Observatorio Tecnológico del Hidrógeno

TECHNICAL WORKSHOP

Ensuring the integrity of hydrogen pipelines

October 30th, 2025

Conclusions

Ensuring the integrity of hydrogen pipelines

Highlights

- **Collaboration** among TSOs is essential to **ensure the safety, reliability and long-term performance** of hydrogen transport networks. **Progress is being made** to guarantee the integrity of both **new pipelines and repurposed natural gas pipelines for hydrogen transport.**
- **Hydrogen interaction with pipeline materials** is well understood and can be accurately **quantified through standardized laboratory and field tests** that provide reliable data, forming a solid foundation for integrity management and decision-making.
- **International standards are evolving rapidly**, providing operators with **clear guidelines and best practices** for new hydrogen pipelines and the repurposing of existing natural gas pipelines.
- Numerous research initiatives are advancing inspection technologies and fitness-for-service criteria. Meanwhile, **adopting case-specific assumptions and conservative strategies enables us to effectively manage pipeline integrity during the transition.**
- The technical workshop "Ensuring integrity of hydrogen pipelines" has achieved its goal: **sharing knowledge, evidence, and technological advancements that build confidence in the safety and reliability of hydrogen pipelines.**

Collaboration among TSOs is essential to ensure the safety, reliability and long-term performance of hydrogen transport networks (1/2)

- Europe's energy system is undergoing a profound transformation, with green hydrogen as a cornerstone for achieving decarbonisation targets. **Ensuring the safety, reliability, and long-term performance of hydrogen transport networks is therefore essential.**
- Fortunately, we're not starting from scratch. Europe already has a vast and well-established gas network, backed by decades of experience in its operation and maintenance. Transmission System Operators (TSOs) across the continent - including Enagás, Snam and Fluxys who were represented at the workshop - are working together to assess and develop strategies for converting existing natural gas pipelines. This collaboration, among technical experts and key stakeholders, ensures that conversions meet the highest standards of safety, efficiency, and reliability.
- After five years of collaboration, initial standardisation has been achieved, cautious but sufficient to ensure that the first 100% of repurposed assets, which are due to start up soon, will succeed and generate new knowledge to strengthen our approach towards 2030.

Collaboration among TSOs is essential to ensure the safety, reliability and long-term performance of hydrogen transport networks (2/2)

- The International Energy Agency (IEA) estimates that **of the 37,000 km of hydrogen pipelines expected by 2035, about one-third will involve repurposing** current gas networks. For example, in Germany, approximately 60% of planned hydrogen pipelines will come from existing natural gas infrastructure, according to the latest European Commission projections.
- Projects such as SunsHyne, a joint initiative involving five operators (Net4Gas, OGE, Eustream, TAG and Snam), illustrate this trend. A study has been completed on a 3,400 km hydrogen corridor from Sicily to Germany which shows that 85% of the route will use repurposed pipelines. Similarly, Thyssengas has started converting a 53 km pipeline between the Netherlands and Germany, with hydrogen expected to be flowing by 2027 and with full network integration expected by 2030.
- Therefore, **repurposing pipelines is an opportunity to enhance sustainability, reduce costs and project development times, as well as minimizing environmental impact** during both construction and operation.

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Technical solutions for hydrogen and repurposed natural gas pipelines. The vision of OEM, asset operators and research centre (1/3)

Laboratory test: **Hydrogen interaction with pipeline materials is well understood and can be accurately quantified through standardized laboratory and field tests. These tests provide reliable data that reflect real-world behaviour, forming a solid foundation for integrity management and decision-making.**

- **Round Robin testing campaigns are essential** to harmonize methodologies, validate results across laboratories, and ensure that **data is representative, repeatable, and conservative**. This collaborative approach supports **the evolution of international standards**.
- EPRG has launched an extensive program of small-scale testing to define fracture toughness parameters for a wide range of materials, including modern and vintage pipes, sour and non-sour gas materials, and welds. Based on this work, **EPRG has developed a best practice guide recommending key test parameters**. With the protocol now established, specimens have been sent to 29 laboratories for a round-robin test.
- **Operators need confidence that laboratory tests truly represent real operational life cycles**. To validate this, EPRG is conducting two full-scale fatigue tests: one on a modern X70 pipe and another on a vintage X60 pipe. These pipes differ significantly—X60 from the 1970s relies on precipitation hardening with high carbon and manganese content, while modern X70 uses thermo-mechanically controlled rolling to optimize grain size. Small-scale tests provide a reliable indication of real pipeline behaviour and, as EPRG has observed, fracture toughness is currently better than what small-scale tests suggest, reinforcing confidence in asset integrity.

Technical solutions for hydrogen and repurposed natural gas pipelines. The vision of OEM, asset operators and research centre (2/3)

Standardisation: **International standards are evolving rapidly, providing operators with clear guidelines and best practices for new hydrogen pipelines and the repurposing of existing natural gas pipelines.**

- **Round Robin Standardisation is advancing faster than ever thanks to an unprecedented level of global collaboration**. Experts, institutions, and organisations such as EPRG and PRCI -along with nearly every country interested in hydrogen infrastructure- are working together to close critical gaps.
- Today's hydrogen pipelines differ greatly from those built a century ago, making ASME B31.12 outdated for current needs. To address this, the **ASME B31 committee has commissioned the development of a consensus-based interim document** (CER, "Consensus Engineering Requirements"), that shall be the base for new specific hydrogen appendixes on ASME B31.8, B31.3, and B31.1, implying the future withdrawal of B31.12. This effort resolves previous compliance uncertainties, as pipelines were originally designed under B31.8.
- In Europe, a special amendment dedicated to hydrogen is being introduced in the revision of EN1594 (EN1594+A1). This "Amendment 1" shall include specific requirements for hydrogen service -both for new and reconverted pipelines-, a procedure for reconversion of existing natural gas pipelines, and specific Annexes for fatigue and fracture mechanics assessment, including 6 different "options" for establishing a crack-like defect dimension, needed for doing the calculations.

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Technical solutions for hydrogen and repurposed natural gas pipelines. The vision of OEM, asset operators and research centre (3/3)

Integrity management: **Numerous research initiatives are advancing inspection technologies and fitness-for-service criteria. Meanwhile, adopting case-specific assumptions and conservative strategies enable us to effectively manage pipeline integrity during the transition.**

- For operators, the central question related to integrity management is whether hydrogen changes pipeline threats: **hydrogen and natural gas pipelines share the same environments**, so they face similar hazards such as corrosion and external damage. The **main difference lies in pressure cycling—fatigue** which can become a critical factor that requires close monitoring. Another important point is toughness. Many older pipelines have low toughness values, while most damage assessment models assume sufficient toughness, creating a gap that needs attention.
- Emerging technologies offer promising solutions. Traditional MFL ("Magnetic Flux Leakage") tools detect metal loss but not all types of damage. **Low-field MFL avoids magnetic saturation, enabling detection of residual stresses caused by metallurgical changes, although interpreting magnetic signatures remains complex especially under hydrogen influence**. Eddy Current technology, still conceptual, could detect early crack formation, offering predictive maintenance capabilities. A breakthrough in Eddy Current technology is the ability to detect cracks in any orientation—not just axial or circumferential. This advancement allows a single inspection to cover multiple scenarios, improving efficiency and reliability.
- **Understanding material behaviour in hydrogen should also guide the design of detection technologies and assessment methodologies. With rigorous testing and conservative approaches, both new hydrogen pipelines and repurposed assets can be operated safely.**

H2BIDEA project: challenges in distribution with 100% hydrogen infrastructures

- Nortegas, Spain's second-largest gas distributor, presented key advances in the **H2BIDEA project**, focused on **developing and modelling hydrogen valleys using digital-twin technology**. The first integrated version—with one producer and one customer—will be **ready for testing by the end of 2025.**

- For this project, a 100% hydrogen ABC compressor was being integrated, capable of operating at pressures between 4 and 30–33 bar, with a hydrogen flow rate of 10–15 Nm^3/h. The compressor is designed as a compact, single-module unit, featuring zero leakage and full compatibility with ATEX zones.

- In addition to compression systems, the project involves industrial partners who are assessing the impact of hydrogen on their production processes. This includes evaluating various pipe materials for use not only in distribution networks but also in high-pressure transport pipelines.

- Nortegas also shared results from the **H2AREA project**, which examines **material and component compatibility in natural gas distribution networks for hydrogen use**. These achievements reflect strong collaboration driving innovation in the hydrogen sector.

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