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NIA Project Registration and PEA Document

Date of Submission

Jan 2014

Project Reference Number

NIA_NGGT0008

Project Registration

Project Title

Develop novel mitigation method for high frequency main pipework vibration

Project Reference Number

NIA_NGGT0008

Project Licensee(s)

National Gas Transmission PLC

Project Start

February 2012

Project Duration

2 years and 11 months

Nominated Project Contact(s)

Joanne Harris (box.GT.innovation@nationalgrid.com)

Project Budget

£202,000.00

Summary

There are a number of possible mitigation methods which can be used to address this issue depending on the nature of the excitation, including:

- Changes to the source such as alteration of compressor impeller clearances
- The installation of compressor Helmholtz dampers
- Installation of acoustic material or a silencer inside the pipe
- Attachment of external damping material
- Welding of stiffening rings to the pipe work.

The practicality and feasibility of each of these methods depends on the stage in the plant life cycle the problem has been identified.

Third Party Collaborators

DNV

Nominated Contact Email Address(es)

Box.GT.Innovation@nationalgrid.com

Problem Being Solved

High frequency acoustic excitation of main transmission pipelines is characterised by excitation of pipe wall 'shell' modes, with local flexing around the circumference and along the length of the pipe section. At high levels, this behaviour can lead to acoustic fatigue at welded features such as pipe supports and small bore connections.

A number of National Grid compressor facilities have experienced problems of this nature. Increased understanding leading to efficient and effective attenuation of these frequencies will lead to improved maintenance and inspection routines.

Method(s)

The following programme of work is proposed to increase understand of the available techniques, and to develop the grouted ring concept into a working prototype:

- Review of mitigation methods for high frequency pipe wall vibration.
- Development of the grouted ring design and modelling to predict performance.
- Laboratory trials of design to validate modelling.
- Field trials on site with known high frequency vibration issues.
- Development of an application procedure.

The project has been progressing well and as part of a stage gate meeting with GL, National Grid requested that additional elements of work be carried out prior to carrying out the field trials in order to have confidence in the solution for a thorough test programme. The additional aspects will give greater insight into the performance of the grouted rings and include:

Construction, and analysis, of a dynamic Finite Element model of a bolted grouted ring prototype

Undertaking dynamic FE analysis of the grouted ring prototype design, the FE model can be validated against the experimental results from subsequent testing and therefore provide confidence in this technique for future design purposes. Furthermore, validation can be undertaken by comparing dynamic analyses of the prototype grouted ring with stresses induced from experiments with a forced input, i.e. results from using a dynamic shaker (or equivalent).

Hammer and shaker testing, for establishing attenuation performance, of a bolted grouted ring prototype on test pipe

During previous laboratory trials, a grouted ring design was shown to greatly reduce dynamic stresses in the region of a welded feature, achieving up to an 85% reduction in amplitude. Whilst the tap testing undertaken has given considerable confidence in the rings' ability to reduce dynamic stresses, several areas still remain to be investigated:

- Performance of ring design with clamp – a finite element study has been undertaken to design a suitable clamping method for the ring. A prototype will be manufactured and tested in order to confirm the design's performance.
- Performance over large vibration amplitudes (linearity of performance) – whilst modal hammer testing has shown a reduction in response for a relatively low force input, measuring the response to large inputs (similar to those seen in the field) would confirm the likely performance of a final design. This can be achieved by using a forced input on the pipe, such as an electrodynamic shaker.

Modal hammer testing of the system with bolted grouted rings shall be undertaken and the results compared against those previously obtained to identify any effects directly attributable to the flange connection modification. Shaker testing would then be undertaken using the method identified in section 1.

Small-scale shaker testing of grout to prove its integrity under sustained vibration loading

Grouted fixtures are used widely in tee and sleeve applications, however it has not previously been used in an area known to suffer from high frequency vibrations, with the purpose of reducing the dynamic stresses experienced by the pipework. It is therefore unknown as to whether performance may degrade over time if fatigue or other damage to the grout were to occur. It is proposed that a small-scale test be undertaken using an electro-dynamic shaker.

Scope

There are a number of possible mitigation methods which can be used to address this issue depending on the nature of the excitation, including:

- Changes to the source such as alteration of compressor impeller clearances
- The installation of compressor Helmholtz dampers
- Installation of acoustic material or a silencer inside the pipe

- Attachment of external damping material
- Welding of stiffening rings to the pipe work.

The practicality and feasibility of each of these methods depends on the stage in the plant life cycle the problem has been identified.

Objective(s)

The programme will theoretically evaluate a series of cost effective approaches to attenuate high frequency vibration within transmission pipe work. The programme will perform proof of concept trials with the currently favoured grouted ring concept.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The programme will deliver an assessment of the latest high frequency vibration attenuation thinking with respect to gas transmission pipelines. This, coupled with the testing of the grouted ring dampener will give National Grid a wide range of effective solutions to deal with this phenomenon.

Project Partners and External Funding

n/a

Potential for New Learning

n/a

Scale of Project

The programme will give assurance that the relevant National Grid engineering methods and standards covering high frequency behaviour of gas transmission pipelines has an enhanced theoretical and testing basis.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL6 Large Scale

Geographical Area

Applicable across the range of National Grid above ground installations.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

IFI - £130k
NIA - £25k + £47k = £72k

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)

The programme is at the research stage and the costs benefits will become apparent once the findings are known. Replacement costs of compressor infrastructure and associated pipes are considerable. Thus the improved knowledge of high frequency behaviour and its attenuation could have significant cost and safety implications.

The benefits of carrying out the above study include reduced risk of vibration-related fatigue failure due to high frequency acoustic noise for compressor station and AGI pipework. Also failure of main pipe welds, pipe supports and impulse pipework can be classed as RIDDOR reportable, a serious safety risk as well as potentially leading to large releases of natural gas into the environment.
A number of National Grid compressor sites have experienced problems of this nature, including the following

- Carnforth Units A/B – failure of a blank weldolet
- Aberdeen Units A & B – high dynamic stresses on discharge impulse pipework
- Carnforth Unit C – high dynamic stresses on discharge impulse pipework
- Bishop Auckland Units A & B – high dynamic stresses on discharge impulse pipework
- Moffat Unit B – failure of the recycle line due to a longitudinal crack through a main weld

The failure of compressor discharge process/impulse pipework, caused by high dynamic stresses, is likely to cost in the region of £50,000 (including materials, manpower and nitrogen purging). There is also a high risk of a loss of network flexibility with compressor units on outage. Historically these have generated losses of around £50,000 on average. A grouted ring solution could be installed (retro-fitted) with minimal disruption to site operations and has the potential to provide savings in the order of £100K/year.

There is an increasing need to monitor vibration across the NTS due to changes in national infrastructure relating to gas inputs and the impact this will therefore have on the use of the NTS. There is the additional environmental benefit of a reduction of radiated noise levels and no requirement to vent the units on installation.

Please provide a calculation of the expected benefits the Solution

N/A - Research

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

The research would be applicable to any gas networks with compressors.

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

The implementation costs will be dependent on the specific issues and solutions. Until a set of holistic solutions has been considered it is not possible to offer any costs.

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 programme will clarify the range of high frequency attenuation methodologies for transmission pipelines. The behaviour of high frequency is generic and thus the results of this programme will have applicability across other pipeline networks.

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

Reliability: The programme will offers considerable benefits in terms of asset modification improving the ability of the National Grid undertake this work effectively and efficiently.

Strategic: The analysis will ensure that National Grid has the best available technical and practical solutions to mitigate against the effects of high frequency vibration of transmission gas pipelines.

☑ 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.

n/a

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

n/a

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

n/a

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

n/a

This project has been approved by a senior member of staff

☑ Yes