REDEFINING LOW FLOW PIGGING AND INSPECTION

By Neil Stewart (Jee), Sean Tucker (Jee), Ben Bergius (NDT Global), Matt Roberts (Serica Energy)

Contents

1 Abstract

As oil production rates in the North Sea continue to decline operators face increasing difficulty pigging and inspecting major trunklines due to low pipeline velocities. This is a major challenge to pipeline operators, presenting a significant issue with regards to maintaining pipeline cleanliness and collecting data for integrity issues. This paper details a case study whereby through working with an inspection vendor to mitigate these issues it was possible to run an inline inspection tool and verify that the regular operational pigging could continue at the nominal low flow rate and significantly below.

Serica Energy, who had a requirement to inspect the 24” main oil line from the Bruce platform, engaged NDT Global to provide a UT inspection tool and Jee to provide project management and technical assurance. Inspection of the pipeline had several challenges including low velocity, limited operational windows for tool loading and retrieval, and the requirement for a subsea activation of the tool. In the early stages of the project it was identified that given the low pipeline velocity 0.0138 m/s, which was below rates seen in other low velocity pipeline pigging, there was a significant risk of the tool stalling in the pipeline.

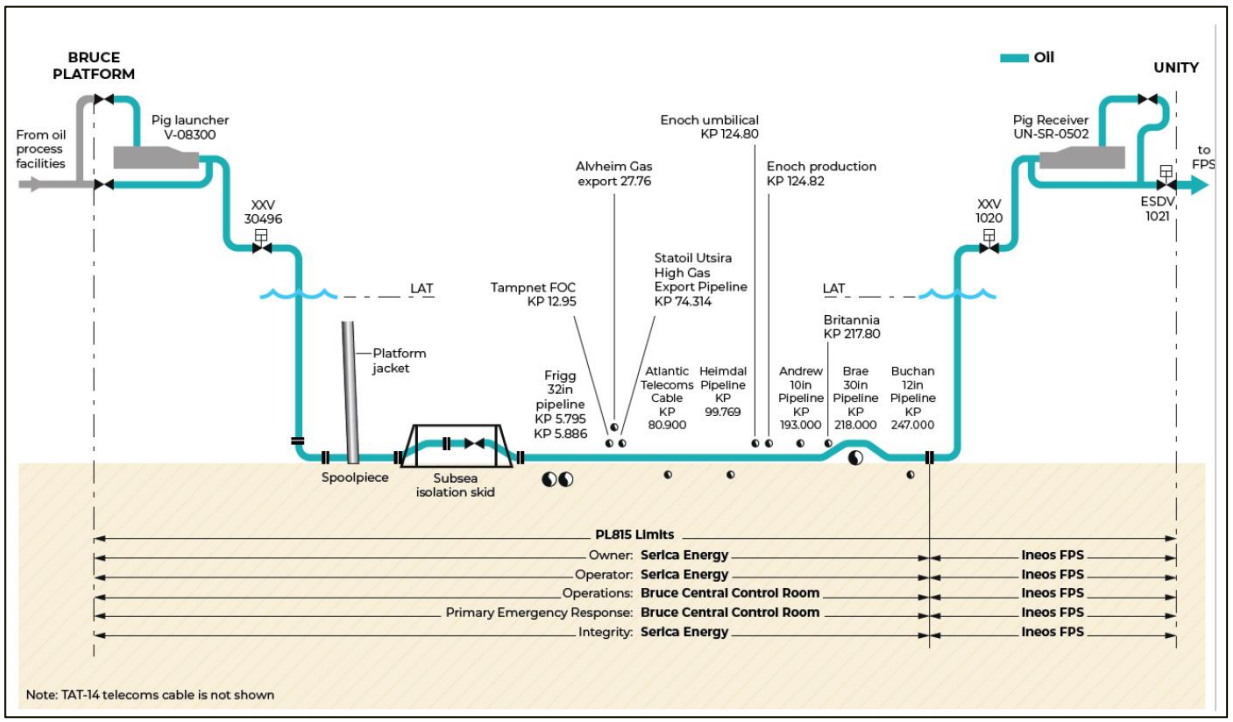
To mitigate the risk, pigging trials were undertaken on both the standard operational pig and the inspection tool. The trials successfully proved that the inspection tool could traverse the pipeline without modification at speeds as low as 0.45 mm/s and the operational pig at speeds of 0.2 mm/s, which with minor adjustment, could have improved performance for future declining rates.

With the trials completed and further technical assurance on the ability to pass the pipeline features performed, the inspection was able to be successfully completed, and operational pigging verified for continued use in a greater operational window.

2 Introduction

The Serica Energy operated Bruce main oil line - which is a 248 km 24” pipeline between the Bruce platform and Unity platform (operated by INEOS FPS) in the North Sea - was due to be inspected in 2020. Due to scheduling constraints, this was postponed until 2022 after a deferral assessment defined a suggested re-inspection date of 2020, or a later inspection date of 2025 if considering a reduced MAOP. The subsea pipeline had last been inspected in 2014 with the riser at the Unity platform inspected in 2015. Due to low flow velocity, the 2014 inspection had only covered the first 37 km of the run after which the tool battery life had depleted.

Figure 2-1 PL815 Schematic



NDT Global were contracted by Serica Energy to provide the inline inspection tool and associated services to facilitate the inspection, as they had for the 2014 inspection, and Jee were engaged to provide project management and technical assurance for the campaign.

3 Inspection plan

As the previous inspection had been performed using ultrasonic technology it was again planned to perform a UT inspection of the pipeline and NDT provided a similar tool to that which had been used in 2014. The pipeline is pigged regularly using a bi-di pig in order to manage the level of industrial methylated spirits in the pipeline, meeting the export specification for the fluid entry into the forties pipeline system, as well as for pipeline cleaning. However, both the launcher at Bruce and the receiver at Unity had issues with the pig trap isolation valves so it was therefore only possible to load and unload pigs and tools when the pipeline was shutdown. This meant the available window for running the ILI tool was limited by the window to load and recover the tool whilst maintaining the required operational pigging.

It was recognised that due to the pipeline flow rate of 0.0138 m/s only a short section of the pipeline would be able to be inspected during the run - with a length of 10 km potentially able to be inspected with the available battery life. A section of pipeline between KP8.9 and approx. KP19.5 was selected to be inspected as it would allow the best number of significant defects that were identified in 2014 to be surveyed, thereby allowing verification of the 2014 inspection results and subsequent assessment of any corrosion growth.

To target this section of the pipeline subsea activation of the tool was required to maximise the tool battery life and therefore the length of the pipeline inspected. To achieve this NDT Global worked with a vendor to use an electromagnetic subsea activation module with the corresponding electronics fitted to the tool to facilitate activation of the tool at KP8.9.

A third-party was also engaged to provide pig tracking via use of a radioactive isotope as they did for the operational pigs.

It was also necessary to coordinate with INEOS as they would be receiving and recovering the tool onboard the Unity platform.

The project was kicked off in early 2022 with the intention of loading the inspection tool during the platform TAR in Q3 2022 with the tool being launched on resumption of production upon TAR completion with tool receipt and recovery sometime in Q2 2023 dependent on the flowrates achieved during the run.

During the initial phases of the preparation, it was identified during the HAZID that there were significant concerns around low flow velocity and the potential for stalling. Consequently, the decision was made to delay the inspection whilst the feasibility of the ILI was investigated.

4 Inspection feasibility

With questions raised regarding the feasibility of the ILI tool being able to traverse the pipeline at the expected flow rate (considering industry track record in low flow pipelines) a two-pronged approach was taken to ensure that an inspection of the pipeline could be undertaken. Firstly, Jee performed a desktop study reviewing what alternative options to using a conventional ILI tool were available and the feasibility of these, whilst NDT Global performed pigging trials to define the minimum flowrate the ILI tool was able to be launched and run in the pipeline.

4.1 Alternative options feasibility study

Several potential options were identified, and a study was undertaken to review and conclude on the feasibility of available alternative methodologies to inspect the pipeline alongside conventional pigging, focussing on:

- Conventional ILI
- Bi-Di ILI
- Crawler inspection
- External inspection

The external inspection and Bi-Di ILI options were considered least preferable due to the significant costs associated with each of these options. It was found that external inspection options would have a significant cost per inspection site due to the significant site work required, including survey, excavation and removal of coatings all of which would require a vessel. The use of a Bi-Di was also considered undesirable as tanker hire would be required to increase flowrates on the outbound run to overcome the same stall risk and to enable offloading of the displaced fluids for the inbound Bi-Di run. The cost of this vessel hire was expected to significantly outweigh any cost benefit due to the reduced runtime in comparison with conventional ILI (if inspection carried out using increased flowrates). In addition, the major ILI vendors approached did not currently have 24” Bi-Di UT tools available hence the cost and time associated with tool development would also be significant.

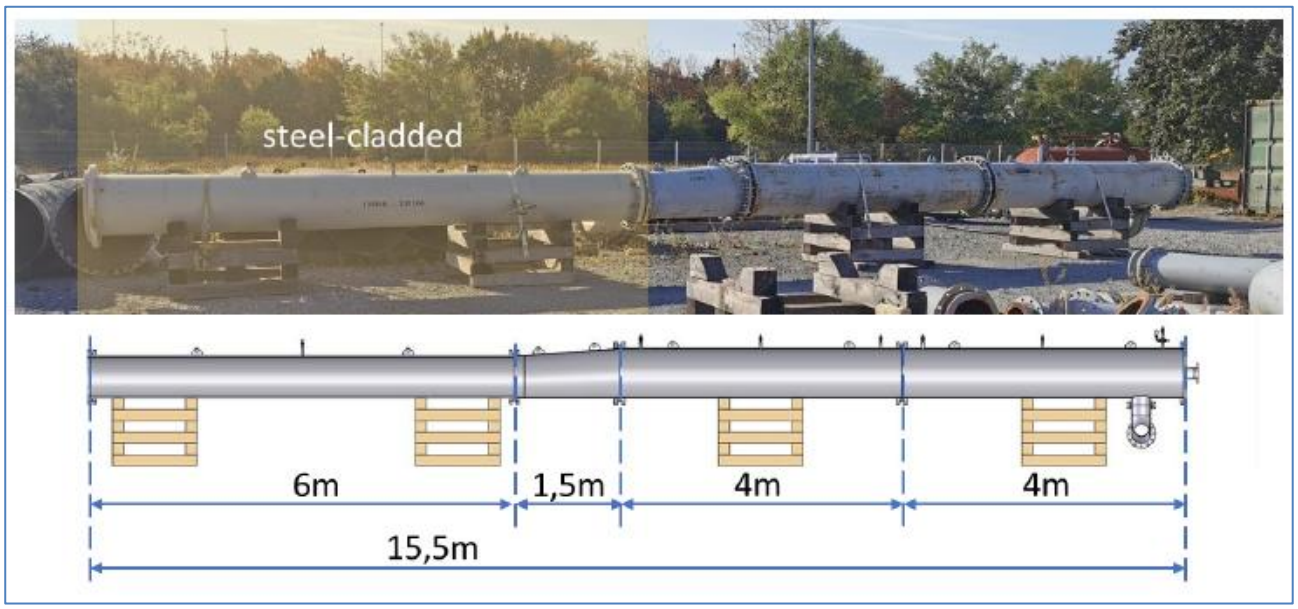
It was deemed that conventional ILI and crawler inspection were the preferred options for re-inspection of the pipeline as conventional ILI had a track record within the system (in particular, NDT Global UT ILI) and the inspection region can be selected to target specific defects based on the remote activation location. The crawler tool could have potentially achieved an inspection distance of up to 24 km which is over double the maximum inspection distance expected for the conventional ILI tool (based on year-to-date maximum flow) and would therefore provide data for more of the intended inspection region than the conventional ILI. In addition, the crawler tool had the shortest lead time for receipt of results (approximately 2 months for final report), with an initial site report issued upon completion of the site works compared to approximately 1 year for the conventional ILI tool, given the transiting time within the pipeline.

Following the study further details of the pipeline and inspection requirements were shared with the crawler tool vendor to progress that option whilst pigging trials were performed.

4.2 Pigging trials

To verify the velocities at which the ILI tool could be launched and driven in the pipeline NDT constructed a test fixture in their yard representing as closely as possible the pig launcher and pipeline.

Figure 4-1 Test setup



The objectives of the trials were to confirm that the tool could traverse the pipeline at the expected tool velocity of 0.138 m/s and to evaluate the minimum velocity at which the tool would still traverse the pipeline. Additionally, Serica provided NDT Global with an operational pig to allow the same tests to be performed so that guidance could be developed for future pigging operations of the pipeline.

Figure 4-2 Operational pig

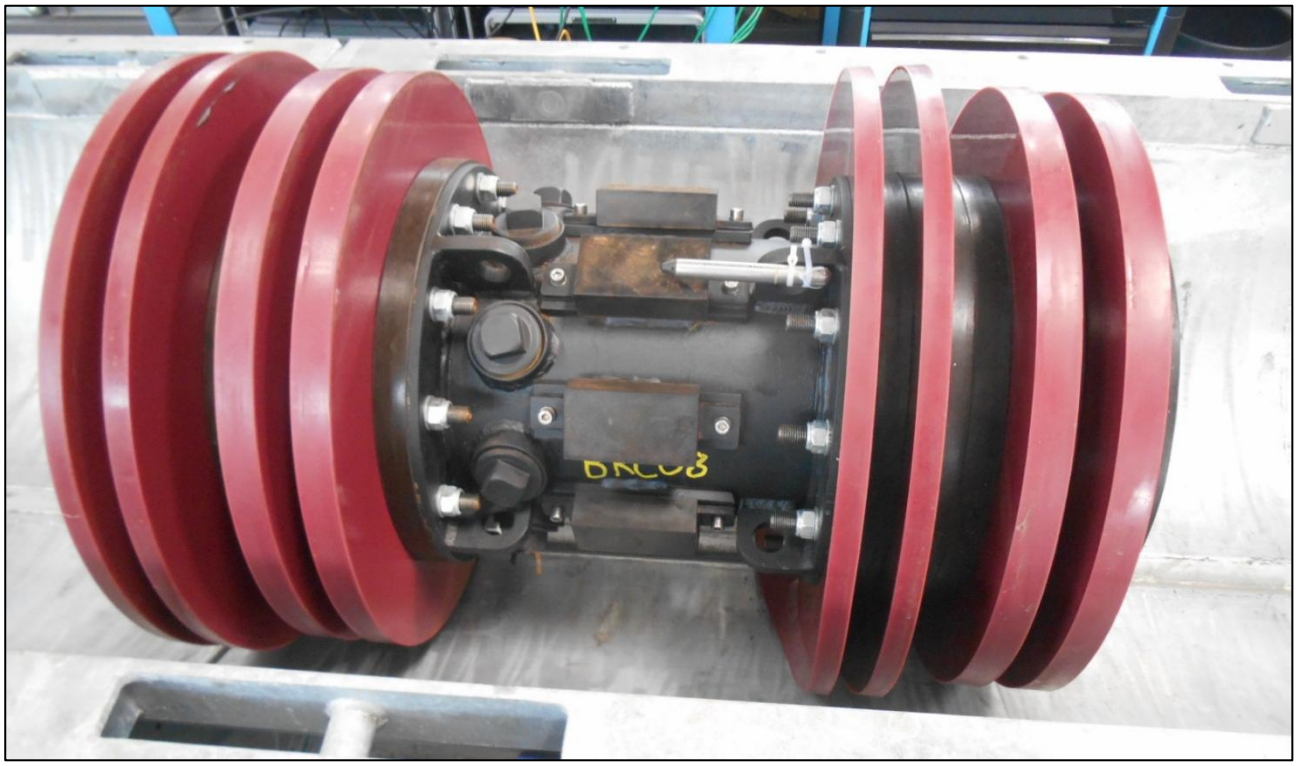
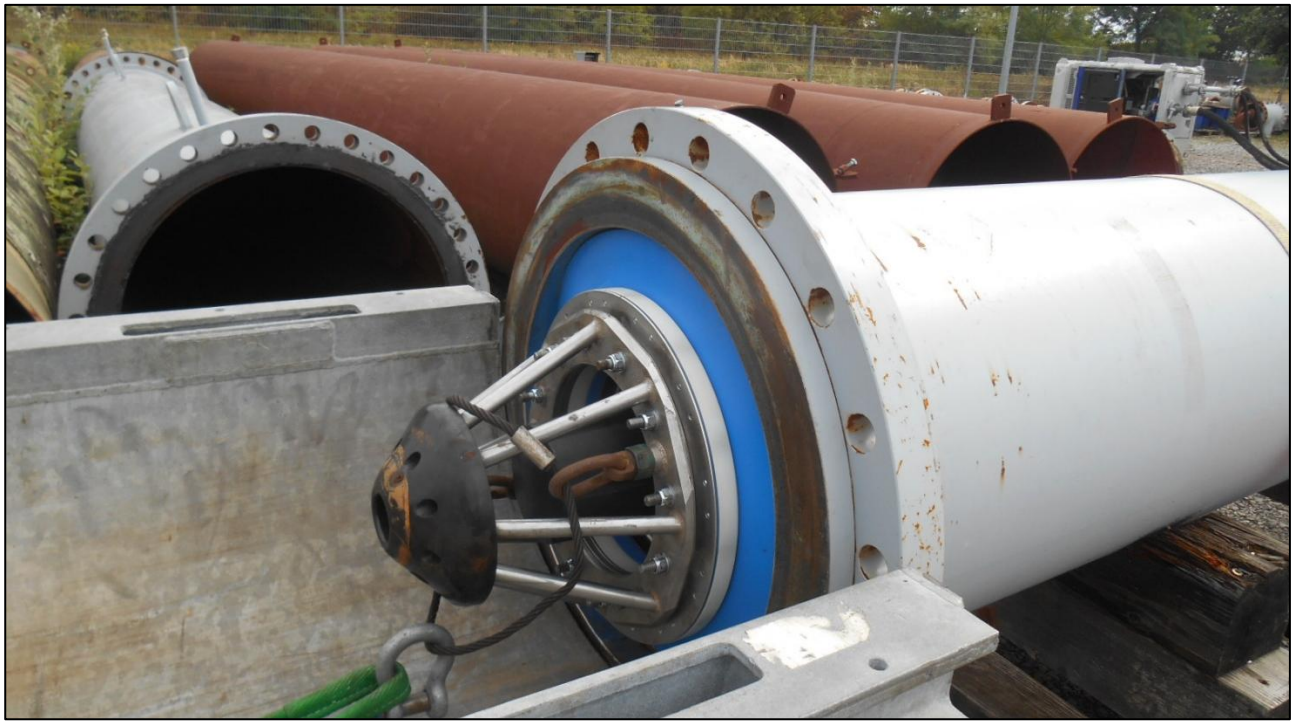


Figure 4-3 ILI tool sealing at end of test rig



A total of 4 testing sessions were performed on the operational pig. Prior to the start of the third and fourth tests the bolts on the pig were tightened which had the effect of reducing the measured bypass by 50%. Following the tests it was found that the operational pig could launch at a pig velocity of 1 mm/s and drive in the pipeline at 0.2 mm/s.

Two tests were then conducted on the ILI tool and again the tool was found to be capable of traversing the pipeline at very low minimum speeds of 0.7 mm/s for launch and 0.45 mm/s to drive in the pipeline.

4.3 Applicability of trials to in-situ conditions

During the preparation for the trials, questions were raised regarding the applicability of the trials to the in-situ conditions. The primary challenges were:

- The potential for unintentional bypass in the pipeline resulting from wear and potential sagging over the significant pipeline length, and through features, with a particular focus on end-of-line performance
- The equivalence of running the tool in water in clean pipe in the fest fixture compared to crude oil in the pipeline resulting in differences in transit friction and differential pressure requirements

To get closer to a representative friction between oil and steel, soap was added to the water and the discs on the pigs were lubricated prior to testing. It was deemed that this was as close as the testing could practicably get to the in-situ conditions accepting that differences in the test spool and pipeline roughness will be present.

Tools run previously had not suffered from significant wear and with the number of sealing elements present along with the ability of the tool to travel at flows significantly below the expected pipeline velocity the trial results were considered a close indicator of in-situ performance, with contingency to account of the uncertainties present.

The residual transit risks of wear, sagging and unintentional bypass were thoroughly assessed through the technical assurance process and risk assessment.

4.4 Feasibility conclusions

Following the completion of the pigging trials, sufficient confidence was gained to recommend that the inspection of the Bruce to Unity pipeline proceed utilising the conventional ILI tool provided by NDT Global. The tests provided assurance that the tool should successfully traverse the pipeline at the low flow conditions expected and for the tool to perform in accordance with the specification. The test results indicated that the tool requires approximately 1/30th of the available flow during the inspection and approximately 1/6th the available flow for launching, significantly below that expected and historically reported within the industry. Following the decision to proceed with the inspection by conventional ILI work to progress the crawler tool option was stopped as this alternative option required significant topsides modifications and logistical challenges not present with the conventional ILI option.

5 Operations

5.1 Engineering and assurance

Preparation for the inspection resumed in Q1 2023 with a planned launch date post TAR in Q3. All necessary documentation, including the bridging document, stuck pig guidance and method statements, were prepared in line with the Serica project management procedure and technical assurance was performed by Jee on the tool design. This identified residual risks to the operation so these could be included in the project documentation and highlighted to the operational teams at site. The main points identified during assurance were the requirement to reduce the pig launcher leak test to 120 barg from the standard test pressure of 127 barg to prevent over pressurising the ILI tool and the risk of the rear of the ILI tool stalling partly within the gate valve closest to the receiver preventing its closure and therefore requiring a non-standard isolation.

The tool was built, prepared and tested by NDT Global by the end of Q2 and prior to the shipment of the tool Jee visited the NDT Global premises in Germany to perform a pre-mobilisation inspection of the tool to verify the tool was built as per design and as tested.

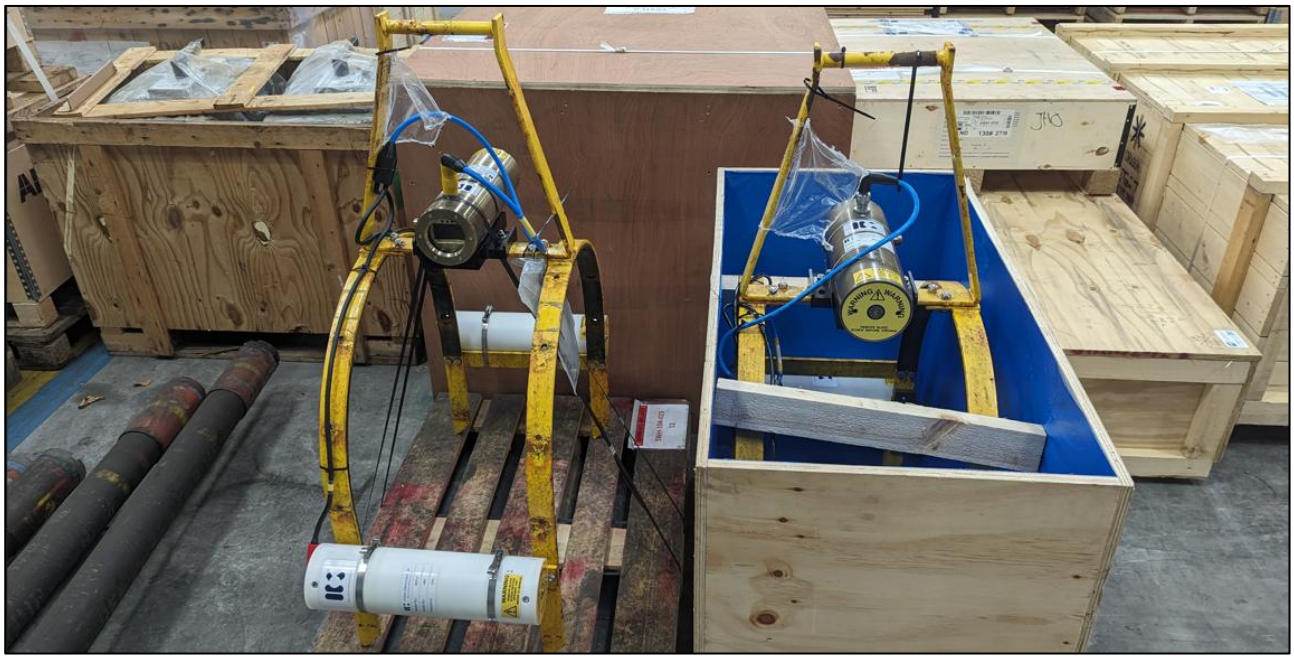
Figure 5-1 ILI tool at inspection

Following the inspection the tool along with the ancillary equipment was shipped to the UK for mobilisation to the Bruce platform.

5.2 Subsea Activation Module

The supply of the subsea activation module was subcontracted via NDT Global and consisted of a cradle which would be placed over the pipeline housing an electromagnetic transmitter with the corresponding receiver housed in the ILI tool. The system had previously been used successfully on the tool and pipeline in 2015 to allow inspection of the Unity riser. In preparation for the inspection the system was refurbished and a second unit was manufactured to provide redundancy and ensure tool switch on.

Figure 5-2 Subsea activation unit



The subsea activation units were mobilised and deployed at KP8.805 and KP8.905 in July, with them being placed 1.4 m away from procedure target location for the primary and 0.4 m for the secondary. The units were deployed in a delayed activation mode to preserve battery life and were set to switch on once deployed and the vessel had left the field.

5.3 Load and Launch

NDT Global were mobilised to the Bruce platform in July to prepare the tool for loading and the tool was loaded into the pig launcher on the 20th of July during the platforms TAR.

Due to delays to completion of the TAR the tool was not launched until the 11th of September once the TAR was completed and flow stabilisation had occurred. Tool launch was performed by the operations team and confirmed using a handheld isotope tracking device.

5.4 Tool running

The tool successfully traversed the pipeline at an average speed of 0.02 m/s arriving at the Unity platform on the 13th of April 2023 giving a run time of just over 7 months. Overall run time was lower than anticipated due to increased production rates in the pipeline resulting from work performed by Serica to boost overall production. The tool activated as required at KP8.89 and recorded an inspection length of 14,460 m, in excess of that expected, before the tool battery depleted at KP23.0. Although the tool velocity was affected by process upsets during the inspection window the tool remained within an acceptable velocity range and data was recorded for the full length of the section.

5.5 Receipt and recovery

The tool was received onboard the Unity platform on the 13th of April 2023 but not recovered from the pig receiver until the 5th of July 2023 due to the requirement to wait for a pipeline shutdown to allow recovery. Tool data was not downloaded until the tool was returned to Germany due to the total depletion of the batteries.

Figure 5-3 ILI tool recovery

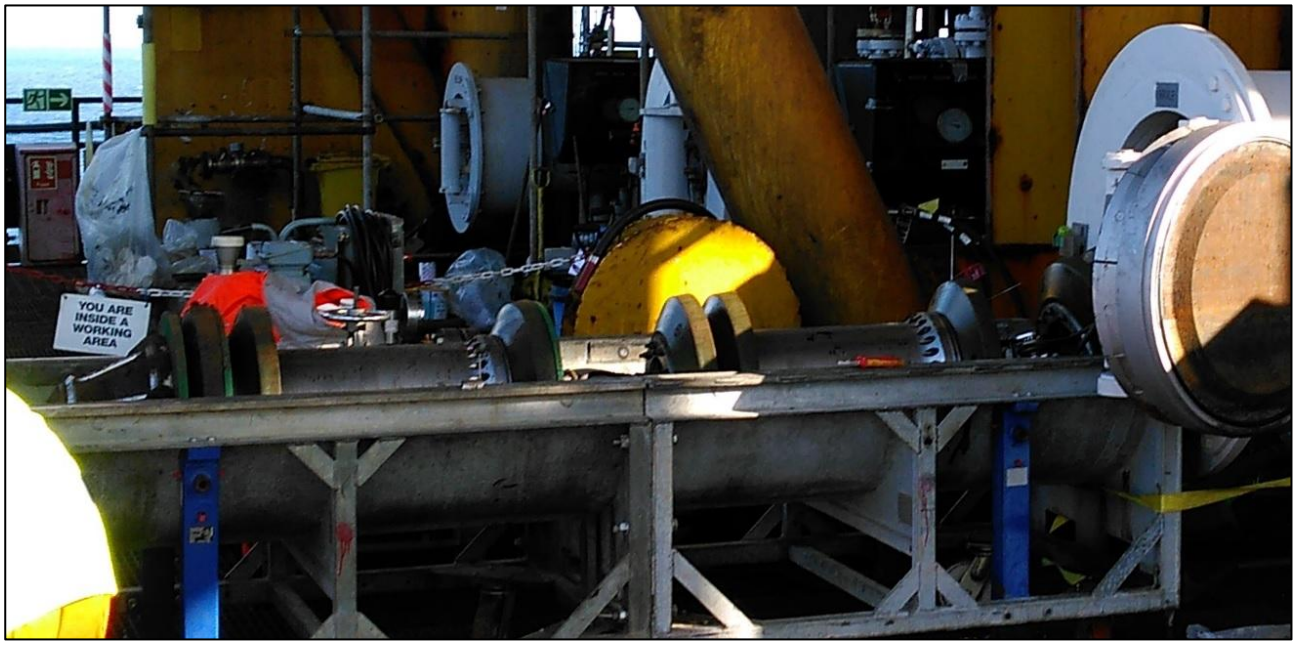


Figure 5-4 ILI tool recovery

5.6 Data and reporting

The ILI results allowed a fitness for service assessment to be completed which concluded negligible corrosion and acceptable pipeline FFS until after current date for cessation of production with no reinspection requirements.

6 Conclusion

This project shows that the generally accepted velocities at which pigging can be performed are not representative of what can be achieved within modern tool designs. With proper preparation and by working closely with operators, vendors and subject matter experts including pre-engineering, pigging trials and technical assurance along with minor adaptations to pigs, confidence can be gained that pigging is possible in pipelines with the ultra-low flowrates which are becoming increasingly common in the North Sea. Further, with subsea activation technology, specific areas of these pipelines can be targeted allowing operators to gain valuable insight into the condition of their pipelines and make informed decisions about their integrity status, using a risk based approach, to ensure they can continue to operate in a safe manner and meet the regulatory requirements.