national gas transmission

NIA_NGT0255 Integrity Management of Hydrogen Pipelines Project

Final Technical Report

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Author	SA
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Executive Summary

This report presents a consolidated review of the Integrity Management of Hydrogen Pipelines and Related Assets project. The programme investigated the suitability of existing integrity management practices for future hydrogen transportation systems, focusing on defect assessment, inspection, repair methodologies, and non-pipeline asset management.

Hydrogen introduces unique degradation mechanisms including hydrogen embrittlement, reduced fracture toughness, and accelerated fatigue crack growth. These effects reduce tolerable defect sizes and challenge the applicability of many existing natural gas integrity management approaches. The project identified the need for enhanced inspection capability, revised defect assessment criteria, hydrogen-specific repair validation, and a risk-based framework for both pipeline and non-pipeline assets.

Definitions

Term	Definition
HE	Hydrogen Embrittlement
NDT	Non-Destructive Testing
ILI	In-Line Inspection
NTS	National Transmission System
NG	National Gas
H_2	Hydrogen

Project Background

National Gas operates an extensive transmission pipeline network that contains a variety of pre-existing and in-service defects requiring regular inspection, assessment and mitigation. Existing integrity management procedures have been developed for natural gas operation; however, the introduction of hydrogen and hydrogen-natural gas blends creates uncertainty regarding the suitability of current engineering assessment, inspection and repair methodologies.

Hydrogen can significantly affect material behaviour, resulting in embrittlement, reduced fracture toughness and increased fatigue crack growth rates. These effects necessitate the development of revised defect acceptance criteria, fracture mechanics-based assessment approaches and modifications to inspection and repair strategies. The project was therefore established to evaluate integrity management requirements for future hydrogen transmission infrastructure and associated assets.

Methodology

The programme was delivered through four interconnected work packages:

WP1 – Defect Assessment Criteria

This work package reviewed current defect assessment procedures and examined the impact of hydrogen on pipeline steels and anomaly assessment methodologies. Activities included:

Review of hydrogen embrittlement effects and industry research.
Assessment of material qualification requirements for hydrogen service.
Comparison of NG procedures against current industry recommended practices.
Evaluation of hydrogen impacts on defect prevalence and significance.
Development of alternative integrity assessment methods suitable for hydrogen operation.
Demonstration of proposed methodologies using representative pipeline examples.
Review of outputs with National Gas and subject matter experts.

WP2 – Defect Inspection and Classification

This work package evaluated the suitability of existing in-field NDT and ILI techniques for hydrogen service by:

Reviewing current inspection methodologies.
Identifying capability gaps relative to hydrogen-related degradation mechanisms.
Assessing inspection requirements for crack-like defects.
Recommending enhanced NDT and ILI approaches.
Identifying required procedural updates.
Reviewing outputs with SMEs and National Gas stakeholders.

WP3 – Defect Mitigation (Repairs)

This work package assessed existing repair methodologies and their suitability for hydrogen service through:

Review of repair techniques currently used across the NTS.
Literature review of hydrogen effects on repairs.
Evaluation of repair method performance under hydrogen conditions.
Identification of preferred and unsuitable repair techniques.
Assessment of procedural modifications required.
Development of recommendations for testing and future qualification activities.

WP4 – Integrity Management of Non-Pipeline Assets

This work package evaluated hydrogen impacts on:

Pig traps
Filters
Pressure vessels

High-pressure storage vessels
Valves
Shell and tube heat exchangers
Water bath heaters

The focus was on inspection, assessment and repair methodologies for metallic components. Leakage mechanisms and non-metallic degradation were excluded from scope.

Results & Discussion

Key Findings

The project identified several common themes across all four work packages:

Material Performance

Hydrogen embrittlement, reduced fracture toughness and increased fatigue crack growth were identified as the primary integrity threats affecting both pipelines and associated assets. These mechanisms reduce allowable defect sizes and increase the likelihood of crack propagation.

Defect Assessment

Existing defect acceptance criteria developed for natural gas service are not always appropriate for hydrogen operation. Future assessments will increasingly require fracture mechanics and fatigue-based methodologies rather than traditional empirical approaches.

Inspection Capability

[redacted] Advanced NDT and crack detection technologies will therefore be necessary.

Repair Strategies

Many existing repair methodologies remain potentially suitable for hydrogen service but require validation to confirm long-term performance under hydrogen-related degradation mechanisms. Weld integrity, fatigue performance and material compatibility were identified as priority areas for future qualification.

Non-Pipeline Assets

Existing integrity management approaches for pressure vessels, filters, valves and heat exchangers cannot be transferred directly to hydrogen service without modification. Enhanced inspection capability, revised acceptance criteria and, in some cases, asset replacement may be required.

Integrated Conclusions

The programme demonstrated that hydrogen fundamentally changes the basis of integrity management across both pipeline and non-pipeline assets. Successful transition to hydrogen transport will require:

- Hydrogen-specific design and material selection.
- Advanced inspection technologies.
- Revised defect acceptance criteria.
- Fracture mechanics and fatigue-based assessment approaches.
- Validation of repair methodologies.
- Integrated, risk-based integrity management systems.
- Continued research and material testing to reduce uncertainty.

Overall, the project concluded that hydrogen transportation can be achieved safely and reliably, provided existing integrity management practices are adapted to account for hydrogen-specific degradation mechanisms and asset performance requirements