Exploring every avenue

Johannes Keuter, ROSEN Germany, details the inspection of an offshore loading line in South America.

There are different types of critical assets in the oil and gas industry that need to be properly managed by operators in order to protect the environment, enable efficient use, and extend the assets' serviceable life. One type is loading lines, which are often located in high-consequence areas and transport medium from onshore tank farms to offshore anchoring. Although integrity management is not just about putting an inline inspection (ILI) tool into the line, but much more about analysing data and making decisions regarding maintenance and repair, sometimes collecting the data is a real battle. Each case needs to be addressed specifically.

Case study

Constructed from 1994 to 1997, the pipeline in discussion must resist several integrity threats such as external corrosion, weather, and external forces, as well as third-party damage. The line is equipped with three barriers to minimise external corrosion, including external concrete coating, cathodic protection, and a certain wall thickness in order to consider a reasonable corrosion allowance.

Previous inspections identified external corrosion close to welds, which was classified as microbiological corrosion (MIC). These anomalies were to be inspected with a higher resolution in order to optimise the integrity management plan. Furthermore, any need for immediate action, for instance due to free span caused by erosion, had to be identified via a geometry inspection. This inspection was also used to identify any third-party damage liable to reduce the internal diameter (such as anchor damage) and verify the passage of the ultra-high-resolution magnetic flux leakage (MFL) ILI tool.

ILI of pipelines usually require a launcher and a receiver to insert and remove the tool properly. Loading lines do not have a receiver; instead, they feature a subsea pipeline end manifold (PLEM), making it impossible to launch and receive the inspection tool in the customary way. Instead of a unidirectional inspection, a bidirectional inspection would be required, which would mean that the inspection tool could be inserted into and removed from the same trap. This specific application requires some specialties in regard to tool design. In this project in South America, more than just a bidirectional inspection was necessary. In order to achieve the highest possible quality in data, the most advanced measurement technologies were chosen.

The solution

ROSEN Group provided advanced measurement technologies, including high-resolution geometry inspections (XT) and ultra-high-resolution MFL inspections (MFL-A Ultra). The latter enable lifelike images of a pipe wall's structure and corrosion anomalies. These inspection technologies were combined with XYZ inspection, with an inertial mapping unit (IMU) and subsea georeferencing to facilitate a bending strain assessment.

Although some ILI technologies are quite robust in withstanding deposits or debris in the pipeline, high-resolution technologies, in particular, require very clean conditions in order to provide the best possible data quality. A normal bidirectional cleaning approach would have cleaned the pipeline in both directions and pushed the removed debris into the PLEM, which was not acceptable. Therefore, ROSEN used a customised asymmetric cleaning approach. This approach is designed to minimise the cleaning effect while the tool is moving from the trap to the PLEM, and to maximise the cleaning effect on the way from the PLEM to the trap. The PLEM was kept free of debris, which was pushed to the receiver side and properly disposed of.

The development of the ILI tools and the organisation of the subsea georeferencing were carried out in parallel. As part of this development, ROSEN modified a high-resolution geometry ILI tool to enable bidirectional application. These tools normally use several sensor arms equipped with different types of sensors that are in contact with the internal pipe wall. Combined, the dipper and the proximity sensor data render the high-resolution internal shape of the pipeline and internal geometry deformations, such as dents.

One sensor uses eddy current technology, which can also be made touchless. As a result of this ability, it was decided to adjust the sensor arms in a certain, constant distance (lift-off) to the internal pipe wall. This can be achieved while keeping the same performance specification in regard to detection capabilities and measurement accuracies. Without getting into any contact with the internal pipe wall, the sensor arms were ready for a bidirectional application. In combination with further design changes, a bidirectional cable ILI tool was provided. This tool was tested with pull tests prior to the inspection, in which the tool was pulled with different velocities in both directions. No mechanical damage was visible, and high-quality data was recorded, confirming proper capability.

ROSEN introduced ultra-high-resolution MFL technology to the market several years ago; it is provided as the RoCorr MFL-A Ultra inspection service. Multiple inspections have taken place over the last few years, allowing operators to optimise their integrity management plans. However, all inspections have been performed unidirectionally, which is why a new design for a bidirectional application of this technology had to be developed for this project. No restrictions of the performance specifications were acceptable, as the technology would need to detect and size very small anomalies associated with external MIC close to the welds.

In combination with sophisticated data evaluation, this technology is designed to allow advanced sizing and anomaly cluster definition, to better prioritise the intervention plan. The sensor carrier design with flexible mounted sensors normally uses sensor ring designs that are optimised for unidirectional application. This design has two layers of sensors in order to get full coverage of the circumference of the pipeline. As such coverage was mandatory, the design had to be changed completely. A sensor carrier design for bidirectional application was developed. The carriers were cast with polyurethane, and the combination of steel and polyurethane led to the capability for bidirectional use, while still having full coverage.

This design was also tested in ROSEN's test yard in Germany prior to the inspection. For these tests, artificial anomalies were defined and manufactured into the test spools, including artificial external anomalies close to the weld. These reflected the expected external MIC in the actual pipeline. After the pull tests with different velocities, the carriers were proven and checked for any damage. Data evaluation experts assessed the recorded data, and the artificial anomalies were detected and sized properly. Finally, all acceptance criteria were reached and high-quality data recorded with the ultra-high-resolution MFL-A Ultra tool in this specific bidirectional design, and the technology was released for use in the field.

Obtaining the data

Once all cleaning tools, ILI tools, equipment, and a team of experts had arrived on-site, a tanker was organised and 'parked' 50 m from the PLEM to receive and pump the oil that would

Figure 1. Loading lines only have one launch/receive site, making bidirectional inspection necessary.

Figure 2. Tool tracking and logistical planning are vital to inspections of loading lines to ensure optimal operation.

allow propulsion of the tools. This logistical challenge required co-operation between ROSEN and the operator. Before continuing, the subsea georeferencing was prepared, which was a complex task. Subsea georeferencing uses magnet markers and differential global positioning system (DGPS) at short intervals between reference points to ensure accuracy. In combination with a specific procedure and further equipment, subsea georeferencing in combination with the marker detection by the ILI tools ensures that the pipeline trajectory is fully covered.

The execution of the inspections required round-the-clock work, and therefore an optimal organisation of the on-site team to guarantee success in the given timeframe. The ROSEN team would alternate to have the necessary experts available at all times. The team was divided into multiple locations along the pipeline route. The first group started with the trap area to prepare the cleaning and ILI tools, execute the installation into the trap, and launch the tools. The second was responsible for the tool tracking with electronic pig detectors onshore and offshore, to ensure that the location of all tools was known. The third team – placed on a boat and on the buoy close to the PLEM – monitored the most critical section of the pipeline just before the PLEM. Neither the cleaning tools nor the ILI tools could enter the PLEM. This would cause them to get stuck, because no flow could be provided within the PLEM. They were stopped before that by the accurate determination of the tool location, and the corresponding adjustment of the flow. ROSEN worked closely with the operator and shared the tool location, which allowed the client to adjust the flow accordingly and stop the tools.

Results

In the end, minor geometry deformations were identified, and the high-resolution data could be used for a detailed analysis of each anomaly. For example, finite element modelling (FEM) methods and dent strain analysis were used in order to assess the most critical anomalies and their potential influence on the pipeline's integrity. The subsea markers were also detected by the ultra-high-resolution MFL tool, and used for the correlation of the anomalies, pipeline 3D trajectory, bending strain, and pipeline movement assessments. This allowed integrity engineers to accurately determine any pipeline curvature coming from free span, anchor, currents, or ground movement.

The ultra-high-resolution MFL data was compared with the high-resolution ultrasonic data from 2014. Two charts were created to show the dimensions of the anomalies and the estimated repair factor (ERF), which is a popular value used as part of an ASME B31G assessment. The more accurate data allows a less conservative and more realistic assessment of the pipeline's integrity, which can save money by avoiding unnecessary repairs and providing the operator confidence in safe and reliable pipeline operation. Additionally, the two data sets of the inspections in 2014 and 2019 can be used to monitor corrosion growth rates to predict when repairs have to be carried out. All this information allows the operator optimal pipeline integrity management in order to protect the environment, enable efficient use, and extend the serviceable life of their assets.