PIPELINE LIFE EXTENSION USING CUSTOM BUILT INSPECTION TOOLS

Primary Author: Holger Kamps, 3P Services GmbH & Co. KG, Germany

Co-Author: Basil Hostage, 3P Services GmbH & Co. KG, Germany

Abstract

Five fields produce oil and gas through commingling manifolds to an FPSO using two main production pipelines. Both lines have exceeded their design life and are known to suffer from a level of corrosion. In-Line Inspections performed in 2013 and 2019 provided the basis to allow extending their operational life.

Before 2013, the 12” pipeline loop was un-inspectable. Obstacles are present that prevented passage of standard ILI tools:

- Tool launch & receive at rotating turret with limited trap length and working area
- Connection to the FPSO via flexible piping with reduced 10” diameter and sensitive internal carcass
- 12” flexible piping with larger internal diameter between the manifolds (installed after 2013 ILI)
- Heavy walled topsides and pipe-in-pipe subsea
- Known presence of debris
- Duplex pipe material affects inspection measurements

GEO+, MFL and UT inspection tools were designed and built to negotiate the existing pipeline configuration. A special test loop was constructed to simulate the obstacles. Tool passage and performance were verified and demonstrated in factory acceptance pump tests before being applied in the target pipeline offshore. Cleanliness assessment and metal loss integrity status of the pipeline were provided to the operator. Comparison of the results was used to prepare a corrosion growth assessment.

Overview of Field

The Guillemot West (GW) Field is operated by Dana Petroleum and located in Block 21/24, approximately 100 km east of Aberdeen. Water depth varies from 83 m to 92 m across the field.

The Guillemot West, Western Extension, Clapham, Pict and Saxon fields are all connected to the Triton Floating Production Storage and Offloading (FPSO) via two common production flowlines. These two lines run from the FPSO, to manifolds located at Drill Centre 1 (DC1), DC2 and DC6 through a pigging loop connecting the two flowlines at DC6. DC6 manifold is a hub for production fluids coming from different manifolds.

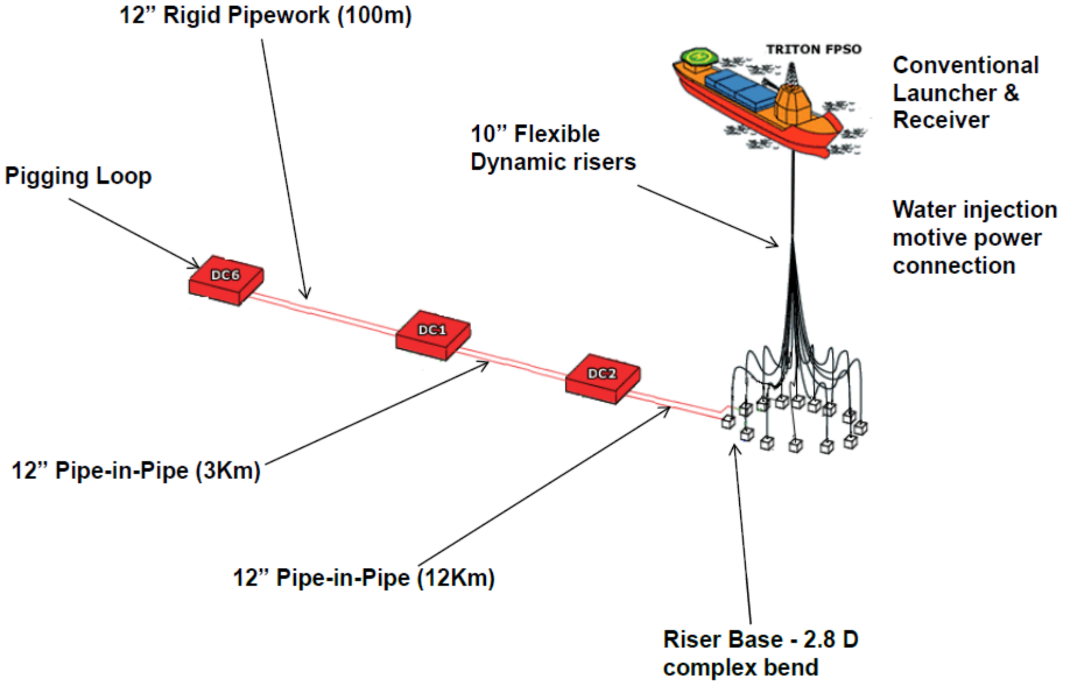

Figure 1: Field Overview

The two 12” production pipelines comprising the system run from the riser base via DC2 and DC1 to the pigging loop at DC6, a distance of approximately 15km (one-way). The flowlines from riser base to DC2, and from DC2 to DC1, are contained within 18” carrier pipe, hence no external inspection has been possible. These lines are the main area of concern for which data are required.

Further, the Triton FPSO is equipped with a pig launcher / receiver connected to each of the two GW production risers.

Objective

The objective was to design and prepare custom built inspection tools that would safely support a progressive In-line Inspection (ILI) campaign. Inspection operations on Triton and in particular on the GW system had never been undertaken, although the subsea installation, riser and GW turret systems were designed to be piggable.

The Challenge

The inspection route contains some features that pose problems for cleaning, gauging and intelligent inspection tools. It was therefore essential that the proposed tools would be capable of navigating the following obstacles without getting stuck:

- Lines had not been inspected since commissioning in year 2000.
- Internal diameters ranging from 253 mm – 304,8 mm
    - Transitions Flex (253 mm)
    - Flexible pipe (304,80 mm) (installed after 2013 execution)
    - Riser base (273,1 mm)
    - Tie in spool (285,7 mm)
    - Pipeline (297,7 mm)
- 10” flexible riser: Concern over mechanical damage to dynamic riser carcass
- Pipe-in-Pipe (PIP) Pipeline 12”; API 5L X65; wall thickness 13,1 mm
- Carrier Pipeline 18”; API 5L, X60, wall thickness 11,1 mm
- Coating: 55,55 mm SPU foam in annulus
- Complex riser base bends (2,8 D)
- Debris location and extent unknown but some history of sand production

Engineering and Testing Phase

A deep tool design phase concentrating on aforesaid challenges was performed in line with the agreed measurement performance specification. A cleanliness assessment and debris mapping tool was prepared for both campaigns in 2013 and 2019. Metal loss inspection was performed using a Magnetic Flux Leakage (MFL) tool during both campaigns, however in 2019 an additional Ultrasonic (UT) inspection tool run was performed.

The aspects driving tool design were mainly the following:

Dual diameter capability

The design of each ILI tool considered proper sealing in 12” and 10” piping. The driving cups were specifically machined to assure proper sealing in both diameters while still meeting the need to achieve an acceptable differential pressure (∆P) sufficient to move the tool with lowest force possible. The measuring units were configured to have a high collapsibility in order to negotiate all diameters and at the same time assure an acceptable measuring performance in the larger diameter of the line, which is the 12” piping. Obviously finding right combination was one of the challenges.

Traversing the flexible hoses

Flexible hose manufacturers are concerned any kind of pigging activity risks causing damage to the inner carcass of the hose, which is often made of relatively soft stainless steel (often 316L). The fear is that metal to metal contact between a pig and the inner surface may cause damage by abrasion or by snagging, tearing, or other mechanical means. MFL tools are of particular concern due to the massive construction of the magnetiser module, with the magnets encased in metallic housings being carried close to the pipe wall.

The final design and build of the MFL tool was based on the principle of “stand-off magnets”. The magnetic yokes are supported by skater wheels which guide them along the pipeline wall. The skater wheels keep the magnets away from the wall and maintain a constant stand-off. Also there are no metallic brushes on the tool.

All other components that will contact the inner surface, especially the odometer wheels, were made of synthetic materials, predominantly polyurethane (PU), which are softer than the stainless steel liner.

These principles of ILI tool construction had been proven in the past in tests witnessed and accepted by a leading manufacturer of flexible pipe.

Limited measuring in DUPLEX material

Both flow lines are fully made of carbon steel pipe material and hence proper measuring according to specification is ensured. However, some very short pipe sections (mainly topside) are duplex, which is known to have significantly different magnetic properties and poor magnetic permeability compared to carbon steel. Consequently any MFL measurements taken in duplex material will be heavily limited.

Trap assessment and tool configuration

Trap dimensions and layouts were assessed and especially their length was taken into consideration during tool design. Since the trap barrels are also heavy wall, the tools' on board transmitters were modified and adjusted in order to send out signals through a 40 mm pipe wall thickness. Launcher and receiver were located next to each other on the rotating turret at the FPSO, where the working area is rather limited. Tools and installation equipment were designed and chosen to allow a quick tool installation and retrieval from the trap.

Figure 2-4: Launch / Receive area at turret

Remaining pipeline debris – sand, scale, wax

A specific debris mapping tool called GEO+ was also designed according to pipeline configuration. This is basically a high resolution geometry (GEO) tool to measure the internal pipeline geometry. However each geometric arm is equipped with an additional sensor which is guided along the wall and measures the distance from its sensor to the next ferritic surface, the pipeline wall. The comparison of the geometric sensor and the wall guided sensor readings allow to distinguish between a geometric anomaly and non-magnetic substance (e.g. debris). This allows to measure the presence and volume of debris remaining in the pipeline and also to create a "map" of concentrations of debris.

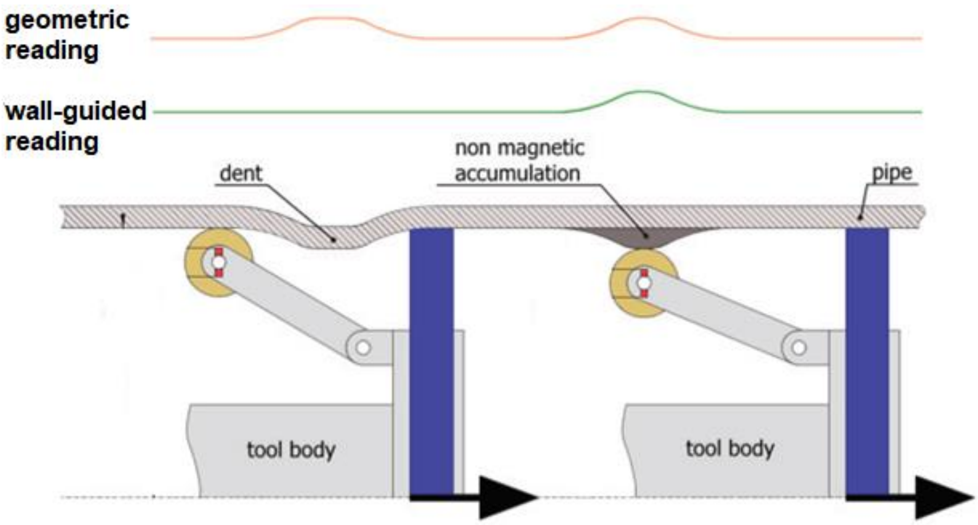

Figure 5: Schematic of GEO+ reading

The tool was deployed to assess the cleanliness of the line and measure and map debris that may remain in the line. Data from the GEO+ tool are used to decide whether to launch the subsequent MFL tool or to continue cleaning efforts.

Factory Acceptance Testing (FAT) 2013

To simulate the various diameter changes and difficult bend configurations on the riser base, all tools were subjected to a pump test at 3P's testing facility to demonstrate their ability to safely negotiate these areas. A (blind) test spool with artificial defects was provided by Dana Petroleum and installed in order to confirm the tools' measuring capabilities. Dana Petroleum representatives witnessed the FAT at 3P Services' base in Germany.

Figure 6-8: Pump test executed in 2013

After completion of the successfully executed pump test runs, inspection data results of the blind test spool were presented to Dana Petroleum's representatives and subsequently a FAT report was prepared and submitted.

Offshore Execution 2013 / 2019

Prior to both ILI campaigns, the line was flushed with treated seawater and left in a state of readiness for the start of the ILI operation. The inspection program involved running a succession of cleaning contractor's gel pigs, gel batches and foam/metal bodied cleaning tool through the system, culminating in intelligent inspection runs executed by 3P Services.

All hard body inspection tools were equipped with isotope tracers to enable tool locating even when the battery life time of the electromagnetic transmitter is expired. This would have become important in the event that any tool became lodged subsea. Active tracking was not foreseen. The time required to determine that a search and locate exercise was mobilised would have been longer than the battery life of the transmitting devices on board the tools.

All inspection tools were launched from and returned to the GW pig launcher and receiver, located in the turret area of Triton FPSO. All tools ran from topside to topside, passing through the existing pigging loop at the DC6 manifold.

The ILI campaign intended to safely execute and deliver information to confirm the integrity status of both GW pipelines, from DC6 manifold to the Triton riser base structures. There was no requirement to confirm the condition of the flexible risers or other flexible pipe sections remaining in the line.

The first 3P Services' tool applied during both ILI campaigns was the GEO+ tool, which identified the pipeline cleanliness status. In 2013 a precaution was taken by equipping the GEO+ tool with "bi-directional" driving capabilities while all other tools in 2013 and 2019 were prepared in a "uni-directional" configuration. This precaution was taken in order to have the capability to pump the tool at reversed flow back to the launch in case of any pipeline restrictions which might hinder the tool passage.

Figure 9-10: Receive of bi-directional GEO+ inspection tool in 2013 execution

After GEO+ tool receipt and data download the inspection data were analysed and 24 hours after the inspection run, a report was delivered to Dana Petroleum advising the cleanliness status of the pipeline

Figure 11-12: Receive of MFL inspection tool in 2013 (left) and 2019 (right)

The final inspection run performed was the MFL tool run concentrating on metal loss on the full internal and external circumference of the pipeline. After the MFL inspection, a site report was delivered confirming its success and so the conclusion of the inspection operations.

The 2019 campaign, unlike that of 2013, included running a UT inspection tool, which was performed to provide additional data and support the MFL inspection data. One benefit of the UT inspection on this project was to get a confirmation of the actual nominal pipe wall thickness and so improving the MFL sizing process.

Figure 13: UT Inspection tool after run in 2019

Two weeks post successful inspection operation a preliminary report was delivered. Six weeks later the detailed final inspection report was delivered.

Investigating Works after 2013 Campaign

After detailed review of the ILI report in 2013 a rigid pipe section was replaced by a new 12” flexible piping. A part of the removed pipe section was deeply investigated. A spool where severe spots of corrosion were reported was examined using different measuring methods.

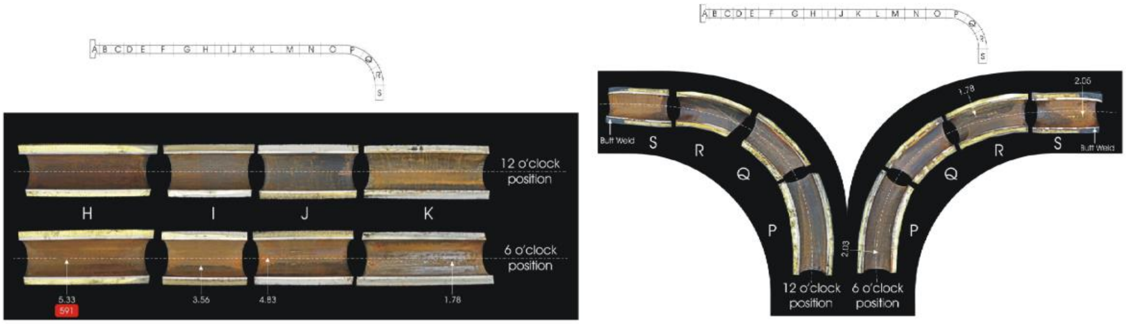

Figure 14-15: Removed spool piece sections

Figure 16-17: Pitting corrosion (left) and girth weld corrosion (right)

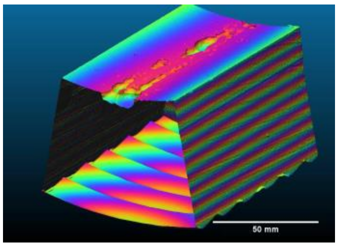

Figure 18: Virtual cross section through UT indication 580.

A pit depth gauge, further 3D laser scanning and metallographic sections advised that the ILI measurements were proper and verified within the applicable tolerances of the tool.

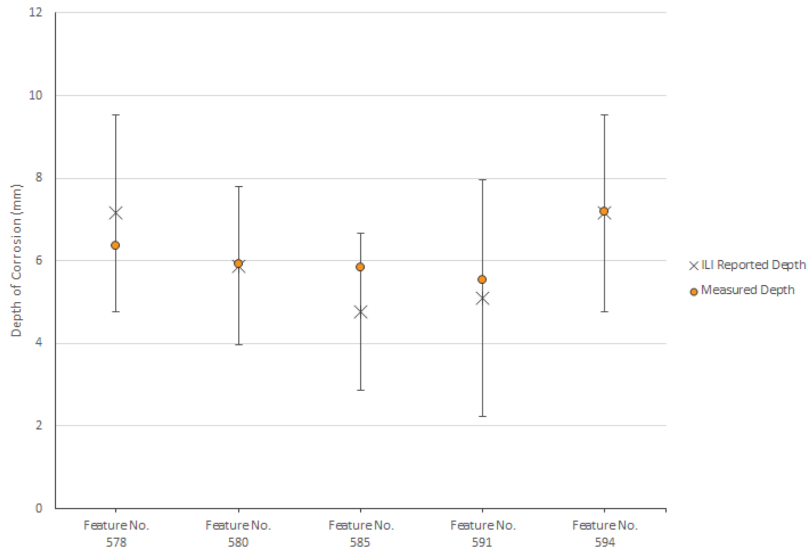

Figure 19: Comparison reported depth vs. measured depth

Conclusion

A never before inspected flowline loop included many obstacles and was previously considered as un-inspectable. During a design and test phase, custom made and flexible ILI tools were built and submitted to factory acceptance demonstration tests with reference to a safe tool navigation and measuring performance.

2013 offshore execution were successfully performed and made the pipeline loop inspectable. Results provided from a GEO+ inspection supported the examination of the pipeline cleanliness condition. Further a MFL inspection determined the integrity status of the pipeline for the first time since pipeline installation. The basis for a calculation of the remaining life time and measures to extend the pipelines life time were provided within the final inspection report.

A repeat of the ILI campaign was executed in 2019 where all the special measures taken in 2013 had meanwhile become routine. The advanced ILI performance allowed determination of the current pipeline integrity status. This information was basis to calculate a new, extended design life and keep the line in operation.

Abbreviations

DC 1-6	Drill Centre 1-6
FAT	Factory Acceptance Testing
FPSO	Floating Production Storage and Offloading
GEO	Geometry
GW	Guillemot West
ILI	In-line Inspection
MFL	Magnetic Flux Leakage
PIP	Pipe-In-Pipe
PU	Polyurethane
UT	Ultrasonic

Reference:

[1] Pigging Contractor Scope of Work; Petro Canada UK Limited; 15/03/10
[2] Final Acceptance Test Report; 3P Services GmbH & Co. KG; 24/09/13
[3] Final Report, 3P Services GmbH & Co. KG, 16/12/13
[4] Examination of P2 Spoolpiece - Greater Guillemot Area PL1653; Intertek; 08/12/15
[5] Review of GGA P2 Spoolpiece Dissection; Origin Integrity Management; 07/06/16
[6] GGA In-Line Inspection Campaign – Scope of Work; Dana Petroleum; 18/01/19
[7] Factory Acceptance Test Report; 3P Services GmbH & Co. KG 05/07/19
[8] Guillemot West, Pipeline Pigging Project, Overall Procedure for Operations 2019 – Procedure; Dana Petroleum; 09/07/19
[9] Final Report, 3P Services GmbH & Co. KG, 30/09/19