SUBSEA CHEMICAL STORAGE AND PUMPING IN SUPPORT OF 42” PIPELINE CLEANING AND INLINE INSPECTION

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Abstract

This paper details the development and application of a subsea chemical storage and pumping system required as part of an inline inspection (ILI) operation on a 42” x 890 km gas export pipeline.

The system incorporated subsea storage for 95,000 litres of Tri Ethylene Glycol (TEG), high flow flushing pumps, high pressure test pump, flow and pressure monitoring and a data logging system, along with mechanical, hydraulic and data Remotely Operated Vehicle (ROV) interfaces.

The inline inspection required the installation of a 42” temporary PLR to facilitate launching of a cleaning pig and intelligent Magnetic Flux Leakage (MFL) pig from the subsea pipeline manifold to the onshore Liquefied Natural Gas (LNG) plant.

The subsea chemical storage and pumping system removed the need for a subsea downline connecting the support vessel to the high-pressure gas pipeline and enabled large volumes of chemicals to be injected into the pipeline with no risk of gas flow-back to the vessel.

Introduction

In late 2022, Halliburton was tasked to supply and operate a subsea chemical storage and pumping system which would be deployed from a Subsea Construction Support Vessel in support of an ILI operation on a 42” gas pipeline. The overall project scope included:

- Preparation of a temporary subsea 42” pig launcher (PLR)
- Onshore preinstallation of a cleaning pig and dual module ILI tool
- Mobilisation of PLR and all support hardware, including subsea TEG storage and pumping equipment, to the work location, offshore Northern Australia
- Preparation of the subsea pipeline manifold (PLEM) for deployment of the PLR
- Subsea Installation and testing of the PLR and pumping system
- Displacement of seawater from the PLR and associated pipework prior to launch
- Launching of the cleaning pig and ILI tool into the pipeline, using product gas
- Purging hydrocarbon gas from the PLR and associated pipework with TEG once the ILI tool was launched
- Recovery of the PLR and reinstatement of the PLEM

Customer Challenge

The project posed many challenges including the following

- Remote location
- Size, weight and complexity of PLR
- Stringent local regulatory requirements
- Risk due to huge gas inventory stored in 42” x 890 km pipeline
- Relatively deep water (250m) diver-less operations
- Short lead time for initial mobilisation
- Equipment availability / lead time

Figure 1: Project Location

Figure 2: 42" PLR

Project Methodology

The initial enquiry for a subsea TEG storage and pumping system was received by Halliburton in late 2022. As part of early collaboration with our client, we questioned why a subsea system was required, rather than a conventional solution using a downline with deck mounted pumps and TEG storage tanks. The deck mounted solution initially seemed more practical and cost effective for operations in 250 metres water depth. However, it quickly became apparent why the clients risk assessments had driven them to use a subsea system.

A downline hose could have been used to convey TEG from the support vessel deck to the PLR, however concerns had been raised regarding the following:

- Hydrocarbon gas flow-back to the vessel via the downline
- Consequences of vessel loss of positioning / run-off
- Methods of connection/disconnection of the downline from the pipeline
- Damage caused should the downline not be able to be disconnected
- Dealing with a gas plume if still connected to the pipeline
- The huge inventory of gas in the pipeline (42” x 890 km)

Subsea chemical storage and pumping was assessed as providing a means of reducing, or eliminating, risks and ensuring an easier path to regulatory approval for the project safety case.

A commitment to subsea pumping had been made to the regulatory authorities which couldn’t be changed without resubmission of the project safety case, most likely causing significant delays.

Overview of subsea chemical storage and pumping system

A proposal was developed for the system, comprising of multiple subsea chemical storage modules (baskets) each containing 10 x 1000 litre underwater storage bladders. The baskets were to be connected to a subsea pumping unit. The baskets and pumping unit would be lowered to the seabed by crane, from a support vessel. The system would then be connected, controlled, monitored and hydraulically powered by work class ROVs deployed from the support vessel.

The connection between the vessel and the ROV would be via an electrical and fibre optic umbilical, which would provide power and data transmission. Consequently, there would be no flow path for gas from the pipeline to reach the vessel via the umbilical. The ROV contained an electrically driven hydraulic powerpack and connected to the pumping unit via a hydraulic valve-stab and contactless optical data modem. In an emergency the valve stab would simply be unlatched by the ROV or a failsafe weak link, allowing instantaneous disconnection if excess tension were created on the valve stab. This solution removed and mitigated the risks inherent in using a downline connecting the vessel to the pipeline.

Figure 3: Subsea Pump Unit Deployment

Figure 4: Subsea TEG Storage Basket Deployment

Project Timeline

The planned project schedule aimed to complete a regulatory 5-year ILI tool run by summer of 2023. An initial proposal was submitted to the client at the end of 2022, based on Halliburton subsea pigging and hydrotesting equipment which is more typically utilised for precommissioning of new pipelines. This is a well proven system, developed over some 20 years and, with some modification, could achieve the project parameters in the required timeline. The contract was awarded in March 2023, with a planned vessel mobilisation, from Malaysia, in August 2023, a very tight schedule.

Detailed design and procurement commenced immediately. An existing subsea pumping skid, which was available in the UK, was selected and 9 new subsea storage baskets, each capable of storing 10,000 litres of chemicals, were designed and built. Wherever possible existing component designs were used, based on proven track records, but with several client requested modifications.

One of the biggest project challenges was ensuring the ability to connect 8 subsea chemical storage baskets simultaneously. A manifold with the facility for 8 hot stab connections was designed and fabricated but procuring the required hot stabs and receptacles in time, proved to be difficult. Fortunately, by reusing hot stabs from a previous project, and designing fabricating and assembling matching receptacles, we were able to meet the project timeline.

Construction and testing of the subsea pumping unit and subsea baskets were completed and equipment shipped mid-June. Long lead time spares following by airfreight.

The equipment was mobilised via Singapore, where final assembly and integration testing of the pumping unit and storage basket was performed in August 2023. At this time, it became evident that the project might be delayed as there had been delays with approval of the vessel safety case. Due to the size and weight (around 100 tonnes) of the PLR, a very specialised vessel with a 900-tonne crane had been selected by the client. The delays in the safety case approval meant that the vessel had missed the planned window of availability, and the project was therefore put on hold for an unknown period.

In May 2024, operations recommenced. Function testing of the equipment was repeated, and all equipment was moved to the mobilisation point in Southern Malaysia – a short distance from Singapore.

The project continued with assembly and filling of the 9-no. 10,000 litre chemical storage baskets; however, it became apparent that there was a manufacturing issue with the bladders we were using, although they had a long track record of previous use. It was decided to change from the 10 individual 1000 litre IBC bladders in each basket to a previous design of a single larger heavy-duty bladder of 10,000 litres volume which worked very successfully.

Figure 5: 10 x 1,000 litre bladders

Figure 6: 10,000 litre IBC Bladder prior to filling

The ILI tool and cleaning pig were installed in the PLR and pipework was filled with TEG in preparation for deployment.

Due to further delays in the construction vessel schedule, the client decided to ship the PLR, subsea pump unit, subsea baskets, and TEG via a cargo vessel to a mobilisation point in Australia where it was then loaded on to the construction vessel.

The construction vessel mobilised to the offshore location and commenced the subsea work scope, summarised as follows:

- Isolation testing of the valves on the PLEM using TEG
- Removal of blind connections, installation of 42” PLR and kicker line spool
- Flushing of PLR and kicker line with TEG to remove seawater
- Hydrotest of the PLR and kicker line connections using TEG
- Valves aligned to launch cleaning pig and ILI tool using product gas
- Closed 42” PLR isolation valves
- Flushing hydrocarbon gas from PLR and kicker line into pipeline with TEG
- Closed kicker line valves, perform isolation tests for PLR disconnection
- Disconnect and recover PLR and kicker spool, reinstate blind connectors
- Hydrotest of 42” and 12” kicker line blinds
- Recover the PLR, kicker spool, pumping unit and storage baskets to deck
- Demobilisation and mothballing of equipment

Figure 7: 42” Subsea PLR on deck

Figure 8: Deployment of 42” PLR

Conclusions

The project was completed with several challenges along the way. The very tight initial schedule influenced some of the decisions made at the time and in retrospect, certain aspects may have been handled in a more optimal way. Some of the key highlights and lessons learned were:

- The project was the first time such a large volume of chemicals had been injected using a subsea pumping Unit.
- Delivery time of subsea equipment can be particularly difficult post Covid 19 and Brexit
- Re-use of existing equipment allowed significant timesaving but can lead to difficulties with certification
- The 1,000 litre storage bladders used in the past proved unreliable and made the overall system overly complex. The larger 10,000 litre bladders worked well and simplified the operation
- On a complex and geographically diverse project like this, interfaces between the client, main contractor and subcontractors involved proved to be a challenge
- Project delays can cause significant difficulties such as continuity of staff, transfer of information, additional maintenance, and recertification