Notes on Completion: Please refer to the appropriate NIA Governance Document to assist in the completion of this form. The full completed submission should not exceed 6 pages in total.

NIA Project Registration and PEA Document

Date of Submission

Sep 2024

Project Reference Number

NIA2_SGN0070

Project Registration

Project Title

Internal Sharp Defect Burst Testing in Hydrogen

Project Reference Number

NIA2_SGN0070

Project Licensee(s)

SGN

Project Start

September 2024

Project Duration

1 year and 7 months

Nominated Project Contact(s)

James Heywood

Project Budget

£729,035.00

Summary

The Internal Sharp Defect Burst Testing in Hydrogen project will build upon the pipeline defect burst pressure testing programme completed as part of the SGN LTS Futures project. Additional burst testing will provide a more comprehensive understanding of the effect of hydrogen gas on internal sharp pipeline defects. These tests will evaluate the vessel conditioning regime and test defects of different dimensions by examining the effect of preheating, repeatability of results and overpressure at the point of defect failure.

Nominated Contact Email Address(es)

sgn.innovation@sgn.co.uk

Problem Being Solved

LTS Futures concluded the first UK pipeline defect burst tests with hydrogen. Nine burst tests were conducted on different defects (smooth dent, external sharp, external blunt, external dent and gouge, internal sharp) in vintage pipeline material at DNV Spadeadam. Comparative testing via hydrostatic and pneumatic (gaseous hydrogen) methods was performed. The testing showed that the vessel containing an internal crack failed at a significantly lower pressure than would be expected with natural gas, highlighting a potential effect of hydrogen.

Further tests are required to confirm initial results, evaluate the vessel conditioning regime and test defects of different dimensions. Vintage pipeline material left over from LTS Futures provides an excellent opportunity to conduct such tests.

Method(s)

Two programmes have been specified as noted below:

Programme 1 (All vessels to be manufactured from the same length of pipe)

- Internal crack, hydrostatic burst test.

- Internal crack, pneumatic hydrogen bust test (3-month soak with 96 hours heating)
- Internal crack, pneumatic hydrogen burst test – no soak.

Programme 2 (All vessels to be manufactured from the same length of pipe)

- Internal crack, hydrostatic burst test (smaller defect).
- Internal crack, pneumatic hydrogen bust test (3-month soak with 96 hours heating & smaller defect)

Complimentary small-scale material testing shall be conducted to characterise the mechanical properties of the pipeline material. This encompasses testing in air (chemical composition, hardness, tensile and V-notch Charpy impact, fracture toughness) and testing in pressurised gaseous hydrogen (tensile and fracture toughness).

Subject matter experts, Dr Andrew Cosham (Ninth Planet Engineering) and Gary Senior (Pipeline Integrity Engineers) will provide technical support to the project including analysis of results, specifying defect dimensions and incorporation of results into the LTS Futures Repurposing Blueprint.

DNV Spadeadam shall fabricate and burst test five vessels with internal defects using the processes and procedures developed within the LTS Futures Work Package 2 testing programme. DNV shall supply all required materials and instruments to carry out this testing except for the pipeline material which is free issue from SGN and on-site already.

Two rings of material shall be sent to the TWI test facility in Cambridge for machining and testing. SGN shall organise transport of material from DNV Spadeadam to TWI Cambridge. TWI shall perform laboratory scale mechanical testing including:

· Transverse Strip Tensile (in air)

· Charpy V-Notch (in air)

· Micrography (in air)

· Chemical Composition (in air)

· Hardness (in air)

· Round Bar Tensile Testing (in air and hydrogen)

· Fracture Toughness (in air and hydrogen)

As the programme progresses, PIE shall support SGN in technical decisions and troubleshooting. PIE shall produce an overall final report, linking the small scale and full-scale testing with discussion of the results their relevance to the UK LTS.

Scope

In order to fully understand the results of the previous burst tests, five additional burst tests shall be conducted on internal sharp defects via the same process as in LTS Futures. The aim of the additional burst tests is to:

· Gather additional learning on the initial internal crack LTS Futures test result;

· Evaluate the effect of preheating vessels on breakdown of surface oxide layer and hydrogen permeation;

· Evaluate internal defects of different dimensions; and,

· Measure overpressure generated during defect failure.

Following the conclusion of the burst tests, some of the pipeline material will be sent to the TWI facility for machining and laboratory scale mechanical testing including:

· Transverse Strip Tensile (in air)

- Charpy V-Notch (in air)
- Micrography (in air)
- Chemical Composition (in air)
- Hardness (in air)
- Round Bar Tensile Testing (in air and hydrogen)
- Fracture Toughness (in air and hydrogen)

Objective(s)

DNV deliverables shall include:

- A final report detailing all elements of testing including fabrication, set-up, conditions, testing, instrumentation, and data.
- Electronic data sets for all tests (pressure, temperature and overpressure at failure).
- Test videos and photographs for all tests.

TWI deliverables shall include:

- A final report detailing all elements of testing including machining, test setup, results, and discussion.
- Raw data sets for all tests

PIE deliverables shall include:

- A final report encompassing the small-scale and full-scale testing with analysis relating results to the UK LTS.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

The outcomes of the project do not contain any adverse effects for vulnerable customers. Instead, it feeds into a wider piece of work to decarbonise the gas network. To do this, the effects of gaseous hydrogen on transmission pipelines need to be further understood.

Success Criteria

Perform both programmes of the additional burst tests and complete all relevant material testing.

Deliver the following reports and data sets

1. Final report from DNV detailing all elements of testing, as well as data sets for tests and test videos and photographs
2. Final report from TWI and raw data tests for all tests

Final report from PIE encompassing all details from small to full-scale testing

Project Partners and External Funding

Pipeline Integrity Engineers Ltd

Ninth Planet Engineering

DNV Spadeadam

The Welding Institute

Potential for New Learning

Reports and learning will be disseminated through working groups, stakeholder engagement, reports, papers and the smarter networks portal.

Scale of Project

Although some burst testing in a hydrogen environment have been conducted, there is limited data for full-scale tests. The findings of this project have the opportunity to be scaled up and impact the wider GB transmission network.

Technology Readiness at Start

TRL5 Pilot Scale

Technology Readiness at End

TRL6 Large Scale

Geographical Area

DNV Spadeadam Test Site, Cumbria

The Welding Institute, Cambridge

Revenue Allowed for the RIIO Settlement

£972,047

Indicative Total NIA Project Expenditure

External: £729,035

Internal: £243,012

Total: £972,047

Project Eligibility Assessment Part 1

There are slightly differing requirements for RIIO-1 and RIIO-2 NIA projects. This is noted in each case, with the requirement numbers listed for both where they differ (shown as RIIO-2 / RIIO-1).

Requirement 1

Facilitate the energy system transition and/or benefit consumers in vulnerable situations (Please complete sections 3.1.1 and 3.1.2 for RIIO-2 projects only)

Please answer **at least one** of the following:

How the Project has the potential to facilitate the energy system transition:

The test, once concluded will confirm initial results from previous burst tests in LTS Futures, and provide empirical test data that will be delivered and incorporated into the final reports to the HSE, increasing understanding of previous test, and evaluate the effect of hydrogen on internal pipeline defects in detail.

It could also develop the evidence base for a future hydrogen transmission pipeline defect assessment procedure

How the Project has potential to benefit consumer in vulnerable situations:

N/A

Requirement 2 / 2b

Has the potential to deliver net benefits to consumers

Project must have the potential to deliver a Solution that delivers a net benefit to consumers of the Gas Transporter and/or Electricity Transmission or Electricity Distribution licensee, as the context requires. This could include delivering a Solution at a lower cost than the most efficient Method currently in use on the GB Gas Transportation System, the Gas Transporter's and/or Electricity Transmission or Electricity Distribution licensee's network, or wider benefits, such as social or environmental.

Please provide an estimate of the saving if the Problem is solved (RIIO-1 projects only)

N/A

Please provide a calculation of the expected benefits the Solution

N/A

Please provide an estimate of how replicable the Method is across GB

The results of this test will have an impact on all GB networks working at similar pressures and with similar pipeline materials. The project partners have significant experience with burst testing, meaning that the methods used in this test meet the required threshold for replicability across the GB network.

Please provide an outline of the costs of rolling out the Method across GB.

Costing for this type of activity is defined on a project-by-project basis

Requirement 3 / 1

Involve Research, Development or Demonstration

A RIIO-1 NIA Project must have the potential to have a Direct Impact on a Network Licensee's network or the operations of the System Operator and involve the Research, Development, or Demonstration of at least one of the following (please tick which applies):

☐ A specific piece of new (i.e. unproven in GB, or where a method has been trialled outside GB the Network Licensee must justify repeating it as part of a project) equipment (including control and communications system software).

☐ A specific novel arrangement or application of existing licensee equipment (including control and/or communications systems and/or software)

☐ A specific novel operational practice directly related to the operation of the Network Licensees system

☐ A specific novel commercial arrangement

RIIO-2 Projects

☐ A specific piece of new equipment (including monitoring, control and communications systems and software)

☐ A specific piece of new technology (including analysis and modelling systems or software), in relation to which the Method is unproven

☐ A new methodology (including the identification of specific new procedures or techniques used to identify, select, process, and analyse information)

☑ A specific novel arrangement or application of existing gas transportation, electricity transmission or electricity distribution equipment, technology or methodology

☐ A specific novel operational practice directly related to the operation of the GB Gas Transportation System, electricity transmission or electricity distribution

☐ A specific novel commercial arrangement

Specific Requirements 4 / 2a

Please explain how the learning that will be generated could be used by the relevant Network Licensees

The project will provide unique and referenceable information for Network licensees and Industry on fatigue crack growth rate on internal defects of transmission pipelines with 100% hydrogen. The learning gained from the project can be applied to Network Licensees and their network operations to facilitate safe transition to hydrogen from natural gas.

Or, please describe what specific challenge identified in the Network Licensee's innovation strategy that is being addressed by the project (RIIO-1 only)

N/A

Is the default IPR position being applied?

☑ Yes

Project Eligibility Assessment Part 2

Not lead to unnecessary duplication

A Project must not lead to unnecessary duplication of any other Project, including but not limited to IFI, LCNF, NIA, NIC or SIF projects already registered, being carried out or completed.

Please demonstrate below that no unnecessary duplication will occur as a result of the Project.

This project will build on previous work in this area and has been discussed with the other networks to ensure there is no duplication of work. The findings from the project will be shared with all key stakeholders.

If applicable, justify why you are undertaking a Project similar to those being carried out by any other Network Licensees.

N/A

Additional Governance And Document Upload

Please identify why the project is innovative and has not been tried before

The project will provide critical insight into any identified issues and illustrate solutions for the commissioning or conversion to 100% hydrogen for the gas transmission networkIt will shed light on the effect of hydrogen on the burst pressure of pipelines with internal defects.

Relevant Foreground IPR

N/A

Data Access Details

Any consumer data gathered throughout this project will be anonymised and will be compliant with General Data Protection

Regulations (GDPR) and the UK Data Protection Act. Any compliant data can be made available for review upon request.

Please identify why the Network Licensees will not fund the project as apart of it's business and usual activities

This project isn't being funded as business as usual because it is deemed an essential part of the 100% hydrogen trials process which is a key step towards conversion of the existing gas network to 100% hydrogen

Please identify why the project can only be undertaken with the support of the NIA, including reference to the specific risks(e.g. commercial, technical, operational or regulatory) associated with the project

The conversion of the GB gas network to 100% hydrogen is key on the road towards net zero. A reliable supply and the assurance of safe operations for workers and the public are crucial to support the viability of the hydrogen transition. The NIA framework can support works that ensure results that play an essential part in the roll-out of hydrogen.

This project has been approved by a senior member of staff

☑ Yes