness. Subsea diverless connection systems can align the pipeline terminations using hydraulic jacks but the size of the equipment for large diameter pipelines makes it heavy and difficult to handle. In addition, subsea connectors larger than 34" are considered new technology that requires a technical qualification programme (TQP).

This paper describes the design challenges of large deepwater PLEM systems that have lead to feasible solutions in 300m and 1300m water depths. Concept development includes modular designs on a sliding foundation that significantly reduce the energy required to make up the connections and facilitate maintenance and repair. The paper highlights key elements of large diameter connector qualification program, and presents solutions to minimize its impact on the overall delivery schedule.

KEY WORDS: Large diameter, diverless connector, virtual qualification, modular design, tie-in loads, FEA

INTRODUCTION

The export of gas from deepwater floating or subsea production systems can involve as large as 36-inch to 46-inch diameter pipeline with a manifold (PLEM) at the deep end. The main functions of a PLEM are to comingle the flow from multiple smaller diameter flowlines or risers, isolate the pipeline and to provide a subsea pig launching and receiving facility. In order to connect to the 46" gas export line, alternative PLEM designs using a reduced 36" bore and a full-bore, 46" piping arrangement have been investigated.

Large diameter connections over 46" have been made by divers using bolted flanges [1]. The large spools are difficult to handle but tighter tolerances can be maintained with diver assistance [2]. Remote connection equipment has to be used beyond diving depth limits which involves greater installation tolerances and larger gap to allow seal tooling access. A 32" remote connector is currently the largest installed subsea while a new 34" subsea connector design has recently been qualified. Development of a 36" subsea connector is considered a sufficiently significant size increase to require qualification testing while a 46" diverless connector would be considered unproven technology [3], requiring a full development and qualification program.

The alternative is to maintain a reduced-bore piping arrangement and considering multi-diameter piping (MDP) solutions instead. Such a piping arrangement also allows installation and intervention to be carried out by a smaller subsea construction vessel other than a large heavy lift vessel. A decade of experience with multi-diameter pigs for commissioning and inspection has revealed the technical limitations of inspecting two diameters and pipe wall thicknesses. The technology is continuously improving while the cost of upgrading existing tools to the latest performance specification is high. The MDP’s are bespoke designs that require qualification testing as part of the TQP but they are not on the project critical path because the first (baseline) inspection can be performed after pipeline start-up.

On the other hand, development and qualification of 46" connectors will be on the critical path of the project but the TQP can be greatly improved by virtual prototyping using finite element analysis (FEA) to reduce the schedule risk of having to repeat the physical tests. The FEA is performed before detail engineering in order to confirm the capacities of the connector design for the specific performance demands of the project. The qualification tests are simulated in order to identify areas for improvement prior to finalizing the design to ensure successful testing of the physical prototype.

Screening of alternative PLEM concepts is presented briefly below while more details can be found in another publication [9]. This paper focuses on the large diameter subsea diverless connectors, connector tie-in loads, and connector qualification. In order to expedite the qualification program, virtual testing using 3D FEA is proposed and supported by general FE modeling guidelines.

CONCEPT SCREENING

A concept screening of alternative PLEM designs for a 46" gas export line has been performed based on functional requirements and the barrier philosophy presented below. The lifting weight is of particular concern because of the heavy ball valves. Installation issues, subsea connectors and multi-diameter solutions were considered in order to develop a design that is compatible with a wide range of construction vessel capacities.