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

Aug 2018

Project Reference Number

NIA_NGGT0129

Project Registration

Project Title

Investigate integrity of plain dents in grade L555 pipe

Project Reference Number

NIA_NGGT0129

Project Licensee(s)

National Gas Transmission PLC

Project Start

August 2018

Project Duration

2 years and 1 month

Nominated Project Contact(s)

Paul Connolly

Project Budget

£893,330.00

Summary

The first use of high strength grade L555 pipe (also commonly referred to as X80) in the UK onshore gas industry occurred in 2000. National Grid (NG) now operates 863Km of 1220mm L555 pipe. It is anticipated that this high strength material will continue to be a preferred choice for future large capacity feeders required for bringing in supplies from new areas, and on future reinforcement projects.

Because of the large diameter to wall thick thickness ratio, 1220mm diameter L555 pipe tends to be more susceptible to denting, particularly during the pipeline construction phase. The acceptance limits currently available - as set out in NG's procedure for the inspection assessment and repair of pipeline defects procedure, T/PM/P/11 - are based on a limited amount of evidence and are thought to be overly conservative for L555.

The project looks to address gaps in evidentiary acceptance limits, provide validation for an increase to the superficial limit for grade L555 pipe, and to confirm the impact of smooth dent damage on the fatigue life of the pipeline. This will provide NG and other gas network licensees with complete, accurate information for the assessment of dent damage on grade L555 pipe. Thereby ensuring that instances of unnecessary remedial action are avoided. Remedial action involves the assessment, repair and replacement of buried pipeline and requires excavation at the site of a dent. Enabling an avoidance of unnecessary excavation will remove the potential for disruption of service for our customers, a disruption to the local environment, and the potential for an average carbon savings of 21,000 tonnes of CO2e per excavation.

Third Party Collaborators

DNV

Nominated Contact Email Address(es)

Box.GT.Innovation@nationalgrid.com

Problem Being Solved

The first use of high strength grade L555 pipe (also commonly referred to as X80) in the UK onshore gas industry occurred in 2000. National Grid (NG) now operates 863Km of 1220mm L555 pipe. It is anticipated that this high strength material will continue to be a preferred choice for future large capacity feeders required for bringing in supplies from new areas, and on future reinforcement projects.

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Method(s)

The method of research proposed for this innovation project includes both static and fatigue full-scale testing, supported by a set of small scale tests to verify the mechanical properties for the line pipe used for the tests.

This two year innovation project will expand knowledge of grade L555 pipe, which can be applied by all network licensees. There is currently no published test data on the fatigue performance of plain dent damage in grade L555 pipe, whereas test data on dent damage in a pipeline constructed from line pipe up to and including grade L450 (commonly referred to as X65) has been sufficiently investigated.

The testing will be conducted in several stages, with some elements overlapping in stage two due to dependencies on deliverables. These are summarised below.

1. Dent static test plan
A total of ten tests are proposed within the dent static test plan on two pipe lengths. This includes:

- Six dents in plain pipe,
- Two dents affecting a seam weld,
- Two dents affecting a girth weld.

The plain pipe dents will be of varying depth, from 2% to 10% (to be confirmed during testing). The depth of the dents affecting either the seam or girth weld will be confirmed based on the performance of the plain dent tests.

Each dent will be pressurised to failure, or else a maximum test pressure.

The tests will be consistent with the approaches previously taken to determine the dent acceptance limits for pipelines constructed from line pipe up to and including grade L450 (commonly referred to as X65).

2a. Dent Fatigue test plan
Following the static test plan, another test vessel will be constructed from two pipe lengths welded together, into which the ten dents will be introduced. The dent depths will be confirmed following completion of the static test program. This vessel will then be subjected to cyclic pressure loading for up to 150,000 cycles. As dents fail they will be cut out from the vessel which will then be re-welded together prior to restarting the fatigue testing.

The test work will be consistent with the approaches previously taken to verify the fatigue performance of dents in pipelines constructed from line pipe up to and including grade L450.

2b. Small scale
A set of small scale work will be undertaken in conjunction with stage 2a. To determine the mechanical properties of the line pipe used in testing.

The small scale tests will confirm compliance with the NG line pipe specification, and provide essential data should a more detailed, expert assessment be required to assess the significance of dent, and other damage types.

3. Development of Assessment Method
The results of the full scale tests will be used to investigate extending the range of applicability of current dent assessment criteria which are currently limited to pipe grades L450 (X65). This includes the dent fatigue life assessment methods developed by EPRG and DNV GL (formerly Advantica), and the UKOPA dent management strategy, which also incorporates a risk assessment methodology for dealing with dents on welds.

The results of the analyses will be shared with Industry towards potential update of the industry recognised assessment methods for

dealing with dent damage to L555 pipelines.

4. Project reports
A serious of reports will be provided throughout the lifecycle of this project. They include the following:
Fortnightly progress reports

- Test (technical) reports, including a final technical report
- Final technical report

Change Control - June 2020:
Considering the comprehensive testing regime of the project, most testing has gone according to plan. However, during the early static tests, it was noted that some of the tests had produced some results which the project team did not anticipate – which in turn could potentially compromise the value of the project output.

To maximise the output from the tests, some modifications were made to the test procedures. This required some additional work, which had a financial impact, and the testing timeframe would be extended as a consequence, resulting in some of the tests being carried out through winter – yet with no anticipated delay to the project finish date.

It was decided that metallurgy investigation and Finite Element Analysis (FEA) would be beneficial to help explain the results the project team were seeing. Subsequent analysis of the results has provided suitable conclusions and recommendations.

This change control seeks to:
Request an additional 3 months to the project timeline to allow sufficient time to compile and review reports and request £14.9k external funding (£17,880 including NG costs) which comprises of and will cover the following project overspend:

- Metallography of plain dent samples (deformation/cracking due to denting): £10.4k
- Trace heating and installation: £4.5k

Scope

The high strength of L555 linepipe is achieved through a complex series of heating, rolling and cooling of the plate material, a process which is not done for the traditional lower strength materials. Unlike dent damage in a pipeline constructed from line pipe up to and including grade X65, there is very limited test data published in the UK and worldwide, regarding the fatigue performance of dent damage in grade L555 pipe.

Being a novel material, NG previously performed a programme of investigation to demonstrate the material can be safely and economically utilized before first use. The scope of work included a series of tests looking at the tolerance of the linepipe to defects including corrosion, gouges, cracks and dent-gouge combinations. During the investigation a very limited scope of work performed on the behavior of plain smooth dents and fatigue testing was not undertaken. This presented a gap in validation that this project aims to address. Notwithstanding the constraint in the overall scope of tolerance testing, the findings from this investigation were able to demonstrate that L555 linepipe can be safely used on the NTS. In addition, the findings enabled defect acceptance limits to be developed for inclusion in our procedure for the inspection, assessment and repair of pipeline defects procedure, T/PM/P/11.

The decision to use 1220mm L555 pipe is predicated on the findings of initial investigatory work, and because of the commercial benefits derived when a large diameter pipeline is required on the National Transmission System (NTS). Whilst L555 is more expensive per tonne than traditional lower strength pipe, the higher strength steel allows for thinner wall pipe, and this leads to less total tonnage required during construction. In addition to cost savings due to reduction in pipe weight, further benefit is derived from a reduction in welding costs for thinner walled pipe. The overall construction cost associated with 1220mm L555 pipe is significantly reduced compared to traditional lower strength pipe (material grades L245, L290, L360, L415, L450).

Therefore, the project scope is designed to validate an increase to the dent acceptance limit for grade L555 pipe, and to confirm the impact of smooth dent damage on the fatigue life of the pipeline. This will ensure that NG and other network licensees using L555 pipe are informed when it comes to accurate assessment of dent damage on grade L555 pipe and can thereby avoid instances of unnecessary remedial action. NG now operates 863Km of 1220mm L555 pipe and it is anticipated that this material will continue to be the preferred choice for any future large capacity feeders required on the NTS.

Objective(s)

Carry out comprehensive testing on plain dents to determine tolerance levels of grade L555 pipe. Incorporate findings into inspection procedures and associated training. Remove any unnecessary remedial action that would impact on local environment and cause service disruption.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The project will provide the GB gas industry with validation of grade L555 pipe tolerance levels for plain dents. This knowledge will be incorporated into NG's pipeline inspection procedures (P11), and will be made available for implementation into industry wide

procedures. National Grid, and the industry as a whole, will benefit from a more detailed understanding of the integrity of plain dents in grade L555 pipe so that appropriate decisions can be made on remedial action, thereby removing potentially costly excavations that would impart environmental impacts and potential service disruption.

Project Partners and External Funding

Project Partner - DNV-GL
External Funding - Nil

Potential for New Learning

High strength grade L555 pipe is used across gas transmission and distribution companies. Therefore, all gas network licensees GB will potentially benefit from the output generated as part of this project.

NG undertakes the inspection, assessment and repair of damaged pipelines in accordance with T/PM/P/11. Other network licensee's adhere to their own version of the P11 procedures. It is anticipated that the findings will be used to update exiting procedures (P11) industry wide.

Discussions are taking place to look at the potential of moving away from licensee specific P11, and moving towards a standardised P11 across the industry. The findings from this project will feed into those discussions.

Scale of Project

In order to test the tolerance levels of L555 pipe, it is necessary to undertake a comprehensive dent test plan within a controlled environment and measure the outputs. The supplier will provide a test frame, instrumentation and infrastructure that will be used to safely undertake the full spectrum of static, fatigue and small scale analysis tests. Thereby removing the requirement to purchase bespoke testing infrastructure.

Technology Readiness at Start

TRL4 Bench Scale Research

Technology Readiness at End

TRL7 Inactive Commissioning

Geographical Area

The full scope of works will be undertaken in a controlled test environment at DNV GL testing facility. Delivery of testing is not dependent upon activities within a working environment. Therefore, the various test activities will not be impacted by a requirement to gain site access or safety constraints associated with onsite activity.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£893390

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:

n/a

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)

This project looks to promote a reduced plan for excavations based on an increase to the superficial limit for grade L555 pipe, which could have the following environmental benefits:

- Less local environmental nuisance from noise, dust, light pollution, road traffic.
- Less use of natural resource, such as backfill, fuel for plant, fuel for staff transport.
- Less risk of damage to wildlife habitats
- Less risk of impacts on areas of outstanding natural beauty and Sights of Special Scientific Interest (SSSI)

The benefits derived from a removal of unnecessary remedial actions will be realised through cost avoidance in the region of £200k to £10m. The figures are dependent upon level of disruption of service, where excavation requires outages or an agreement for reduction of pressure as outlined below. An environmental benefit would also be realized from the prevention of pipeline excavation, delivering a carbon savings of 21,000 tonnes of CO2e per repair.

Please provide a calculation of the expected benefits the Solution

Base Cost: for excavation and repair on 1220mm L555 pipe for dents above 2% diameter:

- For an excavation and repair a where an outage can be agreed to obtain the required pressure reduction for safety, the base cost is approximately £200k.
- In a scenario where an outage could not be agreed for excavation and repair, this leads to a reduced capacity and requirement for compensation of the main suppliers at an estimated cost of £1m per day. A typical repair may take 7 days to undertake, hence costing around £7m.
- The impact on the local environment and carbon footprint: Disruption to the land owner due to excavation. To enable a safe excavation, the materials are stored on site, application of a steel sleveer, and venting of the pipeline resulting in a carbon footprint of 21,000 tonnes of CO2e.

Method Cost: avoidance of excavation and repair on 1220mm L555 pipe for dents above 2% diameter:

- No excavation is required, removing requirements for outages or pressure reduction. Cost avoidance of between £200k to potentially several million.
- The impact on the local environmental avoided.

- This has a benefit to the land owner, where their land does not need to be disturbed and turned into a construction site while the excavation takes place.
- Savings in carbon footprint of, at minimum 21,000 tonnes of CO2e per repair.

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

NG now operates 863Km of 1220mm L555 pipe. This high strength steel material is expected to be the preferred choice for construction of future large capacity feeders be required either for bringing in supplies from new areas or for reinforcement projects. Due to the high strength material, the L555 pipe wall is thinner than lower strength materials, allowing for significant weight reduction which provides considerable cost benefit at the construction phase.

Once the tolerance levels have been identified, the procedures for inspection, assessment and repair of damaged pipelines will be updated (T/PM/P/11), thereby removing any unnecessary remedial activity based across all network licensees that use L555 pipe on their networks.

The quantity of L555 pipe used by other UK network licensees is not known, however, similar updates to other network licensees inspection procedures will be made possible through the findings from this project.

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

It is anticipated that updating our procedure for the inspection, assessment and repair of pipeline defects procedure, T/PM/P/11 and the provision of training will cost approximately £5k-£10k.

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

Grade L555 pipe is used across gas transmission and distribution companies. Therefore, all gas network licensees GB will potentially benefit from the output generated as part of this project. It is anticipated that the findings will be used to update exiting procedures (P11) industry wide.

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

☑ Has the Potential to Develop Learning That Can be Applied by all Relevant Network Licensees

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.

The inspection, assessment and repair of damaged pipelines are performed in accordance with the NG procedure T/PM/P/11. UK network licensee's follow their own version of P11. Discussions are in place looking at the potential of moving away from licensee specific P11 towards a standardised P11 across the industry. This project will feed into those discussions and does not duplicate any current research on dent tolerances for L555 linepipe.

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 is innovative because it seeks to undertake a comprehensive validation of dent tolerance and fatigue analysis on high strength grade L555 pipe that has not yet been completed in GB, for use on the national transmission and distribution network. Where an increase to the superficial limit for grade L555 pipe is proved, these findings will provide network licensee's with the ability to continue safe inspection, assessment and repair of damaged L555; whilst making decisions for the right level of work to be carried out on existing L555 pipe. Further benefit will provide savings in carbon footprint associated with remedial action, and the prevention of disruption to the local environment.

Relevant Foreground IPR

n/a

Data Access Details

n/a

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

The current procedures for inspection, assessment and repair of damaged L555 pipe are used industry wide, but are believed to be conservative and therefore have the potential to incur costly remedial work that, based on the findings of this work, may be deemed unnecessary. This new method requires comprehensive testing, development and demonstration to deliver a validation that will ensure continuation of safe inspection, assessment and repair of damaged L555 pipe that is currently installed on the gas transmission and distribution networks. The level of testing and development required precludes it from business as usual 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

The scope of investigation necessary to deliver an industry accepted validation for tolerance levels of grade L555 pipe requires a costly programme of works that carry a technical risk. In the event the test plan outputs do not validate an increase in tolerance levels, then the current procedure (P11) will remain. The technical constraints, and relevance of findings to all network licensees, further support the case for NIA funding.

This project has been approved by a senior member of staff

☑ Yes