national gas transmission

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

Jan 2014

Project Reference Number

NIA_NGGD0009

Project Registration

Project Title

Orifice Plate Deformation

Project Reference Number

NIA_NGGD0009

Project Licensee(s)

National Gas Transmission PLC

Project Start

February 2011

Project Duration

3 years and 4 months

Nominated Project Contact(s)

NGGD Andy Finch – Project Manager (lead GDN) and
NGGD Andy Newton – Portfolio Manager

Project Budget

£190,154.00

Summary

Orifice plate meters form a substantial part of National Transmission System (NTS) to Local Distribution Zone (LDZ) custody transfer and in order to conform to the orifice plate metering standard, ISO 5167, the plates need to satisfy numerous criteria such as flatness, edge squareness, surface finish, thickness of size of orifice bore and bevel angle, any deviation from the standard can lead to metering errors which can cause under registration of mass flow.

During normal operation, orifice plate meters are subjected to a differential pressure across the plate, design maximum pressures of up to 1000 mbar have been used in these installations. A correctly designed orifice plate will deflect or deform elastically. At higher differential pressures, the plate will reach a point beyond which is will permanently deform, as an orifice plate deforms elastically there are increasing flow errors which must remain below 0.1% to conform with the standard, additionally the plate flatness under load must not exceed 1%. The equations used to predict orifice plate deformation are in question.

Modern computational techniques make it possible to revisit orifice plate deformation using a combination of CFD and FEA. Typical data taken from offtake metering can be used to generate a bespoke and allencompassing solution for calculating the deformation of orifice plates in natural gas systems.

Nominated Contact Email Address(es)

Box.GT.Innovation@nationalgrid.com

Problem Being Solved

There is a need for an agreed industry method of calculating orifice plate deformation more accurately. Equations currently used to calculate orifice plate deformation were derived during the 1920's to 1950's, some work was also undertaken by the British Gas Engineering Research Station in 1975, the results of which are included in a program called Jeplast which is embedded in HPMIS, it

has been noted that there are differences in the results obtained from Jetplast and other equations which are noticeable at higher beta ratios currently and commonly in use in the UK, further differences have also been noted when comparing results obtained from Jetplast and those independent auditors, this has impacted the compliance with the ISO standard.

Method(s)

An initial study has been carried out and comprised a survey of the existing orifice plates in use by National Grid Distribution as well as the existing technical literature and equations currently used to predict orifice plate deformation.

Further stages of the project will involve computational fluid dynamics (CFD) and finite element analysis (FEA) to establish how orifice plates behave in the field, to determine and quantify measurement errors caused by the deflection of orifice plate. CFD runs have to be conducted with the deflected orifice plate geometry which is unknown at the start. For this, iterative runs between CFD and FEA are required, this will establish the parameters and geometries which have the greatest effect on orifice plate deformation, the output from this stage will be a new method for assessing orifice plate deformation based on the worst possible case – this will enable the identification of those parameters which have the greatest impact.

Scope

Orifice plate meters form a substantial part of National Transmission System (NTS) to Local Distribution Zone (LDZ) custody transfer and in order to conform to the orifice plate metering standard, ISO 5167, the plates need to satisfy numerous criteria such as flatness, edge squareness, surface finish, thickness of size of orifice bore and bevel angle, any deviation from the standard can lead to metering errors which can cause under registration of mass flow.

During normal operation, orifice plate meters are subjected to a differential pressure across the plate, design maximum pressures of up to 1000 mbar have been used in these installations. A correctly designed orifice plate will deflect or deform elastically. At higher differential pressures, the plate will reach a point beyond which is will permanently deform, as an orifice plate deforms elastically there are increasing flow errors which must remain below 0.1% to conform with the standard, additionally the plate flatness under load must not exceed 1%. The equations used to predict orifice plate deformation are in question.

Modern computational techniques make it possible to revisit orifice plate deformation using a combination of CFD and FEA. Typical data taken from offtake metering can be used to generate a bespoke and allencompassing solution for calculating the deformation of orifice plates in natural gas systems.

Objective(s)

To improve the measurement of volume and energy flow through orifice plate metering systems by ensuring that orifice plate deformation is calculated correctly.

The achievements of this project will enable the calculation of orifice plate deformation to be carried out more accurately, there is currently not a single agreed industry method and with the advantages of modern computational techniques, it is believed that this can now be achieved; The ultimate aim is to recommend this method as the Industry Standard.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The technical achievements are anticipated to be:-

- Survey of existing technical literature to establish current status of orifice plate deformation calculation.
- Establish the causes of the differences between the Jeplast routine within HPMIS and other equations
- Use computational fluid dynamics (CFD) to calculate the actual load distribution on the orifice plate for a worst possible case.
- Use FEA to calculate the behaviour of the orifice plate under the load distribution calculated from the CFD for a worst possible case.
- Repeat the CFD and FEA calculation method established in stage 2 for a range of plate sizes, beta ratios, seal and mounting types.
- Recommend a method of calculating orifice plate deformation that can be implemented.

Project Partners and External Funding

n/a

Potential for New Learning

n/a

Scale of Project

This project will be carried out over three stages from an initial survey of existing orifice plates in use by National Grid as well as the existing technical literature and equations currently used to predict orifice plate deformation, this part of the project has been completed under the Innovation Funding Incentive and established that there are technical challenges that need to be addressed and that modern computational
techniques are not able to provide solution.

Stage two of the project will involve computational fluid dynamic and finite element analysis to establish how orifice plates behave in the field. To determine and quantify measurement errors caused by the deflection of orifice plates CFD runs have to be conducted with the deflected orifice plate geometry which is unknown at the start. For this, iterative runs between CFD and FEA are required; this will establish the parameters and geometries which have the greatest effect on orifice plate deformation. The output from stage two will be a new method for assessing orifice plate deformation based on the worst possible case – this will enable the identification of those parameters which have the greatest impact.

Stage three of the project will be determined by the output of the work in stage two, however it is planned that the CFD and FEA calculation method identified in stage two will be extended to cover the matrix of orifice plate sizes, types, materials and geometries being used in the field, this will establish how orifice plates behave in operational conditions. All three stages are essential in that the results from each stage will establish a proposed method and possibly an equation for predicting orifice plate deformation and flow errors, this can then be shared with the industry to establish wider acceptance and a consistent approach for calculating orifice plate deformation.

Technology Readiness at Start

TRL4 Bench Scale Research

Technology Readiness at End

TRL7 Inactive Commissioning

Geographical Area

Loughborough, East Midlands

Revenue Allowed for the RIIO Settlement

No Revenue Allowed for in the RIIO Settlement

Indicative Total NIA Project Expenditure

NGGD
£18,861 IFI Project expenditure
£18,842 NIA Project expenditure
£37,703 total Project expenditure

NGGT
£16,000 IFI Project expenditure
£24,000 NIA Project expenditure
£40,000 total Project expenditure

SGN
£7,993 IFI Project expenditure
£25,388 NIA Project expenditure
£33,381 total Project expenditure

NGN
£12,920 IFI Project expenditure
£66,150 NIA Project expenditure
£79,070 total Project expenditure

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)

If the solution is successful this will reduce the uncertainty surrounding the assessment of orifice plates and billing queries, therefore avoiding the potential to replace orifice plates that are not really deformed, as well as improving shrinkage management and apportionment of cost. Associated cost savings are expected to be in the excess of £1 million.

Please provide a calculation of the expected benefits the Solution

Base Cost (Circa £1 million, cost of metering uncertainties and orifice plate replacement costs) minus Method Cost (£0 datum, cost avoidance) = circa £1m cost savings.

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

This Method could be applied across the whole of GB, where reliable and accurate methods for calculating orifice plate deformation at typical Gas Distribution operating conditions are sought.

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

£20,000/ site. Site numbers and locations to be confirmed

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)

☐ 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

Accurate custody transfer metering will benefit the entire natural gas transportation industry in the UK because it leads to accurate billing between parties. An industry recognised method of calculating flow errors from the deformation of orifice plates will facilitate the calculation of metering errors.

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

Not applicable

☑ 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