THE APACHE INTELLIGENT PIGGING PROJECT

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Introduction

In-line inspection of offshore aging pipelines can become an increasingly challenging task, for example because of wax build up or depleting production and consequently low flows.

This paper discusses a recent example of such a case: the in-line inspection of PL120.

The challenge

Apache's PL120 is an offshore 18"-20" pipeline that transports stabilized crude oil from Beryl B to Beryl A platform in the North Sea.

The main pipeline characteristics were as follows:

- Large internal diameter variation, from 489 mm in the topside 20" pipework to 385 mm in the subsea 1.5D bends
- Heavy wall pipe ranging from to 17.5 mm to 50 mm
- 1.5D back-to-back subsea bends, coupled with the smallest internal diameter
- Short launcher and receiver dimensions
- 5 bar export pressure, 0.2 m/s average pigging velocity, and a maximum allowable operating pressure (MAOP) of 13.1 bar
- Located offshore, in the North Sea

Although the pipeline previously had favorable operating conditions for pigging, these conditions had worsened over time, which caused the inspection to be challenging due to a combination of factors, including:

- Operating at low pressure
- Operating at low flow
- Presence of wax deposits

Despite comprehensive cleaning campaigns, attempts to inspect the line using Ultrasound Testing (UT) technology failed due to excessive wax. Magnetic Flux Leakage (MFL) technology is generally more robust and less sensitive to waxy debris. However, the magnetic forces require higher differential pressures, which means that negotiating a geometrically complex line with unfavorable operating conditions is more challenging compared to UT.

The combination of a geometrically complex line with unfavorable operating conditions also limits the possibilities for cleaning campaigns. Aggressive cleaning pig setups, which would typically be needed to clean the maximum internal diameter (ID) section of the pipe, introduce a risk of creating a wax "plug" in front of the pig. This situation could result in the need for more pressure to push the pig than the MAOP of 13.1 bar.

The solution

In order to ensure the safe and continued operation of the pipeline system, APACHE approached ROSEN to develop an inspection solution. The pipeline was considered a high-risk asset due to having not been successfully inspected since its construction in 1983.

Apache's requirements included that the pipeline must be inspected on-line, with crude oil as the pigging medium. The MAOP of 13.1 bar was also a requirement for the inspection. The flow in the pipeline was typically around 0.1-0.2 m/s, so a combination of relatively low flow and low pressure resulted in challenging operating conditions for an MFL tool.

As a part of the project, the ILI tool had to be qualified by a pump test through a test loop. This test loop contained the range of internal diameters, similar bends, specifically the 1.5D heavy-wall back-to-back bends present at the base of the pipeline riser, and replicas of the short launcher and receiver barrels. Additionally, the operating conditions during the pump test were equal to those of the actual pipeline operating conditions.

Since no off-the-shelf solution existed, a customized solution was developed specifically for this inspection. The short traps required the tool to be compact and, in order to ensure sufficient seal at low friction, a unique PU design had to be developed. This was a challenge on its own, since high seal and low friction contradict each other; adding PU increases the seal but also increases the friction.

The goal was therefore to find the optimum balance between sealing and friction. This was finally achieved by adding sealing discs of varying diameter and harnesses in order for the tool to maintain sealing in all internal diameters. The sealing was distributed along the tool so the tool could more easily be pushed into the short receiver.

The PU set-up was developed through an iterative testing process, with the acceptance criteria defined as:

- The tool shall pass the test loop at a lower flow than what would be expected during the inspection, with negligible bypass.
- A differential pressure of less than 10 bar is required to negotiate the 1.5D back-to-back bends.
- There should be no visible damage to PU or magnetizer.

The pipeline is known to produce large amounts of wax. MFL tools, unlike UT tools, have the ability to penetrate wax layers to gather data on the pipe wall. However, MFL tools are also known to be very efficient cleaners, which increases the risk of a wax plug built up in front of the tool.

In order to minimize the risk of building up a wax plug, the MFL tool was optimized to negotiate the wax rather than pushing it ahead. For this purpose, a special combo magnetizer was designed. The benefit of this design is that comparable large gaps between the yokes allow for the wax to bypass, whereas the combination of two magnetizers ensures full coverage measurement. In order to minimize the friction from the magnetizer, the magnets strength was only as strong as needed for the pipeline.

In order to prepare for the inspection, and as part of routine maintenance pigging, the line was pigged generally once per week. One of these cleaning tools was also pumped through the test loop. In order to measure the differential pressure during the pumping trial as well as in the pipeline, a pipeline data logger (PDL) was installed in the cleaning pigs.

The PDL is a device that provides a time-based recording of pressure, temperature, differential pressure and inclination. The benefit of the PDL, in this instance, was that the cleaning tool behavior in the pump test loop was recorded and reviewed. This data was then compared to the data obtained when the cleaning tool ran in the Apache pipeline.

The highest differential pressure measured during the field run was 3 bar, compared to 5 bar in the test loop. This indicates that conditions in the test loop were likely more conservative than in the actual pipeline.

Furthermore, the PDL data from the cleaning run in the pipeline showed regular differential pressure peaks from the tool passing girth welds, indicating that the welds were not covered with wax. This observation provided further confidence that the pre-ILI cleaning campaign had reduced the wax to low enough levels for the MFL tool to be run.

Result

In February 2018 the inspection was completed successfully, smoothly and incident-free. Apache received essential information about the pipeline, confirming its integrity, with no negative impact on production, allowing them to continue safe operation of the pipeline.

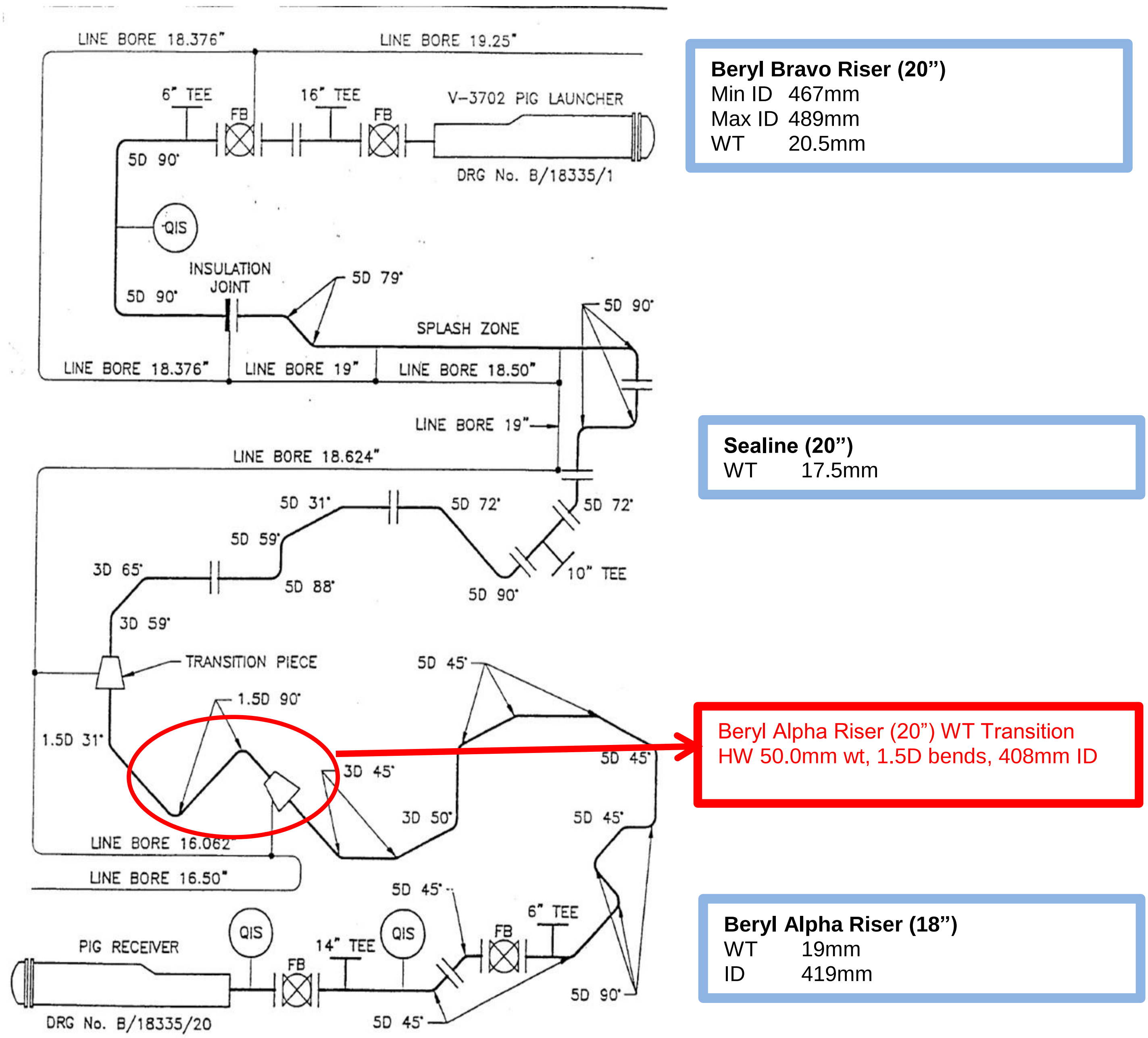

Figure 1 Pipeline schematic

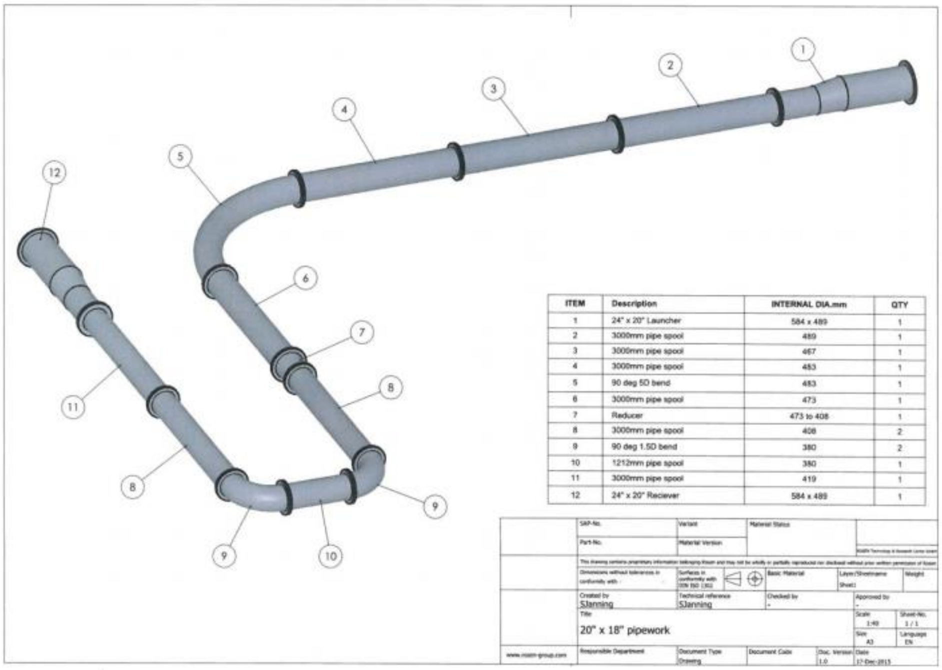

Figure 2 Test loop design

Figure 3 Test loop at ROSEN test facility in Lingen, Germany

Figure 4 Combo magnetizer optimized for negotiating ID range, wax as well as for full measurement performance in the PL120 pipeline

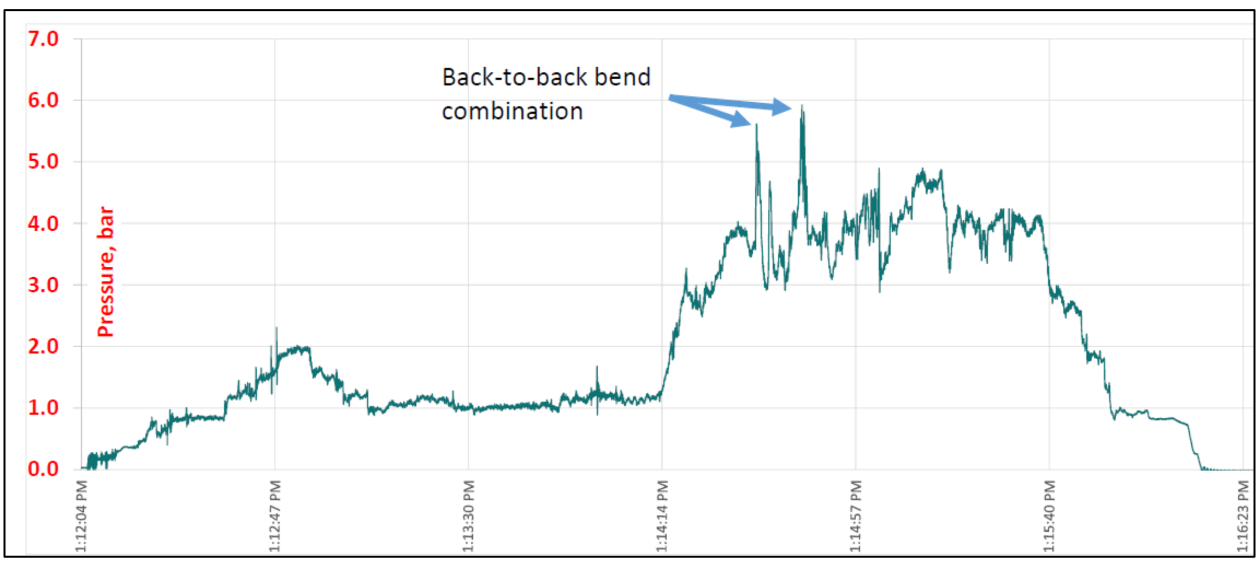

Figure 5 Differential pressure from the MFL tool in the pump test loop

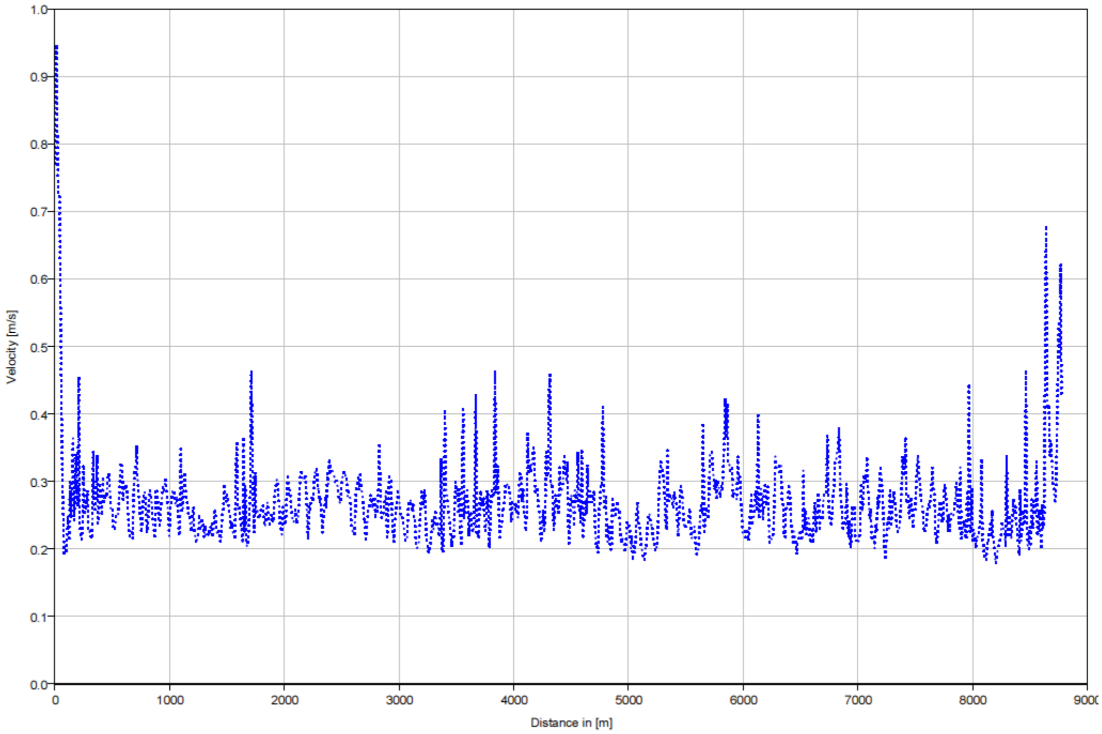

Figure 6 ILI tool velocity as recorded during the inspection run