Unpiggable **no more**

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Rosen's Challenging Pipeline Diagnostics Division has, for the first time, used an MFL-equipped robotic-propulsion unit to assess the condition of a vent line that was previously considered unpiggable.

Offshore subsea vent lines are a crucial part of processing systems. They are designed to ensure the safe disposal of the excessive hydrocarbon gas inventory in the installation during operation, emergency or shutdown situations.

Since the gas cannot be stored or commercially used and therefore must be released, it is essential that the risk of fire and explosion be reduced by venting the excessive gas at a safe distance from a platform. Because these pipelines provide such important safety measures, operators consider vent lines as equally important as other pipeline systems, and are therefore eager to have a comprehensive knowledge of their integrity.

In-line inspection (ILI) is the most reliable and accurate method for collecting the highest-quality data possible on the asset. However, vent lines were not designed to be internally inspected, nor had a successful inline inspection of a vent line ever taken place.

In response to this growing need in the industry, Rosen began an in-house assessment of potential ILI solutions for these complicated offshore assets. Various options were explored and assessed in great detail, including the free-swimming approach, umbilical approach, and the robotic-crawler approach.

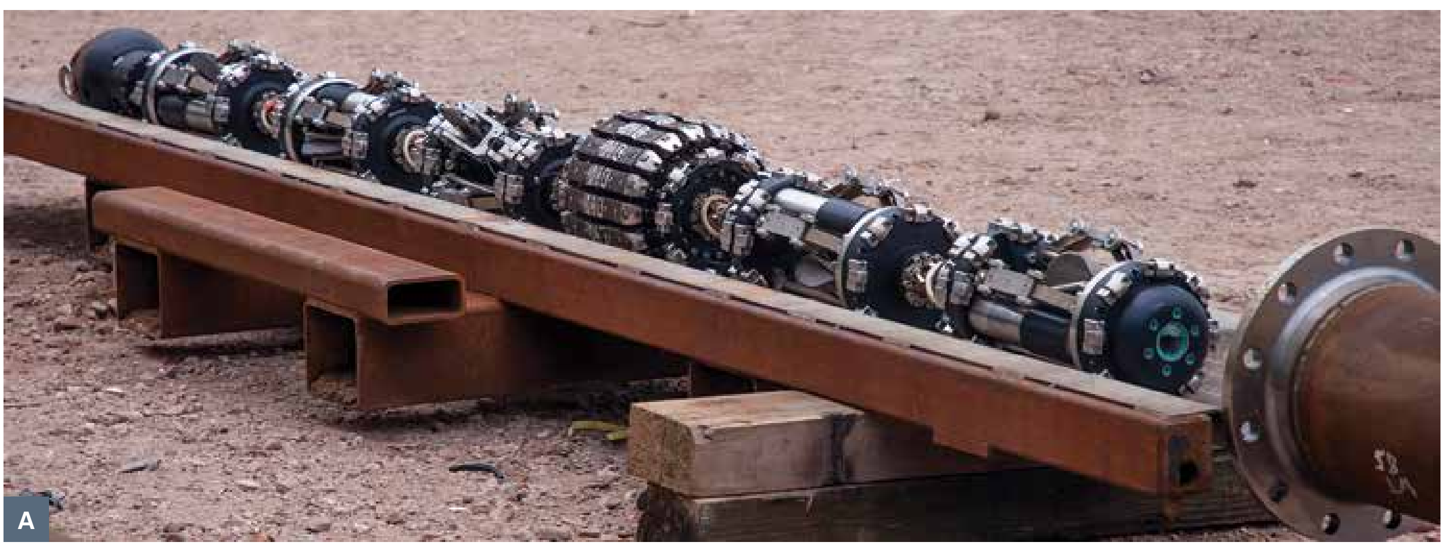
THE CHALLENGE

Rosen's Challenging Pipeline Diagnostics Division was well prepared for the challenge of performing an ILI on the previously unpiggable 10- inch subsea vent line, offshore Borneo. The operator's inspection goals were to identify the presence of any internal or external corrosion.

After a comprehensive assessment of the asset, the Rosen team identified several challenges that needed to be addresses for a successful ILI. These challenges included:

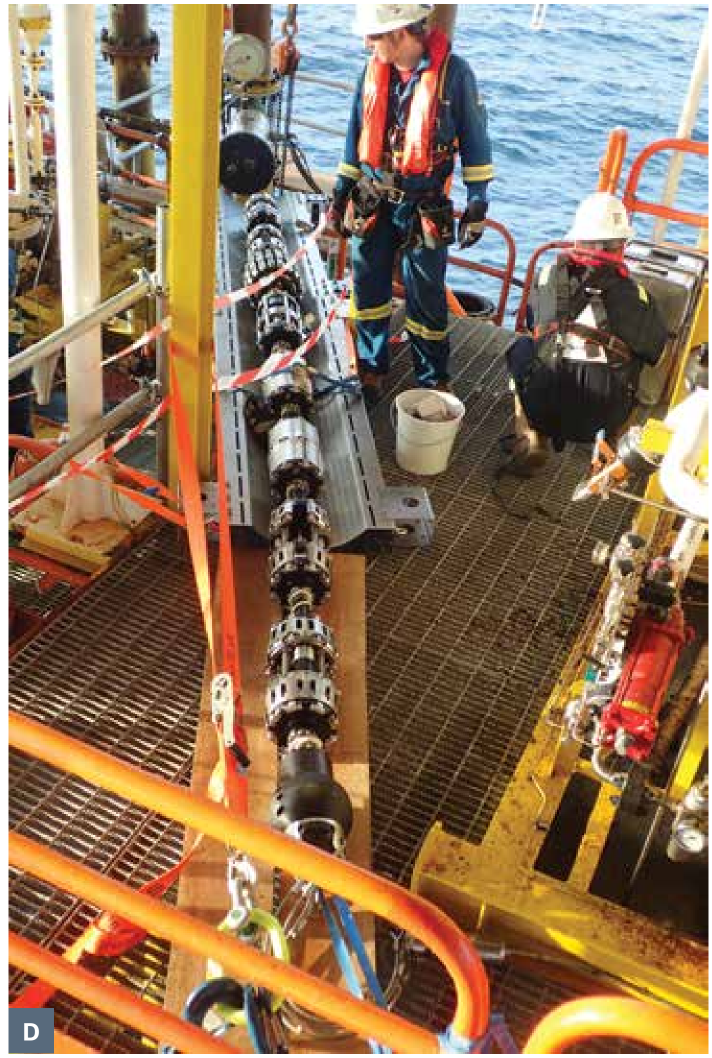
- no conventional access for ILI tools
- limited accessibility (the pipeline was only accessible from the main platform)
- no or very low flow and pressure
- no previous inspection knowledge
- unknown cleanliness.

After reviewing the limitations, it was determined that the most viable solutions for moving forward with an inspection would need to be based on low-friction technology, have bidirectional and self-propulsion capabilities, and be able to cope with moderate amounts of debris. Additional boundary conditions were set by the operator, including that the inspection be



A

B



A: Robotic-propulsion unit with MFL technology (10 inch configuration without batteries).

B: The configuration of the robotic-propulsion unit allowed for both vertical and horizontal bi-directional movement and distance tracking.

C: The solution was tested extensively at the replicated vent line in the testing field in Lingen, Germany.

D: Due to space limitations at the platform, the robotic-propulsion unit was launched horizontally.

performed during a regularly scheduled shutdown, that no liquid filling be used, that subsea and vent tower activities be kept to a minimum, and that the inspection introduce zero risk to the vent line's operational abilities.

Various mechanisms, both procedural and mechanical, may allow for an inspection tool to manage these challenges and traverse obstacles, such as small deformations and debris. The real difficulty often lies in installing reliable failsafe measures that ensure the safe retrieval of the tool, should it encounter an impassable obstacle or experience a malfunction.

Finally, the greatest challenge relating to this specific inspection was that a comparable inspection had never been completed before.

As there was no benchmark to work from, testing facilities and methods had to be created and formulated from scratch to account for the challenges associated with this offshore vent line inspection.

THE SOLUTION

After meeting with the customer and assessing all available information on these unique assets, Rosen's Challenging Pipeline Diagnostics Division recommended the use of a robotic crawler unit. As a result, a sophisticated 10 inch robotic-propulsion unit was developed.

Rosen drew on its established toolbox method, which combines various sensor technologies, access elements, and propulsion units to tailor a solution that is specific to the needs and expectations of the operator regardless of the challenges associated with the pipeline. In this case, the solution included specialised-cam driving components that provide an increase in pull-force capabilities, allowing for the utilisation of extensively tested high-resolution magnetic-flux-leakage (MFL) technology.

The design also contained both vertical and horizontal bi-directional movement capabilities and distance tracking, all of which were critical for this application. In order to confirm the tool had the capabilities to negotiate the vent line, the inspection conditions were replicated with the construction of a test tower and loop at Rosen testing grounds in Lingen, Germany.

E: Vent lines reduce the risk of fire and explosion in processing systems by releasing the excessive gas at a safe distance from the platform.

The structure consisted of a vertical riser containing a pipeline exceeding 20 m in height, with a 3D bend situated at the bottom of the pipe to transition the pipe from vertical to horizontal. The horizontal section consisted of one 3D bend with two straight pipe connections. The self-propelled robotic-propulsion unit successfully made its way through this test loop and crawled up the 20 m long vertical riser unassisted.

To ensure zero risk to the future operation of the valuable pipeline, various failsafe measures were implemented, including visual and sensor monitoring to allow for the safe approach of possible deformations and tees, as well as onboard power storage and monitoring. A tethered retrieval unit was also installed to ensure the tool could be pulled out in the event of failure.

The cams on the propulsion module were programed to collapse into a 'failsafe mode' in the event of a limited power supply, allowing for the tool to be easily removed from the pipeline if necessary. After extensive testing and tool configuration, the robotic-propulsion unit was approved for the inspection.

Both horizontal and vertical launching/receiving approaches are generally possible, depending on the setup of each individual platform. For this inspection, the horizontal launch was preferred due to access constraints.

On the riser, a transition spool was replaced with a 2.5D elbow to create an appropriate entry point that transitioned the tool from horizontal to vertical. During the 29-hour operational shutdown, an explosion-safe atmosphere in the pipeline needed to be established, which was achieved by introducing nitrogen into the pipeline opening prior to tool loading. A continuous inflow of nitrogen ensured an overpressure in the pipeline, which prevented any ingress of air.

During the inspection, the robotic-propulsion unit functioned properly and was able to manoeuvre in and out of the pipeline as expected, successfully negotiating the 645 m section of pipe without the need to use the retrieval contingency. Throughout the inspection, all functional components and communication remained fully operational and the data collected met all reporting requirements.

The inspection was the first time an MFL-equipped robotic-propulsion unit had been successful used for the ILI of a subsea vent line. Following the groundbreaking achievement, Rosen has subsequently completed multiple inspections in the Borneo area.

The inspection has allowed the operator to obtain a comprehensive understanding of the asset, with no loss in production or negative impacts on pipeline operations. The optimised high-resolution MFL measurement unit successfully detected and accurately measured internal and external pipeline anomalies such as corrosion, girth weld features, and mill defects.

The full integrity assessment enabled the operator to move forward with critical integrity management, while securing the safety of the environment and platform workers, as well as managing public perception. **P**