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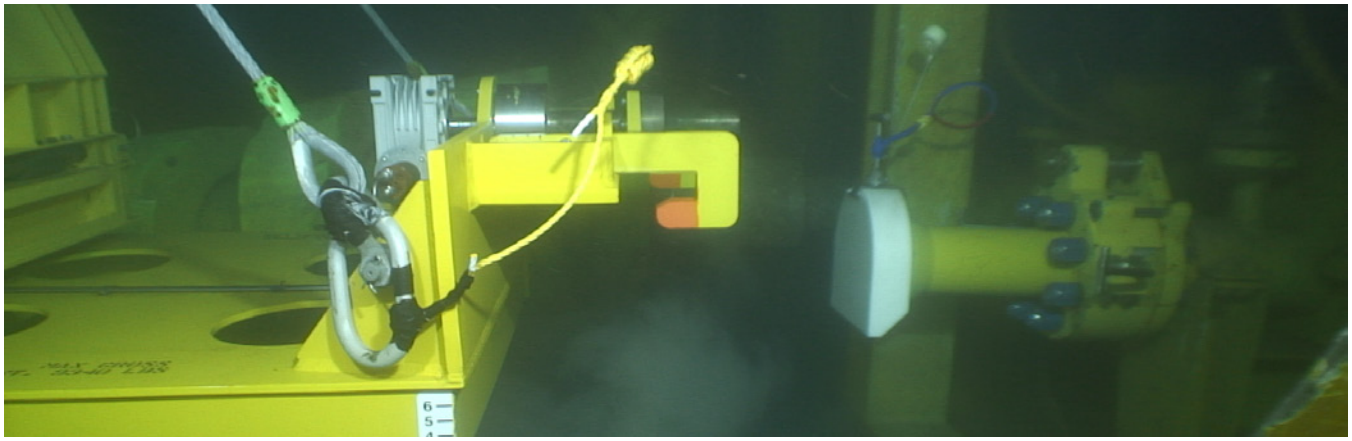
Subsea Development Retrofitted to Enable Diverless Functionality

Oceaneering ROVs convert diver-installed infrastructure with custom engineered solutions to bring field into production



Project Overview

Over the span of two offshore campaigns, Oceaneering retrofitted subsea infrastructure in 450 fsw offshore Trinidad and Tobago to enable subsea connectivity with remotely operated vehicles (ROVs), and reconfigured the infrastructure to bring new production online.

The existing subsea system consisted of a four-slot manifold connected to three horizontal trees via flexible well jumpers, electrical flying leads and steel flying leads. All the connections had been made with saturation diving support. Oceaneering successfully adapted existing API flanges to allow for alignment, pull in, and remote connection of flexible jumpers without typical connection systems.

Issues

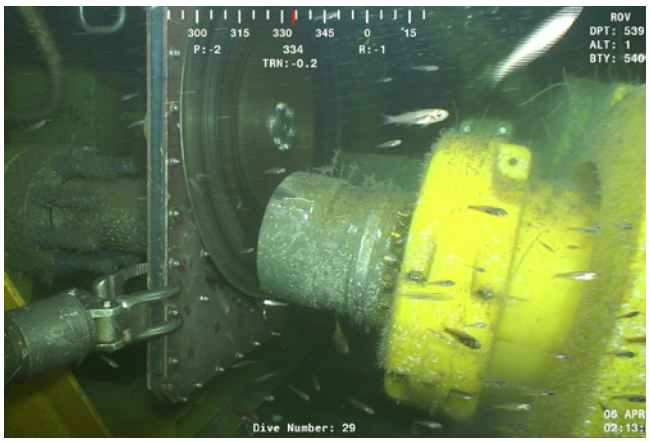
The field did not produce for a three-year period after an attempt to bring production online failed. During this time, the field was acquired by a new operator. The original operator had planned to use saturation divers to perform

installation activities at the field. In the interests of safety and cost savings, however, the new operator approached Oceaneering in early 2017 to retrofit the field for diverless capacity and make connections to three new wells. The new operator's decision was driven by the high cost of utilizing diving services in a remote location, and the weather and water currents that made the subsea infrastructure inaccessible to divers most of the time.

Executing the project would require the re-route of existing flexible jumpers and installation of new flexible jumpers to interface with the existing subsea production system. The project also involved horizontal flange connections. Without the use of divers, no standard solution existed for addressing these flanges.

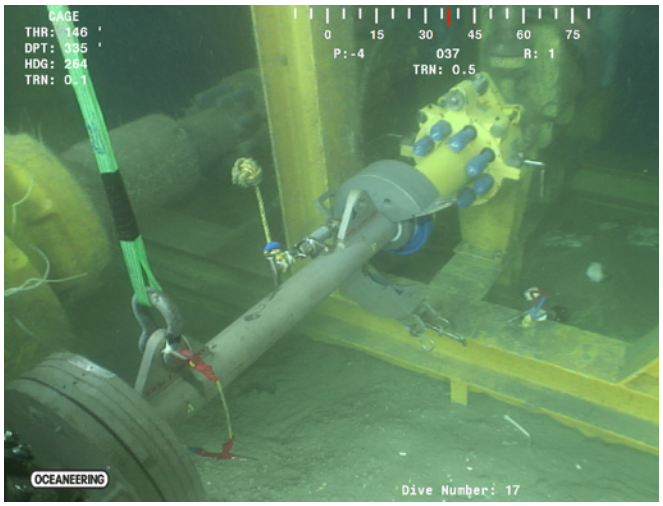
The Oceaneering Solution

Oceaneering utilized companywide resources to create a comprehensive solution including onshore and offshore project management, engineering, assembly, testing, installation aids and personnel for the project, including an ROV access study to prove tooling feasibility. Oceaneering's study concluded that, although the ROV access had extremely tight tolerances and some limitations, tooling and installation aids could be developed to overcome the challenges and ultimately provide a diverless installation solution to complete a three well tie-in, bringing the field into production.



Execution Plan

Work conducted in the first campaign—which took place during the first quarter of 2018—included the diverless conversion of two API flanges and the installation of a wet parked flexible jumper. The manifold blind flange was removed using ROV-operable tools and the API by Grayloc flange adapter tool installed. Next, the pull-in frame was deployed and flexible jumper recovered to the hang off frame, where a Grayloc Remote clamp was installed on the end fitting. The flexible jumper was then landed into the pull-in frame, aligned and the remote connection was made.



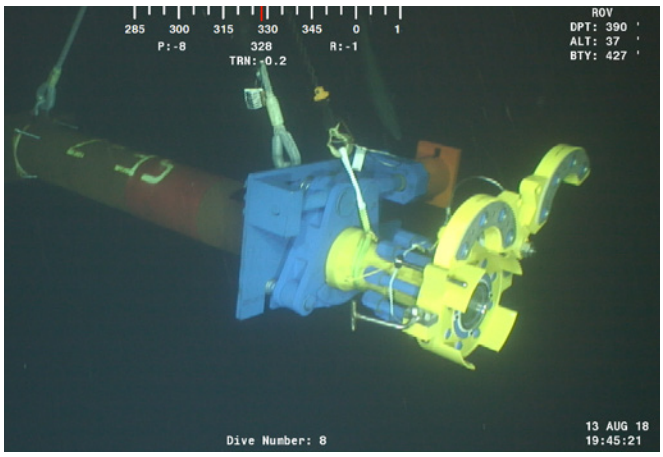
The second campaign in the third quarter of 2018 involved re-routing and performing the diverless conversion of an existing flexible jumper, making a remote connection on the flexible jumper bridge connection, and installing a new flexible jumper via a pull-in frame. To execute this work, the existing flexible jumper connection was removed and shifted to the bridge. The API flange was adapted by installing the flange adapter and the new extension flexible jumper was shifted into the bridge with the Grayloc Remote Clamp pre-installed. The bridge was then aligned and the remote connection made.

Next, the pull-in frame was deployed and

installed onto the manifold. A new flexible jumper was deployed into the pull-in frame with a yoke assembly installed, aligned and the remote connection made. The final connections were tested via a multiple quick connect interface.

Challenges

- Extremely tight schedule to allow the project planning and engineering
- Extremely tight schedule to allow for fabrication and testing of hardware and installation aids
- Executing an international project in a country where Oceaneering does not regularly import and export vessels and equipment
- Building equipment and tooling based on third-party construction drawings without access to perform a fit check prior to installation
- Subsea connections at the production manifold were API flanges recessed in the manifold's super structure, intended for saturation divers to complete the tie-ins
- Recovering flexible jumpers to the side of the vessel and holding the assemblies while installing additional components



- Installing hardware subsea with +/- 5 in tolerances
- Disconnecting and reutilizing existing subsea flexible jumpers via an Oceaneering bridging structure
- Installing ROV-friendly equipment onto assemblies built for diver use
- High current environmental conditions

Equipment Highlights

Oceaneering demonstrated its ability to innovate with its custom engineering of ROV specialty tools and installation equipment for the project, including:

- ROV Operable Flange Removal Tooling
- API x Grayloc Flange Adapter
  - Diverless solution used to adapt an API flange to a Grayloc hub to enable remote clamp connection
  - ROV deployable via installation tool designed to account for change in weight and center of gravity before and after installation
  - Designed to adapt API 17D 5-⅛ in flange while retaining the gasket and mounting hardware required to make the connection by ROV
- Grayloc Remote Clamps
  - Grayloc metal-to-metal seal
  - API 17H Class 4 Torque Bucket interface
  - Simple, reliable trunnion and screw mechanism
  - Retained seal ring with test ports
- Flexible Jumper Bridge
  - Diverless solution that connects two flexible jumpers subsea by providing adjustment in three dimensions
  - Utilizes mechanical drive mechanisms through a API 17H Class 4 Torque Bucket interface

- Flexible Jumper Pull In Frame
  - Diverless solution that connects a flexible jumper to a manifold by providing adjustment in three dimensions
  - Utilizes hydraulic drive mechanisms through hot stab manifolds
- Flexible Jumper Hang Off Frame
  - Designed to hold the recovered flexible jumpers on the side of the vessel during flooding, flange removals, make-ups and pressure testing
  - Served to install the gooseneck and running tool for deployment and installation to the subsea trees

Results

Oceaneering successfully removed existing flanges, adapted API flanges to enable remote connectivity, and aligned flexible jumpers for subsea make-up, ultimately resulting in the connection of flexible jumpers to three wells. The client safely and successfully initiated gas production from the field, which is expected to peak at 250 Mcf/d.

Other benefits to the customer included:

- Cost benefit of using MSV versus a dive vessel
- Project executed subsea utilizing ROVs without diver intervention
- Project completed within budget and on schedule
- Techniques and equipment proven for future diverless conversion projects
- 44,628 man hours worked without any lost time incidents

Project Highlights

- Oceaneering ROVs performed delicate tasks for retrofitting subsea hardware to diverless functionality
- The design and fabrication of fit-for-purpose hardware to integrate with existing subsea architecture installed by ROVs
- Validation of products through controlled environment testing with ROV at NASA's Neutral Buoyancy Laboratory
- Future IMR can be accomplished with engineered solutions versus diver intervention