LCRI LOW-CARBON RESOURCES INITIATIVE

EPRI GTI ENERGY

EXECUTIVE SUMMARY

TRANSITIONING LINE PIPE TO HYDROGEN SERVICE

Integrity Management

It is well established that the world uses significant volumes of energy from a wide range of sources, which provides benefits in terms of security of supply; however, many of the fuels (or energy carriers) have been linked to environmental issues and climate change. Thus, global efforts are on-going to transition to sustainable, safe and low carbon alternatives. The potential for hydrogen to become a primary energy carrier of the future has been widely discussed, but a key concern is whether hydrogen can be safely, economically, and reliably stored and transported, while also minimizing risks to system integrity. For transport, it is clear that pipeline transmission through an integrated network offers the necessary means to move large volumes of energy over relatively long distances.

In the United States, more than half of the nearly 300,000 miles (~483,000 km) of in-service natural gas pipelines transmission were built prior to 1970 using codes, standards and materials specifications that have evolved over time. While the opportunity to use these natural gas pipelines for transmission of hydrogen gas has huge potential cost benefit, it is imperative that the technical challenges and risks associated with introducing hydrogen to the existing infrastructure are identified, and the required engineering assessments are performed to maximize safety. Thus, as a pipeline is transitioned from natural gas to hydrogen service integrity management programs must be reviewed and updated to account for the additional threat that hydrogen has on system integrity.

A pipeline integrity management program (IMP) is a set of safety management, analytical, operations, and maintenance processes that are implemented in an integrated, logical and rigorous manner to accurately identify, assess, and mitigate pipeline integrity threats. The program should provide an approach to obtain information required to make technically sound engineering judgements. Of course, there must be customization within the framework to develop a program best suited for its pipeline system(s) and operations. Thus, although each integrity management program is required to include specific core integrity management program elements, the details will be system specific.

Pipeline integrity management programs for existing natural gas service is a mature technical discipline, based on extensive operator experience, as well as analytical, experimental, and empirical data. Yet, even with the broad experience, IMPs are constantly developing and improving. Conversely, experience with hydrogen transport for pipelines not originally designed to hydrogen standards is limited, and the potential for hydrogen to exacerbate certain defects is well recognized, which increases the complexity of this challenge. Therefore, considering the potential detrimental impacts of hydrogen on susceptible pipeline materials, it is crucial to assess the suitability of pipelines for hydrogen service, including understanding the existing condition of the pipeline, presence of relevant threats, and how exposure to hydrogen can affect the acceptability of flaws.

Key findings and integrity management considerations for transitioning pipelines to hydrogen service that are highlighted in the full report include:

- In the United States, the Pipeline and Hazardous Materials Safety Administration (PHMSA), an agency within the Department of Transportation (DOT), has federal jurisdiction for regulating and ensuring the safe transport of hazardous materials, including transmission and distribution of gas through pipelines. Title 49 of the Code of Federal Regulations Part 192 *Minimum Federal Safety Standards for Transportation of Natural and Other Gas by Pipeline* (Part 192), provides minimum safety requirements for pipeline transport of gas including integrity management regulations based on ASME B31.8S (2004) *Managing System Integrity of Gas Pipelines*.



- ASME B31.12, PL-3.21 and EIGA IGC Doc 121/14 Appendix H detail requirements and recommendations for converting existing steel pipelines to hydrogen service. Results of document review, visual and in-line inspection (ILI), physical testing and chemical analysis are required to qualify pipelines for hydrogen and establish the maximum allowable operating pressure (MAOP) of the converted pipeline for hydrogen service.
- Transitioning a pipeline from natural gas to hydrogen or hydrogen blend service is considered by PHMSA to be a product change, and is regulated under Part 192. Thus, integrity management of converted or repurposed gas pipelines to hydrogen service are required to follow Part 192 and ASME B31.8S. However, integrity management programs (IMP) will need to be reviewed and modified to account for the potential impacts that hydrogen may have on pipeline system integrity.
- Hydrogen embrittlement directly affects defect tolerance of crack-like flaws by reducing the acceptable critical crack size and accelerating the accelerating the crack growth rate.
- Flaw detection thresholds and capabilities using existing inspection methods, including in-line inspection (ILI) and non-destructive evaluation (NDE) must be assessed to determine they are adequate or if improvements are required to provide rigorous and reliable detection and sizing of crack-like flaws, which may be smaller for hydrogen service.
- Integrity management should include the use of Fitness-for-Service (FFS) to properly assess the structural integrity of in-service components that contain a flaw to inform run, repair, replace decisions. Critical crack size shall be calculated based on a failure assessment diagram (FAD) using a suitable fitness-for-service (FFS) methods.
- Integrity assessment intervals should be revisited and adjusted accordingly as more data become available, specifically with regard to the largest remaining defect in the inspected segment and estimated time to failure when representative growth rates are applied to the defect. Reinspection should be scheduled prior to one half of the predicted remaining life, or as required by Code or regulatory limits.

The Low-Carbon Resources Initiative

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