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

May 2024

Project Reference Number

NIA_NGT0233

Project Registration

Project Title

HyNTS Weld T-Sections & Fittings

Project Reference Number

NIA_NGT0233

Project Licensee(s)

National Gas Transmission PLC

Project Start

May 2024

Project Duration

0 years and 11 months

Nominated Project Contact(s)

Robert Best, box.GT.innovation@nationalgas.com

Project Budget

£750,000.00

Summary

Most of the material testing being performed, both by National Gas and the rest of industry, is focussed on characterising the behaviour of internal planar defects in high-pressure hydrogen due to static or cyclic stresses in the pipeline. Much of the material being studied has been taken from the parent metal of the pipeline, as well as a select number of seam and girth welds where available. However, one area of uncertainty the intersection between the seam weld, carried out in the pipe mill using methods such submerged arc welding (SMAW), and the girth weld (carried out in the field when laying line pipe). Fusion welding causes significant microstructural change in and around the weld zone and despite not being explicitly requested in the existing hydrogen codes (e.g. ASME B31.12 and IGEM/TD/1 Supplement 2) the interaction of the two weld microstructures might be critical for hydrogen service.

Third Party Collaborators

Element Materials Technology

Nominated Contact Email Address(es)

Box.GT.Innovation@nationalgrid.com

Problem Being Solved

Most of the material testing being performed, both by National Gas and the rest of industry, is focussed on characterising the behaviour of internal planar defects in high-pressure hydrogen due to static or cyclic stresses in the pipeline. Much of the material being studied has been taken from the parent metal of the pipeline, as well as a select number of seam and girth welds where available. However, one area of uncertainty the intersection between the seam weld, carried out in the pipe mill using methods such as submerged arc welding (SMAW), and the girth weld (carried out in the field when laying line pipe). Fusion welding causes significant microstructural change in and around the weld zone and despite not being explicitly requested in the existing hydrogen codes (e.g.

ASME B31.12 and IGEM/TD/1 Supplement 2) the interaction of the two weld microstructures might be critical for hydrogen service.

Furthermore, there is little data on the performance of pipe fittings such as tees, weld neck flanges and cold bends in high-pressure hydrogen gas.

In the absence of specific hydrogen test data, a number of assumptions in terms of the relevant material property data would need to be made to run assessments of the capability of gas network assets for operation in hydrogen. These assumptions should be validated to ensure safety and optimised efficiency of hydrogen networks.

Method(s)

This project will comprise work packages to characterise and test a selection of weld T-sections and fittings representative of the National Transmission System. This data will then inform indicative Engineering Critical Assessments (ECAs) of network assets. The proposed project structure is shown below:

WP0: Project Management, Standards & Reporting

- Project Management Documentation
- Technical Report including Technical Summary
- Policy & Procedure Review
- Closure Report

WP1: Material Characterisation

1. Source and prepare materials for characterisation
2. Conduct characterisation of materials
3. Analyse and report out results

WP2: Material Mechanical Testing

1. Source and prepare materials for mechanical testing
2. Conduct mechanical testing (fracture toughness and fatigue crack growth) in high-pressure gaseous hydrogen
4. Conduct mechanical testing (fracture toughness, tensile, Charpy V-notch testing) in air
5. Analyse and report out results

WP3: NTS Contextualisation

1. Compare T-sections data with other datasets
2. Undertake indicative Engineering Critical Assessments (ECAs) to assess impact of results on pipeline operation
3. Recommend updates to internal and external codes, standards and guidelines

Measurement Quality Statement

The measurement approach used to meet Data Quality objectives will be through the identification of high calibre project partners who are experts in their given field. In this instance the project will be limited to a laboratory testing and analysis from TRL2 to TRL4 to generate test data to feed into indicative Engineering Critical Assessments (ECAs) of network assets.

Data Quality Statement

The project will ensure that data used is of sufficient quality to deliver project objectives. The relevant data and background information will be stored for future access within the National Gas Transmission Innovation SharePoint site.

Scope

The National Transmission System (NTS) in the UK offers a resilience to the UK's varying energy demand and supply. It enables suppliers to input gas at one location in the country and transport it to consumers via the distribution networks whilst simultaneously acting as a storage system to ensure there is energy available even on the coldest winters day. The NTS currently transports natural gas which on combustion produces carbon dioxide plus other greenhouse gases which contribute to climate change. The UK has set an ambitious target of eliminating net carbon emissions by 2050 and a wide range of green technologies are required to reach this goal.

A key technology in this transition is hydrogen as an alternative for carbon fuels in heat, transport, and industrial uses. Transporting hydrogen across the UK and connecting renewable energy producers to customers is an opportunity for the NTS and a potential way to extend the life of assets already paid for by UK consumers. However, the NTS was not designed to transport hydrogen and learning needs to be developed on the capability of these assets in this new use case.

This project will generate key knowledge on the performance of pipe T-sections and fittings in high-pressure hydrogen. This will enable more representative assessments of the capability of the NTS to transport hydrogen thereby supporting the overall safety case whilst enabling optimisation of network operations.

The project scope is summarised below:

In Scope

- Above ground and below ground pipe and piping assets
- Girth-seam weld intersections ("T-sections")
- Pipe fittings
- Material characterisation of pipes and fittings
- In-air and in-hydrogen mechanical testing of pipes and fittings
- Indicative Engineering Critical Assessments (ECAs) of representative assets
- Regulation and standards review

Out of Scope

- Pipe-pipe welds
- Pipeline specific assessments
- Non-metallic components

Objective(s)

This project has the following overall objectives:

1. Metallurgically characterise NTS pipe weld T-sections and fittings
2. Generate mechanical performance data on weld T-sections and fittings
3. Understand criticality of T-sections and fittings with regards pipeline performance in hydrogen
4. Recommend next steps, including follow-on testing and, if appropriate, updates to internal (National Gas Transmission) and external (e.g. applicable IGEM/ASME codes) codes, standards and guidelines

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

The National Transmission System (NTS) is a key UK infrastructure for the transport of gas to consumers, including those considered vulnerable. In a scenario where hydrogen replaces methane as a household heat source, it is essential the vulnerable are not excluded by virtue of fuel inaccessibility. In cases where vulnerable consumers already utilise gas, it is likely that in a net zero future the optimum option is to provide a consistent energy solution. The transition to hydrogen within the NTS provides continuity of access to the vulnerable of hydrogen as a replacement to methane, with ongoing benefits of efficiency and economy of scale within a closely regulated environment. This project supports the transition of the NTS to hydrogen which in turn supports the availability of gas to the vulnerable.

An assessment of distributional impacts (technical, financial and wellbeing related) for this project has been carried out using a bespoke assessment tool, which assesses the project as having a positive, negative, or neutral effect on consumers in vulnerable situations. To help inform the assessment, this tool considers the categories of consumers identified in the Priority Services Register. This project has been assessed as having a neutral impact on customers in vulnerable situations. This is because it is a transmission project

Success Criteria

Success is defined by delivery of project objectives:

· Metallurgically characterise NTS pipe weld T-sections and fittings

· Generate mechanical performance data on weld T-sections and fittings

· Understand criticality of T-sections and fittings with regards pipeline performance in hydrogen

· Recommend next steps, including follow-on testing and, if appropriate, updates to internal (National Gas Transmission) and external (e.g. applicable IGEM/ASME codes) codes, standards and guidelines

The following deliverables are envisaged:

WP1: Material Characterisation

1.1 Characterisation Plan

1.2 Characterisation Results

WP2: Material Mechanical Testing

2.1 Mechanical Test Programme Plan

2.2 Reported Mechanical Test Programme Results

WP3: NTS Contextualisation

3.1 T-section Data Comparison Report

3.2 ECA Reports (including identification of “at-risk” scenarios/use cases)

3.3 Summary of recommended internal and external codes, standards and guidelines/procedures updates

Project Closure

Technical Report

Technical Summary

Closure Report

Project Partners and External Funding

Gas Network – National Gas Transmission PLC

Technical & Industrial Lead – Element Materials Technology – Hitchin Ltd

Potential for New Learning

The project will generate data on impact of high-pressure hydrogen on pipe T-sections and fittings. This data will then be used in indicative assessments of assets representative of the National Transmission System to inform decision-making and resource planning for future programmes of work, including Project Union.

These results might be informative to other transmission networks globally as well as domestic and international gas distribution networks. Where appropriate, results will be disseminated via meetings, committees and conferences.

Scale of Project

This project is a laboratory and desktop-based study that will provide critical data on pipe T-sections and fittings, on which there is currently very limited information. Testing in high-pressure gaseous hydrogen is required by national and international codes to enable optimised network operation, however, such testing does incur a significantly higher cost than traditional in-air testing. To mitigate these high costs, a staged approach in which data is first generated on a comparatively small test matrix. The results are then compared to existing datasets and analysed to identify trends in the data which could enable extrapolation to other, as yet untested configurations. Such an approach would also identify knowledge gaps which could be addressed by follow-on testing programmes.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

United Kingdom

Revenue Allowed for the RIIO Settlement

None – Hydrogen network focused project

Indicative Total NIA Project Expenditure

External – £ 600,000.00

Admin – £ 120,000.00

Internal – £ 30,000.00

Total – £ 750,000.00

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:

For the transition to hydrogen, the National Transmission System (NTS) will need to ensure hydrogen can be supplied to consumers reliably. To undertake accurate assessments of the pipeline assets to transport hydrogen data on the performance of girth-seam weld T-sections and pipe fittings in high-pressure hydrogen would be needed. Without this data, assumptions on the performance of these assets will need to be made which might be overly conservative and as a result lead to a non-optimised operation of the National Transmission System.

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

Although this project does not directly affect vulnerable consumers the energy transition may and as such, we must consider the effect of the work we are doing through the NIA funding. The National Transmission System (NTS) is a key UK infrastructure for the transport of gas to consumers, including those considered vulnerable. In a scenario where hydrogen replaces methane as a household heat source, it is essential the vulnerable are not excluded by virtue of fuel inaccessibility. In cases where vulnerable consumers already utilise gas it is likely that in a net zero future the optimum option is to provide a consistent energy solution. The transition to hydrogen within the NTS provides continuity of access to the vulnerable of hydrogen as a replacement to methane, with ongoing benefits of efficiency and economy of scale within a closely regulated environment. Ensuring robust NTS assets and consistent hydrogen production options will support the transition of the NTS to hydrogen which in turn supports the availability of gas to the vulnerable.

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

This project will generate key knowledge on the performance of pipe T-sections and fittings in high-pressure hydrogen. This will enable more representative assessments of the capability of the NTS to transport hydrogen thereby supporting the overall safety case whilst enabling optimisation of network operations. The project solution will contribute to enabling the repurposing of existing asset plus construction of new pipeline for hydrogen transmission.

The overall benefit will be the ability to transport hydrogen in lieu of natural gas thus contributing to greenhouse gas emission reductions. Repurposing existing assets will represent the lowest cost and quickest solution to the end-user.

The project value tracking is listed below:

· Maturity

o TRL 2-3. Research project incorporating laboratory testing,

· Innovation Opportunity

o >50% or multiple asset classes. Multiple assets classes covered - line pipe and various fittings.

· Deployment Costs

o £0.00. Project is research and there will be no technology developed to be deployed.

· Innovation Cost

o £ 750,000.00. Cost of innovation project.

· Financial Saving

o £ 0.00. Data generated in the project could enable operation of gas network assets at higher pressures than would otherwise be permissible thereby avoiding the need for new pipeline assets to be installed.

· Safety

o 0%. Data generated in the project will inform assessment of defects in hydrogen ensuring continued safe operation.

· Environment

o 0.0 tonnes CO2e. Not expected to result in CO2e save or other environmental benefits.

· Compliance

o Support compliance. Work supports transition to hydrogen.

· Skills & Competencies

o Individuals. Work will augment knowledge of individuals involved in project.

· Future Proof

o Supports business strategy. Results will support operation of future hydrogen national transmission system.

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

The project will characterise and test materials in accordance with latest industry knowledge and codes where appropriate. The materials tested will be taken from the National Transmission System. Nevertheless, the knowledge gained will be applicable across the gas industry and the testing design can be mimicked by other networks.

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

The information from the indicative Engineering Critical Assessments will inform the type and level of assessments that would be needed for conversion of a pipeline to hydrogen. At present it is not possible to outline the associated costs as the impact this project will have on the required assessments cannot be known until after the project.

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 research and analysis undertaken in this project will be applicable to pipeline operators and will inform the strategy for pipeline/asset repurposing for the energy transition.

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.

There will be no duplication of activities done as part of this program. There is work undertaken, globally, on hydrogen impacts on pipeline materials, however, there is limited data on T-sections and fittings and none of this research has been executed on the NTS and the materials in the NTS.

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

There is currently very limited data globally on the impact of high-pressure hydrogen gas on pipe T-sections and fittings. This project will be the first to determine the impact of high-pressure hydrogen on T-sections and fittings from the National Transmission System. This is novel as this work has not previously been undertaken.

Relevant Foreground IPR

This project and the resultant outcomes/deliverables will conform to the default treatment of IPR as set out under the agreed NIA Governance (where the default requirements address two types of IPR: Background IPR and Foreground IPR).

The results of the project are not expected to generate any foreground IPR, as the proposed approaches conform to industry practices.

Data Access Details

Data for this project, and all other projects funded under the Network Innovation Allowance (NIA) funding scheme, can be found, or requested in a number of ways:

· A request for information (RFI) via the Smarter Networks Portal at https://smarter.energynetworks.org. National Gas Transmission regularly publishes much of the data arising from our innovation projects on the ENA portal, before submitting a RFI check this website.

· Via our managed mailbox box.GT.Innovation@nationalgas.com. Further data can be shared upon request through the innovation mailbox. Each request will be assessed by the NGT Innovation Team for its merits and viability.

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

This project is focussed on the impact of high-pressure hydrogen gas on metallic network components, as the existing network does not carry hydrogen gas this work cannot be considered business as usual. It is therefore relevant for NIA funding.

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

This approach is unknown and there are many routes that could be taken, there is a risk that without this work the different energy networks would spend time and money on carrying out the research and testing. The NIA funding reduces this risk and enables the feasibility of repurposing existing assets to be assessed.

This project has been approved by a senior member of staff

☑ Yes