
A 30 inch bi-directional tool with temporary pipe spool upon completion of first inspection run.

Getting a grip on non-piggable lines

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Looking back at a few decades of intelligent pigging, it is amazing what the industry has achieved. Accurate and free flowing inspection tools using high sensitivity sensors and specially designed on-board electronics operate in harsh environments to collect faultless data sets. Increasingly, the industry is focusing on so-called 'unpiggable' or difficult-to-pig pipelines.

This article will focus on four case studies of such pipelines, and address four extremes in the field of oil and gas transmission lines: low flow pipelines, high flow pipelines, bidirectional operation and multi-diameter pipelines.

Low flow pipelines: the Guinness Book of Records run

A typical example of such a line is the 20 inch, 84 km pipeline which brings crude oil from the North Sea to the onshore storage and processing plant. The pipeline has been in operation since the 1970s and the field has exhausted. Currently, the export pipeline is operating at a velocity of 0.03-0.04 m/s and maximum 7~8 barg operating pressure. Calculated over a distance of 84 km, this results in a pigging run time of 27 days. It goes without saying that this is a real challenge, both for the cleaning and inspection of the pipeline.

A small leakage across the pig may result in loss of propusion and the pig may get stuck. If debris accumulates in front of the cleaning pig, drive-pressure may rise and the pig might again stall in the line. The inspection tool will require a very dependable system for data collection, data storage, and power supply in order to make a successful pig run.

With a number of pig runs that take about one month each and the various onshore and offshore mobilisations, this project turned out to be a unique case where the actual field work and run time of the pigs exceeded the

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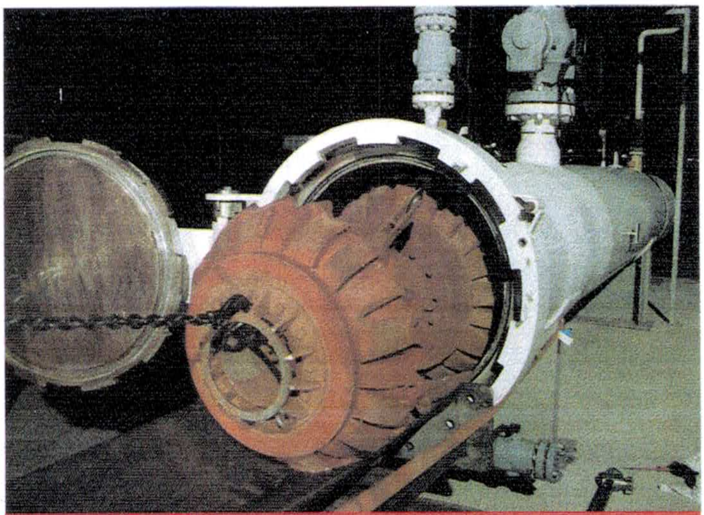
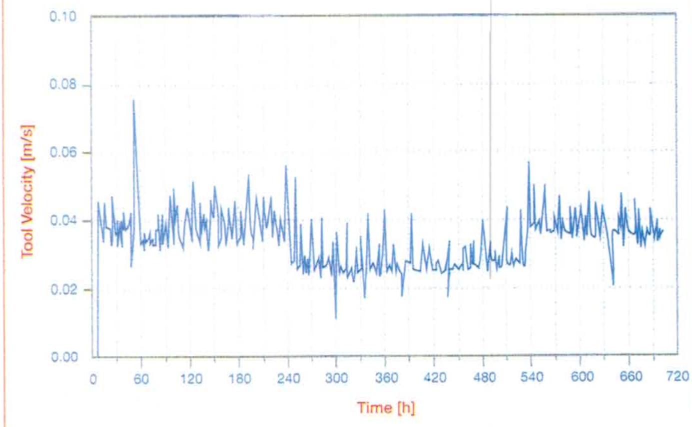


A 32 x 24 inch multi-diameter MFL being retrieved after a 153 km pig run.



The velocity profile of a low-flow pipeline: 700 hours at an average of 0.04 m/s.

post processing and data analysis. After ample considerations, cleaning with the aid of chemicals was discarded and the pipeline was cleaned with a relatively soft and flexible bidi pig. Since the inspection technology chosen was high resolution MFL, it was anticipated that the inspection tool would be forgiving towards a sub-optimally cleaned line and still collect useful data.

After successful cleaning of the line, a caliper tool was run to collect the geometrical data. This data was first analysed to make sure no unforeseen features were in the line that could prevent a safe passage of the intelligent pig. The MFL tools required special preparation. The board computer and sensor pads were subjected to a real full scale test, to make sure that the system would operate without flaw for a continuous period of one month. The power packages were specially designed, using special circuits and multiple fuse and safety systems to make sure the system could never generate unsafe current modes. Finally, the pig was launched and, after a total run time of 720 hours, it was received in perfect condition.

The tool had collected >99.9 per cent data, all of it good quality. This extreme case study of low-flow pipelines has proven that these lines are now within the realm of piggable pipelines.

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Bi-directional pigging

An example of this type of inspection occurred during inspection of a long distance oil transmission line in Central Europe with intermediate pumping stations and tank storage. The pipelines towards the storage tanks are all 30 inch in diameter and vary in length from 100-500 m. Most of the pipeline is buried, having 1.5D radius bends. The pipeline has no pig traps – oil is pumped from the central pumping station towards the storage tanks and it flows back by gravity. In order to get a complete assessment of the pipeline integrity, it was decided to conduct an in-line inspection.

The aboveground section of the pipeline had flanged spools which could be taken out relatively easily. A temporary pipe spool was created that could act as a temporary pig trap. The spool is complete with connections, flanges and attached piping and hoses to operate in both flow directions. A temporary pump spread was brought to place to create flow in the line from the storage tanks towards the pumping house. The pump of the pumping house would be used to create the reverse flow and move the tool back towards the temporary pumping station.

A real size mock of the system was first built in the yard in order to check the MFL tool flipover pressure and behaviour. When this was proven successful the system was brought to the field.

Five of these pipelines were inspected in one mobilisation. The work in the field included: (1) mechanical work on all lines – removal of existing piping, installation of temporary piping, and reinstatement of the original piping in order to bring the pipeline back to its original status; and (2) operational work – inserting the pig, pig tracking and pumping. In addition to the field work, all lines were analysed in accordance with the prevailing standards.

Field work on all five lines together was completed within three weeks and all lines reported successfully. The tools operated at flows below 2 barg pressure, including the static pressure of the storage tanks. The project proved to be a very time- and cost-effective method for inspecting non-piggable pipelines in tank farms, loading lines and jetties.

Multi-diameter pipelines

A great number of multi-diameter pipelines exist, which may range from next-size diameter variations to larger and more extreme differences. They may be due to valve stations, river crossings, connection of two previously separated pipelines, or the pipeline may simply have been designed that way. This case study refers to a major gas trunk-line in Central Europe that transports gas for domestic, industrial and power-plant use.

The mainline is designed at 32 inches, but it connects to a major river crossing – already in place for a couple of years – of 24 inches. The result is a difficult configuration, where the pig not only has to collapse from the first, large section into the second, small diameter, but has to expand again to traverse another 100+ km in the large diameter pipe. The tool needs to be optimally centralised and sealed in the last section to guarantee a successful pig passage and measurement.

A self-centralising and flexible MFL measurement module was developed, pulled by a module with board computer and odometer. Special design cups were developed that provide two important features: (1) the cups easily collapse and give minimum friction in the small diameter pipe. As a result, there will be minimal difference in pressure in both pipe sections. This is important at the point where the pig enters and leaves the reduced bore: a high differential pressure would result in a large expansion of gas when the pig enters the large section again and an associated speed excursion – having prevented this, all data collected is useful for evaluation. (2) The cups are highly flexible and have sufficient self-centering capability so that the pig will travel in a good in-line position through the remainder of the pipeline.

Again, before the field work was conducted, a real 1:1 mock-up model was built in the yard with an exact copy of the pipe reducer, in order to ensure a smooth transition of the pig in both ways. Prior to the inspection run, a cleaning pig with magnets and spider nose was run through the line in order to ensure that the smaller pipe section in particular was free from debris that could impact the passage of the inspection tool.

A dual-size caliper pig was run, with two measurement units, in order to get proper geometrical data from all pipe sections. Inspection data proved to be 100 per cent within specification and multi-diameter lines are now inspectable without the need for exorbitant prices or high-impact mechanical work, or dividing the line into its different diameter sections.

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High-flow pipelines

The last case study refers to pipelines at another extreme of operation: high gas flow. MFL tools will function properly up until velocity of approximately 4 m/s. The faster the tool moves, the stronger the induced magnetic field that originates from eddy currents induced by the moving magnetic field.

The eddy-current-induced magnetic field works opposite the magnetic field of the tool, reducing the overall level of magnetisation. As a result, the magnetisation will drop below 10 kA per metre and inspection data will not meet the required level of accuracy and confidence.

Reduction of gas flow would be required in order to achieve a successful inspection. For several reasons, reduction of gas flow may not be feasible, be it from an economic perspective or from strategic power considerations.

In order to move the tool through a high production pipeline, an active speed control unit was designed which regulates the amount of gas bypass through the tool while moving through the pipeline. Again, a trial set-up was built in order to investigate the behaviour of the tool at various speeds and the computer unit of the speed control device tested. The bypass valve system was also tested in static and dynamic conditions in order to get a close picture of the system in the pipeline. Finally, the fail-safe mechanism was tested in order to ensure that, whatever the condition of the tool and the gas flow, the inspection tool would always travel to the receiving station.

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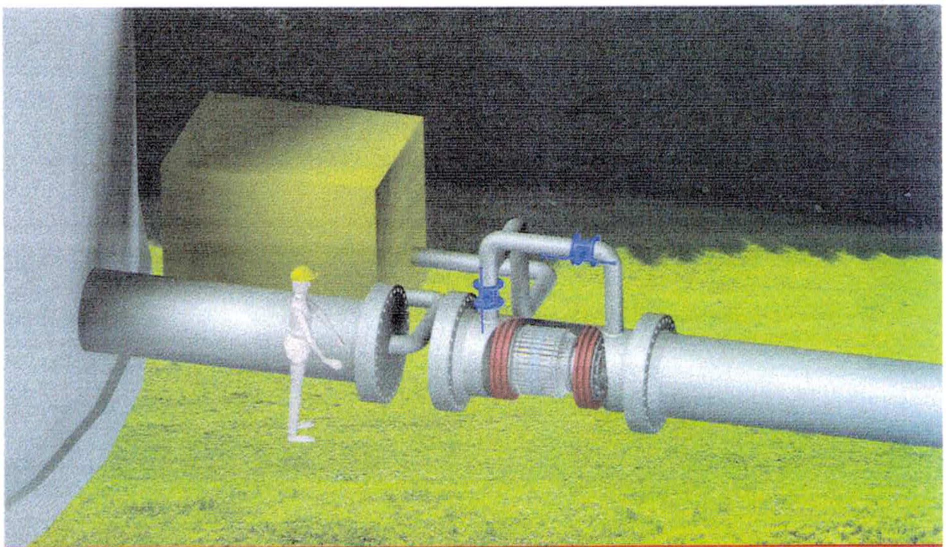
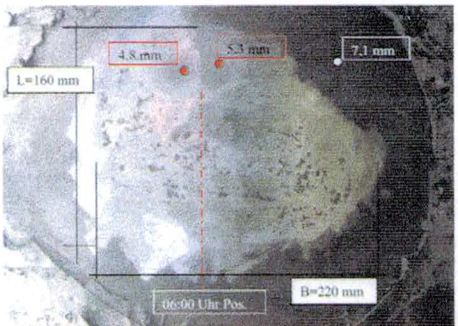


A temporary pipe spool and pump spread used for bi-directional pigging of a non-piggable line.



Pitting corrosion accurately detected and sized by XHR MFL tool.

MFL tool with active speed control successfully retrieved after long distance subsea pipeline inspection.

The high resolution MFL tool with inertial navigation system and active speed control unit (ASCU) was brought to the field to inspect a 28 inch, 250 km subsea gas transmission line. The operation for the ASCU was evaluated upon completion of the pig run and the tool had travelled at the pre-set conditions of 3-4 m/s in a gas line, with velocity of 5 m/s at launch, heading towards 9.5 m/s at the receiving end.

Conclusions

This article has discussed several examples of pipeline conditions that would be considered 'non-piggable' in the conventional sense, either from a constructional or from an operational point of view.

By using new design of the MFL module and associated technology, difficult-to pig pipelines are now within the scope of pipeline inspection and pipeline integrity management.

Pipesurvey International is a full member of the Pigging Products & Services Association. For more information, go to www.pipesurveyinternational.com or www.ppsa-online.com