Inspection of a hydrogen pipeline

In recent years, the demand for alternatives to hydrocarbon fuels has been steadily increasing for different reasons. One important goal is to slow down global warming by reducing the pollution of the air and the environment, as well as the emission of greenhouse gases, while another goal is the elimination of economic dependence.

One way to decarbonise our future is investing in the hydrogen economy, as the only byproducts of hydrogen power are water and heat. The availability of hydrogen is unlimited, and a hydrogen-fueled energy infrastructure can be locally produced, meaning countries can power themselves independently without having to rely on external energy suppliers.

Hydrogen can be extracted from a wide range of substances, including oil, gas, biofuels, sewage sludge and water. The cleanest way to produce hydrogen is to extract it from water through electrolysis, which requires electricity.

For the process to be truly green, this electricity must be produced with renewable energy. This is where the loop closes; since hydrogen is a reliable and efficient energy carrier, it potentially solves the biggest challenge currently faced by renewable energy: its storage and transportation.

Therefore, replacing fossil fuels with hydrogen produced by renewable energy would enable completely carbon-free power generation.

A report from the International Energy Agency – requested by Japan under its G20 presidency – found that "clean hydrogen is currently enjoying unprecedented political and business momentum, with the number of policies and projects around the world expanding rapidly." However, less than 0.1 per cent of global hydrogen production today uses water electrolysis.

Natural gas is still the main source by far, providing three quarters of the current 70 million t of hydrogen worldwide.

The US alone produces 10 million t of hydrogen each year, with approximately 2,574 km of hydrogen pipelines operating in the country. Research currently focuses on solving challenges related to pipeline conversion as using existing gas infrastructure offers ideal conditions for storing, transporting and distributing increasing amounts of hydrogen.

However, this requires significant modifications to the pipelines due to the physical and chemical properties of hydrogen. Hydrogen is very small and mobile, which enables it to permeate various

ILI tool on arrival at the receiver.

materials, including plastic and steel.

This may lead not only to leaks of much higher volume than with natural gas, but also to the embrittlement of pipe material, thus speeding up cracking of the pipeline walls. To prevent this from happening, hydrogen pipelines must be subject to thorough and rigorous integrity management.

The pipeline industry has been taking close note of the increased demand for hydrogen – and the accompanying requirement for hydrogen transport pipelines – over the last decade. However, there are currently very limited inline inspection options that do not require taking these lines out of service or the use of nitrogen, which can be costly for operators.

A CASE STUDY

A 19 km pipeline segment, 10 inches (254 mm) in diameter and installed in 1996, was set up for the transport of hydrogen. When this line segment was initially inspected by a smart tool, the industry was not prepared to run their tools in such explosive environments.

The only way to inspect hydrogen pipelines was by utilising water as a propellant; however, this process comes at a high cost to the operator and can be quite time consuming, as it requires the line be taken out of service for the inspection and the necessary drying process.

As the industry gained a better understanding of the requirements for these environments, the operators pushed for more cost-effective solutions.

TOOL SETUP FOR HYDROGEN

In 2015, the operator approached ROSEN for a method to safely inspect the line segment with a combination of geometry and magnetic flux leakage (MFL) technologies. The following

The ATEX-compliant MFL ILI tool.

measures allowed ROSEN to successfully complete the requested inspection in January 2017 and again in 2019.

For any inspection conducted in an explosive atmosphere, tools are set up in compliance with the European Union's ATEX directives. This allows for a considerable reduction of risk in such a project by preventing the occurrence of sparks within the tool, providing a flameproof enclosure for the components, having a pressurised enclosure for the electronics and utilising intrinsic safety with voltage-restricted electrical circuits.

Due to the harsh product, the tool was set up with non-standard cups, differing in shore – meaning hardness. The cups are designed to lower the risk of static electricity, resist decomposition and allow for proper resistance to uneven wear.

For the standard tool set up, a minimum of 435 psi is typically requested. However, this was not something the operator would be able to provide while propelling with the product.

Instead, the team was required to move forward with a pressure of ~270 psi and a flow rate of 11 MMscfd for the first inspection. In order to reduce excessive velocity from pressure build-up in installations while still providing enough seal to propel the tool through the line, various bypass holes and notches were applied to the design.

Finally, protective measures for the magnet circuits were taken. Hydrogen can be extremely damaging to magnets and the impairment of the magnet circuit may lead to lowered levels of magnetisation of the pipe wall, thereby reducing data quality.

FIRST INSPECTION IN 2017

Once the tool was extracted, there was no damage to the tool or its components, and the cups showed minimal wear. The resulting data from the combination tool showed 100 per cent sensor coverage for both the geometry and MFL portions, and magnetisation levels were within the predicted ranges.

While the tool did experience a few spikes in velocity when traversing installation areas, the overall data quality was acceptable for evaluation.

REINSPECTION IN 2019

Given the success of the first inspection, the operator returned to ROSEN when it was time to reinspect the line segment in 2019. This time, it was able to provide a pressure of ~340 psi while maintaining the same flow rate.

Due to the successful outcome of the previous inspection, the same tool configuration was chosen for the reinspection. Once again, the cups showed minimal wear, and the tool was generally in good condition.

However, during this inspection, the combination tool did acquire some damage. The damage was determined to be the result of the higher-than-usual velocity while coming into the receiver and hitting the door of the trap.

No electronic connection could be established with the tool on-site; however, the data could be extracted without difficulty at the maintenance workshop.

During the data review, it was noted that the tool still experienced a few velocity spikes in installation areas, but the increased pressure allowed for an overall reduced speed and a more stable inspection of the line segment. The data was again at 100 per cent sensor coverage for both the geometry and MFL portions and was acceptable for evaluation.

A HOLISTIC APPROACH FOR SUSTAINABLE DECISION-MAKING

Service providers must support pipeline operators in the process of change in order to extend the lifetime of valuable assets beyond the decarbonisation of the energy system. Besides adapting existing technologies and services to the special requirements of a hydrogen grid, this means for ROSEN that all service offerings for hydrogen assets are integrated into a holistic integrity management framework that addresses hydrogen-related threats, interactions and defects.

With this integrated approach, risk reduction is provided for the injection of hydrogen into an existing network of gas pipelines. Pipeline operators are then able to make sustainable decisions for the conversion of their existing gas grids to hydrogen, ensuring hydrogen transport operations that are reliable in all aspects of performance, safety and security. P

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