EXPERIENCES WITH ULTRASOUND IN WAX RICH PIPELINES

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Abstract

In the past Statoil performed several pipeline inspections which failed due to wax covering the ultrasonic sensors and/or where the inspection tools odometer wheels had stopped due to build up of wax.

The phenomena were typically seen in wax rich pipelines. There were at the time no inspection tools on the marked that were fully suitable to be run in wax rich pipelines and at the same time collect inspection data over the whole pipeline length.

In most cases, the pipeline cleaning is the responsibility of the pipeline operating Company and such the inspection Contractors did not have any responsibility if the inspections failed due to wax settling on the ultrasonic sensors or the odometer wheels stopped due to wax.

This paper presents the work process taking place, from the first unsuccessful Ultra sound Testing (UT) inspection, resulting in a project to develop a UT tool solution which handles wax rich pipelines.

A new UT inspection tool was developed together with a supplier. The new technology have been utilised in several of Statoil's wax rich pipelines with good results. Statoil's experience from the utilisation of the new technology will be presented.

Introduction

The 16" 89 km long Troll Oil Pipeline 1 (TOR1) pipeline, running from Troll B platform to the Mongstad refinery comprises the following elements:

- Flexible riser
- Subsea pipeline
- Landfall (where the pipeline enters an onshore tunnel)
- Onshore pipeline/pig receiver

The most critical part of the pipeline, related to integrity management and of interest, is the land fall area at the onshore tunnel. In order to achieve acceptable wall thickness data, an ultrasonic wall thickness inspection tool had to be used.

In 2006 Statoil experienced an unsuccessful inspection of the TOR1. When removing the inspection tool from the pig receiver, it was seen that the tool was covered by wax.

After analysing the inspection data, it became clear the odometer wheel had slipped, and after 18 km the odometer wheels started to slide. When the Odometer wheels are turning the inspection tool is collecting data as normal, but in this case the odometer wheels stopped turning and therefore also the data collection stopped.

The wax had also settled on the ultrasonic sensors, resulting in the ultrasonic pulses not being able to enter the pipe wall, hence no echo.

Receipt of not clean 16" Ultrasound- based ILI after un-successful inspection of TOR1 pipeline at Mongstad 2006

After the unsuccessful UT inspection attempt in January 2006, Statoil realised the challenge with UT in wax rich pipelines.

A paper was presented by Statoil at the PPSA seminar in 2006 [1] covering the challenges related to inspection of wax rich pipelines. In the same time period Statoil decided to contact several In-Line Inspection Contractors and map the possibility of improving the tool design in order to achieve successful inspection of wax rich pipelines.

Based on feedback from the inspection Contractors, Statoil started a project, where the main goal was to be able to perform inspection of wax rich pipelines and specifically the TOR1 pipeline, where the previous inspection had failed.

Define the challenge

The project group had to identify the main reasons for previous inspection failure and explore the possibility to improve the technique.

The wax interfered with the ultra sound sensors as well as the odometer wheel resulting in loss of echo or loss of trigger signal for the sensor. Two main challenges where defined:

- Ensure inspection tool performing all necessary measurements (fire UT waves at all measuring points
- Ensure inspection tools capacity to actually measure the wall thickness of the pipe wall at all measuring points.

Based on the above challenges, Statoil prepared a scope of work and an enquiry was sent out to several Inspection Contractors, requesting them to identify possible tool modifications that could lead to a successful inspection in wax rich pipelines. The proposals from the Contractors was evaluated, both on a commercial and technical solutions.

Project Start

The project started in 2006 and was divided in four independent areas:

1. To obtain more detailed information about the wax contained in the crude
2. To obtain information about the thickness of the average wax layer adhered on the pipe wall
3. To study the weak points on a typical UT inspection tool
4. To develop an improvement programme accordingly

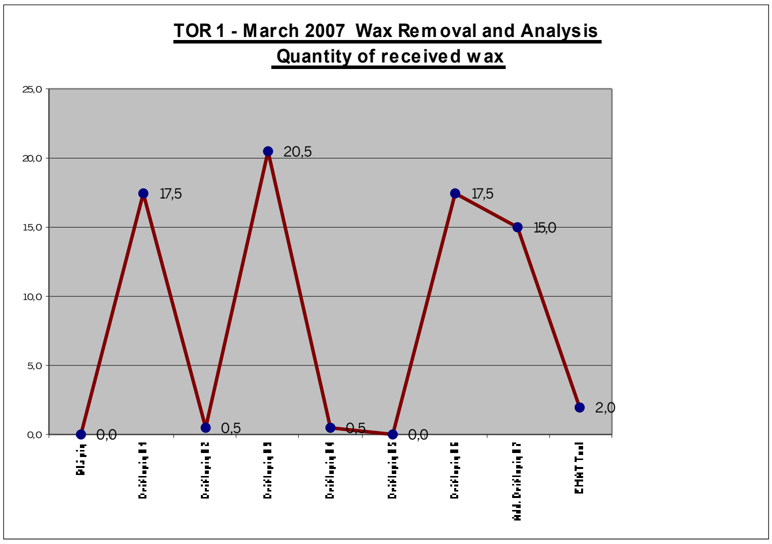
1. Wax Removal and Analysis

To obtain more details about wax settlement in the TOR1 pipeline 8 custom designed disc type cleaning pigs were run consecutively and at similar constant speed whereby all pigs were launched with new scraper discs each time.
At first one standard disc type pig equipped with a gauge plate followed by seven “cog wheel” type operational BiDi cleaning pigs.

Disc Type pig with gauge plate

“Cog Wheel” BiDi tools

As a result the amount of received wax was rather moderate but varied significantly between pig runs as can be seen in the graph below.



Graph showing amount of wax per pig run

However, the appearance of wax varied significantly from very soft, the photo to the left below, and slimy to rather hard and pebble- like, the photo to the right below.

Soft wax on cleaning pig

“Pebble- like” wax after cleaning run

Neither a trend could be identified nor became a certain pattern obvious. High temperature gas chromatograph analysis of the wax was performed, without providing valuable results.

2. Wax precipitation on pipe wall

Immediately following the cleaning pig runs an Eddy Current based ILI tool, see photo below, was launched. The aim was to inspect the wax layer thickness, position and orientation on the pipe wall.

The survey indicated that

- The deepest (“thickest”) features were towards the end of the pipeline
- The features were expected mainly between 10:00 and 12:00 orientation

Eddy Current - based ILI in receiver tray at Mongstad

The results from this survey did tell us we hade some wax still in the pipeline. It was difficult to draw any significant good conclusions from the results of this survey.

3. Identification of weak points on previously used Inline Inspection tools

Information from previous in-line inspections gave input to a root cause analysis. The results from the analysis were the following:

- Poor self cleaning ability of sensor carrier resulting in poor ultrasound signals and subsequent data loss of up to 80%, see group of photographs below top.
- Tendency of odometer wheels clogging in wax, resulting in interrupted signal trigging UT sensors, see group of photographs below bottom.
- Data recording dependency on proper odometer performance.




Example of wax covered sensor carriers on top and odometer wheel on bottom.

4. Modification programme to an ultrasound based in-line inspection tool.

Already back in 2006 Statoil approached several vendors of ultrasound based in-line inspection services to participate in an improvement programme for robust ILI operation in wax rich pipelines. One vendor accepted the invitation and joined the project.

Following Statoil’s requirement summary a joint team brainstormed the critical areas and developed a scope of work as well as functional requirements. A five– step approach had been chosen:

A. “As is” analysis of the identified areas
B. Testing of critical areas following the analysis
C. Design and manufacturing of optimised parts following test results
D. Full Scale flow testing of modified parts and areas
E. Test the modified UT inspection tool in the TOR 1 pipeline

A. “As Is” Analysis

The focuses were on the odometer units, including the trigger mode, and the sensor carrier.

On the odometer unit, previous experienced results from failed ILI showed that wax rich conditions in the pipeline would let the odometer wheels suffer from clogging at an early stage. The existing wheel arrangements would neither cater for self cleaning nor would the applied friction forces allow for continuous rotation under harsh conditions. The odometer unit is triggering the UT measurements by increased distance seen by the odometer wheel. If the odometer wheel stops, no measurements are executed.

On the sensor carrier, the heavy wax precipitation on the individual sensor bars often lead to poor sensor signals and it showed that installed self cleaning devices (dp- based flushing) could not reliably solve the problem.

B. Testing of critical areas

The applied forces on the odometer wheels were measured and documented. The resulting friction parameters were identified.

Surface and shape of the sensor bars as well as flow capacity over the sensor track were modelled and analysed in wind canal tests.

C. Design and Manufacturing of optimised parts

Modified odometer wheels with an increased diameter and optimised shape were designed. Further higher spring forces on the odometer arms were included in the new approach allowing for better traction of the wheel on the pipe wall. Additionally the odometer positioning on the tool train was changed from mid tool to the rear end of sensor carrier. This way wax accumulated between tool bodies would no longer lead to clogged wheels due to fill up of limited volume between tool units. Instead the chosen new position would allow for free “tail flow” of potential wax lumps. The inspection tool was also set up to trigger the measurements by time and not distance. Hence the UT inspection tool will be independent of the odometer wheel movement.

On the sensor carrier the results gained from modelling and subsequent wind canal tests, the liquid flow over the sensors could be increased. Also the area of the flow inlets to the sensor bars was increased. Both measures were intended to improve the carriers’ self cleaning ability particularly in handling heavier wax.

D. Full Scale Testing

An approximately 50 m long 16” test site was built and ready in November 2007.

For improved monitoring and visualisation of flow effects the layout included an 1100 mm long acryl glass spool. The entire inspection tool was tested under conditions comparable to the Troll 1 pipeline. Besides others the main goal was to verify the plausibility of the flow modelling/ wind canal tests results which could be confirmed. The flow dependent parts could then be finalised and planned to be used for a next ILI of the TOR1 pipeline. Pictures of the flow loop can be seen below.

16” Test site

Acryl glass spool

Test ILI in TOR 1 pipeline

The results from the full scale test were implemented and the in-line inspection tool was prepared and launched in March 2008.
The evaluation of inspection data showed echo loss rates below 1 %. The inspection data covered the entire pipeline length and circumference. The quality of the inspection data were considered good. Photos after inspection tool run are shown below.

Receipt of clean 16" Ultrasound- based ILI after successful inspection of TOR1 pipeline at Mongstad

Statoil's experiences with other wax rich pipeline have showed the same results; low echo loss rates and UT measurements covering the entire pipeline circumference and length. Statoil's experiences are from 12" to 28" wax rich pipelines. The photo below is from Statfjord B.

Famous picture from Statfjord B, this pipeline is also successfully inspected.

Conclusion

It is possible to successfully inspect wax rich crude oil pipelines with ultra sound tools.

References

[1] Pigging of Pipelines with High Wax Content, PPSA Aberdeen Seminar 2006, Alf Tordal Statoil ASA, Stavanger, Norway