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

Jul 2024

Project Reference Number

NIA2_SGN0065

Project Registration

Project Title

NDT Fatigue crack growth rate of hydrogen pipelines

Project Reference Number

NIA2_SGN0065

Project Licensee(s)

SGN

Project Start

June 2024

Project Duration

0 years and 5 months

Nominated Project Contact(s)

James Heywood, Max Koronka

Project Budget

£94,295.00

Summary

This project proposes the use of a Non-Destructive Testing (NDT) tool on LTS Futures pneumatic fatigue test vessels to assess fatigue crack growth rates of internal pipeline defects. Internal crack fatigue crack growth rate for lower alloy steels in a hydrogen environment has been studied, but there is limited data from full scale tests. The LTS Futures project is performing full-scale fatigue testing of pipeline defects on fatigue vessels that have been fabricated using vintage pipeline material taken from the existing SGN LTS network, thus providing additional learning to their offsite testing program.

Third Party Collaborators

Applus + RTD

DNV

Nominated Contact Email Address(es)

sgn.innovation@sgn.co.uk

Problem Being Solved

The UK Local Transmission System (LTS) consists of 11,000 km of high-pressure pipelines delivering gas from National Transmission System (NTS) offtakes to towns and cities across the country. The SGN LTS Futures project will result in a blueprint methodology for converting LTS pipelines from conveying natural gas to hydrogen. A first-of-its-kind repurposing trial and demonstration will be undertaken providing critical insight into operational activities, repurposing standards, and conversion techniques. A large volume of offsite testing is being undertaken at DNV Spadeadam to provide further evidence including Hot Works Trials, Burst and Fatigue Testing, Venting and Flaring and PRS Testing.

In order to repurpose the LTS network assets for hydrogen in a safe manner, it is critical that the behaviour of pipeline defects in a

hydrogen environment is understood. An exact measure of the internal crack fatigue growth rate of pipelines in hydrogen has not been measured on a full-scale test, although several studies have been conducted on a laboratory scale. These include using NDT instrumentation to measure fatigue crack growth rates of internal defects on higher alloy steel (X70). A gap in knowledge exists for lower alloy steels such as X52, which comprises a large part of the LTS network and correlates in providing additional deliverable to the LTS Futures scope of works.

Method(s)

The LTS Futures project is performing full-scale fatigue testing of pipeline defects including a smooth dent, external crack, external blunt defect, external dent and gouge and internal crack. Fatigue vessels have been fabricated using vintage pipe sections taken from SGNs existing LTS network. One vessel will be tested hydrostatically and the other pneumatically with hydrogen to provide a reference and determine any difference when using hydrogen. The number of cycles to failure will be measured for each pipeline defect and compared with values from the counterpart hydrostatic test vessel. The fatigue crack growth rate of the external crack defect will be measured in-situ using a clip gauge. Strain gauges will also been positioned around defects allowing the stress concentration to be measured.

It is proposed using Non-Destructive Testing (NDT) to measure the fatigue crack growth rates on these vessels. Time of Flight Diffraction (ToFD) is one of the most reliable NDT methods for inspecting welds and defects. This is an ultrasonic method that is used in several industries including petrochemical, chemical, oil and gas, power generation and fabrication.

A pair of ultrasonic probes are placed on opposite sides of the weld or tested area (e.g. a defect). One of the probes acts as a transmitter and sends out an ultrasonic pulse that is picked up by the other probe which is the receiver. With an undamaged item, the signals picked up by the receiver probe are from two waves – one wave that travels along the surface (lateral wave) and one that reflects off the far wall (back wall reflection). If there is a flaw, such as crack, there is a diffraction of the ultrasound pulse from the tips of the crack. By measuring the time of flight of the pulse, the depth of the crack can be calculated using trigonometry. The technique has several advantages including recordable data generation, immediate results, and no requirement for shutdown. It provides one of the most accurate sizing of defect techniques on the market.

Scope

The testing will take place at the DNV site at Spadeadam, using the pipe material already in use as part of the LTS Futures WP2 pneumatic fatigue rig. Applus RTD is expected to supply and install the following:

- 6 x Transducer ToFD 65 Degress -15MHz/3mm

- 6 x RG174 Cable with connertors (75mm)

- 6 x Mounting Brakets

- 1 x ToFd System which will be rented.

Installation is expected to have a duration of two days and some post installation support will be required.

DNV is expected to supply and install the following:

-The safety power and control system to isolate ToFD in the presence of hydrogen gas

- Site support and welfare for Applus RTD

- Data downloads and handling.

Data will be reviewed and analysed under the LTS Futures and outputs publish

Objective(s)

The objective is to investigate full-scale fatigue crack growth rate of an internal pipeline defect in gaseous hydrogen using NDT. This will support development of the LTS Futures blueprint methodology. The project will provide critical insight, allowing gas network operators to design hydrogen pipelines with the appropriate safety margins.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

A successful trial at the Spadeadam test site will provide additional evidence in support of converting natural gas transmission pipelines to hydrogen. 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

Monitor and record the required data, so that SGN are satisfied that enough data was provided for fatigue crack growth rate of a pipeline defect on a full scale.

Project Partners and External Funding

Applus + RTD

Det Norske Veritas (DNV)

Potential for New Learning

The project will provide unique and referenceable information for Network licensees and industry on fatigue growth rates of internal cracks on transmission pipelines with 100% hydrogen. All the learning gained from the project could be applied to other Network Licensees and their network operations to facilitate safe transition to hydrogen from natural gas.

Scale of Project

Although some fatigue crack growth rate tests of steel in a hydrogen environment have been conducted on a laboratory scale, there is limited data from full scale tests. Testing by the European Pipeline Research Group (EPRG) is underway but focuses on higher alloy steel that would be present in the National Transmission System rather than the Local Transmission System. Hence the need to perform the test on the LTS fatigue rig at Spadeadam, which will provide a more extensive data profile on the behaviour of this defect in hydrogen.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

The project will take place at the DNV testing site at Spadeadam.

Revenue Allowed for the RIIO Settlement

£94,295

Indicative Total NIA Project Expenditure

External: £70,721

Internal: £23,574

Total: £94,295

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:

This test, once concluded, will provide critical data on the behaviour of internal cracks under fatigue loading in a hydrogen environment. The learnings can then be disseminated among the networks and support industry wide development of appropriate design factors for pipelines repurposed for hydrogen transmission.

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

NA

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)

NA

Please provide a calculation of the expected benefits the Solution

NA

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

Applus RTD are an NDT inspection service company that have significant experience with this technique, meaning that the methods used in the tests 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. This is because variables including the scope, crack diameter, pressure of test, test setup and a multitude of other factors determine the overall cost of each 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

- [ ] 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)
- [x] 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)

NA

Is the default IPR position being applied?

- [x] 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.

NA

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 unidentified issues arising from internal cracks in pipelines operating at pressure in a hydrogen environment. This type of test has been performed in a laboratory environment, however there is very little detail on full-scale tests. This project thus covers the knowledge gap on internal crack like defect fatigue crack growth data.

Relevant Foreground IPR

NA

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