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

Sep 2022

Project Reference Number

NIA2_SGN0028

Project Registration

Project Title

Hypurge Safe Tooling

Project Reference Number

NIA2_SGN0028

Project Licensee(s)

SGN

Project Start

September 2022

Project Duration

0 years and 6 months

Nominated Project Contact(s)

David Raymond

Project Budget

£62,260.00

Summary

The objectives of this Project are set out below:

- Investigation of flame arrestor development, (IGE/SR/22 requires flame arrestors to be used on vents that flow less than 10 m/s.) Investigations should be made to see if these need sourcing for hydrogen and if so, identifying where and how this can be done.
- Calculation of purge tables and purge calculators for hydrogen use as specified in ML2 and other SGN procedures.
- A purge vent design that is clearly different to a natural gas vent that can be used for hydrogen. The vent is not expected to include a flame arrestor but instead produce a flow speed sufficient to prevent burn back during a purge.
- Mitigating unwanted ignition mechanisms including non-sparking hand tools – review non-sparking tools used in the offshore environment and provide recommendations for H100

Preceding Projects

NIA2_SGN0008 - HyPurge

Third Party Collaborators

Steer Energy Solutions

Nominated Contact Email Address(es)

sgn.innovation@sgn.co.uk

Problem Being Solved

SGN has recently completed the HyPurge project that has examined direct purging of the gas network to and from hydrogen. The scope of work compared the purging performance of hydrogen compared to methane for pipe diameters up from 63 mm to 250 mm and pipe lengths up to 100 m with a run of 375 m planned.

The project has undertaken over 750 purges across a range of pipes and fittings both in the workshop and offsite. The outcome of the HyPurge project is the evidence that in terms of gas exchange, hydrogen performs at least as well as methane, in some cases hydrogen performs better than methane. A conclusion of this project is that direct purging is achievable for network commissioning and can be considered for H100 Fife.

As part of HyPurge and other projects, project partner, Steer Energy, has carried out detailed literature reviews of the purging process and relevant standards. This included information relating to hydrogen and Natural Gas properties and the tooling currently specified for use during purging.

The flammable range of hydrogen is greater than Natural Gas and it requires less energy to ignite flammable fuel-air mixtures in hydrogen. While there are very few unwanted ignitions during purging activities and anecdotally no cases were known to the wider project team, it is unclear if this greater flammability will lead to more ignitions during purges in hydrogen. Steer Energy has witnessed no unwanted ignitions during all of the hydrogen projects carried out to date. Ignition measurements have been taken as part of risk assessments and safety cases and that has shown hydrogen to be easier to ignite than Natural Gas.

It is clear that some of the tooling specified by the IGEM standards for use in Natural Gas will not be suitable for use in hydrogen. In particular, the standard for network purging, IGE/SR/22, requires flame arrestors to be used on vents that are used in block and bleed operations. If this requirement is to be carried forward to H100 for hydrogen use, then flame arrestors suitable for hydrogen will need to be specified and produced for use during H100 commissioning.

Flame traps are considered to not be required if the vent speed is fast enough, but speeds are only fully specified for Natural Gas.

IGE/SR/22 states:

- *5.5.6 (d) A flame trap should not be fitted unless the venting velocity is below10 ms-1 for Natural Gas. Other gases may need a higher venting velocity. Flame speeds range from between 0.5 ms-1 for Natural Gas and LPG, and 3.5 ms-1 for hydrogen. The responsible engineer should check the flame speed of any other gases before proceeding.*

Testing should be carried out for hydrogen-air mixtures to demonstrate safe vent speeds so that this can be updated for hydrogen with similar safety values. Vents that promote high flow speeds have been used by Steer during their testing, and purging over a live flame has been demonstrated with no burn-back into the pipe.

- *5.5.7 When purging services up to and including 50 mm diameter, it is acceptable to use a flexible purge hose with a flame trap venting to a safe place outside the building.*
- *8.6.2.2 Services (b) A flame trap should be fitted to the purge hose outlet.*

This again suggests that a flame trap will be needed that is suitable for hydrogen use.

- *8.3.4.1 To prevent stratification of gases it is necessary to maintain a minimum purge velocity. The Purge velocity should not exceed 20 ms-1.*

The exclusion zones used for purge operations are set to a 5 m general zone. The venting standard IGE/SR/23 deals with much larger venting operations than most routine purges and the 5 m zone is a catch all for the minimum operations. Steer have already carried out ignition tests for small plumes such as may be vented from a purge of a domestic installation and to ignite the plumes the igniter needed to be within 1 m of these plumes. This was for small plumes from pipe diameters up to 35 mm, it would be useful for H100 to extend this work to 1” and 2” vents that will be used for purging and venting operations during commissioning and other routine work. This could be used to assess the 5m exclusion zone and also create training material or hold demonstrations for SGN employees working on the H100 project.

As part of HyPurge, the comparative purge effectiveness for hydrogen and methane were investigated up to 250 mm diameter. Specifications for setting up these purges are contained in the tables in section 28.3.2 of ‘SGN-PM-MSL/1 Management Procedure for Distribution Mainlaying and Servicelaying Activities’. The tables will need to be modified for hydrogen; in the first instance a subset of tables could be generated for the limited sizes investigated to date. At some point the full set of data will need to be generated. If purge processes are to be modified using different tooling such as the purge whistle or a reduced vent nozzle for safer purging then the tables and procedures will need to be modified as well.

Some of the literature states that spontaneous ignition can happen in hydrogen and that this might be linked to rust or other particulates being carried by the gas. The premise is that ignition is caused by heat or sparks generated when particulates impacting the pipe wall. The physical properties of hydrogen will mean that many purge and flow processes will be up to 3 times faster in hydrogen than in Natural Gas. The HyPurge project measured this ‘speed up’ effect in hydrogen during routine purging operations. This is also a possible topic for further study. Other topics could include investigating the use of non-sparking tools which are a requirement offshore and used to be a requirement on the gas network.

Method(s)

The outline of work to be carried out includes:

- Investigation of flame arrestor development, (IGE/SR/22 requires flame arrestors to be used on vents that flow less than 10 m/s.) Investigations should be made to see if these need sourcing for hydrogen and if so, identifying where and how this can be done.
- Calculation of purge tables and purge calculators for hydrogen use as specified in ML2 and other SGN procedures.
- A purge vent design that is clearly different to a natural gas vent that can be used for hydrogen. The vent is not expected to include a flame arrestor but instead produce a flow speed sufficient to prevent burn back during a purge.
- Mitigating unwanted ignition mechanisms including non-sparking hand tools – review non-sparking tools used in the offshore environment and provide recommendations for H100.

Scope

WP1: Project management, and communications

The first work pack is the project management, regular updates and project reporting to wrap up the various work packs delivering the individual tool elements.

The individual work packs have individual reporting requirements, it is expected that the individual reports would be collated together in the form of a concise final report. It is not expected that this will be a detailed theoretical report, but a collection of evidence to support the design of the various tools.

WP2: Flame arrestors (for use on bleed vents)

The purge standard IGE/SR/22 requires flame arrestors to be used on vents that flow less than 10 m/s. The picture to the left shows four end of line flame arrestors being used on bleed pipes during a dead insertion of new PE pipe into a cast iron main. The requirement for flame arrestors needs verifying for hydrogen.

A market survey is then required to identify where flame arrestors for hydrogen could be sourced. Flame arrestors are available for use with hydrogen in certain process industries. We will explore the transfer or development of this tooling for use in the Gas industry.

Proposed scope of work

- Review standards to understand the requirement of flame arrestors, discussions with SGN and third parties to confirm field uses and requirements of flame arrestors.
- Carry out a market survey on flame arrestors used in the gas industry and flame arrestors used for hydrogen (including in-line and end of line arrestors) for the process industry. The survey could also include liquid seal arrestors.
- Identify gaps between requirements and products available
- Identify supplier/s willing to develop hydrogen flame arrestors
- Scope up for stage 2 if development is required
- Short report of findings and recommendations
- The standard review and market survey may extend to examining the requirement for bleed vents. Options may include producing a bleed design that will mitigate ignition of the vent without the need for a flame arrestor.

WP3: Calculation of purge tables

Work from the HyPurge project has shown that gas exchange between air and hydrogen is as efficient as that between air and methane in like for like conditions. The ‘speed up’ effect in hydrogen tends to improve purges for hydrogen over methane in the field. Gravitational effects due to the very low density of hydrogen hasn’t caused any more challenges to the purge process than with methane, even at slow speeds. The purge calculator spreadsheet used by SGN refers to section 28.3.2 of ‘SGN-PM-MSL/1 Management Procedure for Distribution Main-laying and Service-laying Activities’ as a reference document for the tables (named C11, C12 and C13 in the calculator). These tables are the basis of minimum rider and vent sizes for use with methane systems.

The tables dictate the rider and vent sizes to be used to guarantee flow rates. It is likely, however that if the same tables and equipment is used for hydrogen then the flow rates will be significantly different once hydrogen dominates the system. Flow rates in hydrogen are likely to be x2.8 those for methane which will result in much faster flows during purging and other vent operations. It would be prudent to re-calculate relevant tables for use with hydrogen.

The tables themselves refer back to Table 2 of IGE/SR/22 and are also linked to Table 12 of the utilisation standard IGE/UP/1. A full re-write of the standards for hydrogen would involve testing large diameters which although needed at some point is not required for H100 Fife. The proposed scope is therefore to produce a subset of tables for pipe diameters up to those involved in H100 Fife, (up to 250 mm).

Once the theoretical calculations are made, a selection of examples should be tested to compare the theoretical calculated results with actual measurements. One of the challenges expected here is that purge speeds are established in air, but the speeds will change dramatically as the air transitions to hydrogen. This may need to be noted in the updated tables.

The scope will also look at options for setting up a training rig that can be used for validation measurements. The training rig is also to be scoped to provide demonstration tests of purging in hydrogen and also as a training rig to be used to train operators to carry out purging operations on relevant network sections.

Proposed scope of work

- Theoretical work to update purge tables as per ML1 and ML2.
- Practical work to test a couple of instances of this on relevant network pipes to validate the theory
- Providing assistance in re-writing the relevant sections of SGN documents (Schedule H of ML2)
- Scope up training opportunities for SGN commissioning teams to give exposure to hydrogen purging

Deliverables

The deliverables for this work pack are a section of updated purge calculations that can be used in place of Table 56 in ML1 and Table 46 in ML2 up to 250 mm diameter. A short report will provide details of the theory used for this work and the evidence generated to support the theory that leads to the tabulated data and the purge calculator. Demonstration of purging with hydrogen, (using the purge vent from WP4) and scoping of training for H100 Fife commissioning teams.

WP4: Hydrogen purge vent design

Before commissioning the H100 Fife network, vent stacks should be checked and agreed to be suitable for use with hydrogen. In particular, checks should be made to see if a new minimum vent speed is required to guarantee an acceptable safety factor in preventing burn back in hydrogen-air mixtures during venting operations.

The purge standard IGE/SR/22 section 5.5.6 states that:

- *'a flame trap should not be used unless venting velocity is below10 ms-1 for Natural Gas. Other gases may need a higher venting velocity. Flame speeds range from between 0.5 ms-1 for Natural Gas and 3.5 ms-1 for hydrogen'*

The laminar flame speed for Natural Gas is given as 0.5 ms-1 and the minimum vent velocity 10 ms-1. This implies a safety factor of 20. The laminar flame speed for hydrogen is given as 3.5 ms-1 with the same safety factor, this suggests a minimum vent velocity of 70 ms-1. A formal recommendation of a safety factor is not provided in the standards.

The work will carry out experiments to review the possibility of burn-back during a purge. The vent speed will be varied and the degree of burn back measured for methane and hydrogen. This will allow comparisons to be made between existing vents and modifications to achieve similar performance in hydrogen. The results of these tests will be used to recommend the design of a modified purge stack for hydrogen. A vent stack with a restriction at the end will significantly increase the vent speed at the end of the stack, moving towards ensuring that the fastest speed during the purge is at the vent itself, potentially making the vent process safer.

Production of a hydrogen vent stack will also facilitate the use of the Hydrogen Whistle, a passive hydrogen indicator being developed by Steer. The sample point on the stack could have a mount for the whistle that delivers an audible tone indicating real time the purge progress and confirmation of purge completion, minimising the volume of excess gas vented during a purge.

Proposed scope of work

- Scaled vent flow tests to assess likelihood and degree of burn back with various air-hydrogen mixes
- Ignition tests with vent pipes up to 2" during hydrogen purges
- Modification of vent stacks to mitigate burn back in the event of slow purges
- Tests using additional equipment such as the hydrogen whistle and pressure measurement to give real time, passive indication of the purge progress
- Design of a clearly labeled hydrogen purge vent

Deliverables

A purge vent suited for hydrogen and clearly marked to be different from a purge vent used for Natural Gas. A short report and demonstrations on the safe use of the stacks to be used in H100 commissioning operations.

WP5: Mitigation of ignition mechanisms

Over 750 purge operations have been carried out to date on the HyPurge project. During this time no unwanted or unexpected ignitions occurred, this is a small data set compared to the number of gas operations safely carried out each year. There is however, anecdotal evidence in the literature involving ignitions of hydrogen-air mixtures and this is a cause for concern regarding the safety of hydrogen in future. The exact nature of the ignition mechanisms is often unclear but suggestions include sparking from static electricity or heat or sparks generated by particulates such as rust impacting the pipe wall during high flow venting operations.

Offshore oil and gas operations often specify non-sparking tools to be used in zoned areas where flammable atmospheres could be present.

This work aims to look at realistic ignition mechanisms that are likely to exist during commissioning of H100 Fife and identify mitigation methods recognising that this is a trial and so the consequences of an unwanted ignition go beyond the safety of the individuals concerned. In the first instance we need to ensure the safety of all workers carrying out operations on the network. There then needs to be an additional level of confidence of safe operations to provide overall assurance for a transition to hydrogen as a domestic fuel.

Proposed scope of work

This work will carry out a review of possible ignition mechanisms aims to develop an understanding of those ignitions in hydrogen and looks at methods to reduce the probability of unwanted ignitions occurring. This could include non-sparking tooling and anti-static clothing.

Literature review of potential ignition mechanisms in gas networks (building on work already carried out for UK hydrogen projects).
Examination of practices in other industries such as offshore sector in zoned areas.
Review of tooling that is used during purging and identify where non-sparking alternatives are available.

Deliverables

The deliverable is a report on ignition mechanisms that may be applicable to H100 Fife and options of tooling to mitigate unwanted ignitions.

Objective(s)

Work Package 1: Project management, and communications

The first work pack is the project management, regular updates and project reporting to wrap up the various work packs delivering the individual tool elements.

The individual work packs have individual reporting requirements, it is expected that the individual reports would be collated together in the form of a concise final report. It is not expected that this will be a detailed theoretical report, but a collection of evidence to support the design of the various tools.

Work Package 2 Flame arrestors (for use on bleed vents)

The deliverable for this work pack is a short report detailing what is required / desirable in terms of flame arrestors and a market survey of what is currently available. The report will ideally include likely candidates for manufacturing flame arrestors purposed for hydrogen and suited to the gas market.

Work Package 3: Calculation of purge tables

The deliverables for this work pack are a section of updated purge calculations that can be used in place of Table 56 in ML1 and Table 46 in ML2 up to 250 mm diameter. A short report will provide details of the theory used for this work and the evidence generated to support the theory that leads to the tabulated data and the purge calculator. Demonstration of purging with hydrogen, (using the purge vent from WP4) and scoping of training for H100 Fife commissioning teams.

Work Package 4: Hydrogen purge vent design

A purge vent suited for hydrogen and clearly marked to be different from a purge vent used for Natural Gas. A short report and demonstrations on the safe use of the stacks to be used in H100 commissioning operations.

Work Package 5: Mitigation of ignition mechanisms

The deliverable is a report on ignition mechanisms that may be applicable to H100 Fife and options of tooling to mitigate unwanted ignitions.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

N/A

Success Criteria

Success Criteria below:

- Flame arrestors (for use on bleed vents)

Investigation of flame arrestor development, (IGE/SR/22 requires flame arrestors to be used on vents that flow less than 10 m/s.) Investigations should be made to see if these need sourcing for hydrogen and if so, identifying where and how this can be done.

- Calculation of purge tables

Calculation of purge tables and purge calculators for hydrogen use as specified in ML2 and other SGN procedures.

- Hydrogen purge vent design

A purge vent design that is clearly different to a natural gas vent that can be used for hydrogen. The vent is not expected to include a flame arrestor but instead produce a flow speed sufficient to prevent burn back during a purge.

- Mitigation of ignition mechanisms

Mitigating unwanted ignition mechanisms including non-sparking hand tools – review non-sparking tools used in the offshore environment and provide recommendations for H100.

Project Partners and External Funding

Steer Energy will be the partner for this project.

Potential for New Learning

The project will provide learning on the following topics:

- Flame arrestor development, (IGE/SR/22 requires flame arrestors to be used on vents that flow less than 10 m/s.) Investigations should be made to see if these need sourcing for hydrogen and if so, identifying where and how this can be done.
- Calculation of purge tables and purge calculators for hydrogen use as specified in ML2 and other SGN procedures.
- A purge vent design that is clearly different to a natural gas vent that can be used for hydrogen. The vent is not expected to include a flame arrestor but instead produce a flow speed sufficient to prevent burn back during a purge.
- Mitigating unwanted ignition mechanisms including non-sparking hand tools – review non-sparking tools used in the offshore environment and provide recommendations for H100.

The outcomes of the project will be made publicly available following completion via the ENA smarter networks portal.

Scale of Project

This project is investigating the use of purge tooling for use with hydrogen. This will involve lab based testing and desktop analysis. The research findings will be relevant to all GB gas networks.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

The research findings will be relevant to all GB gas networks.

Revenue Allowed for the RIIO Settlement

Not applicable

Indicative Total NIA Project Expenditure

External cost: £62,260

Internal cost: £20,753

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:

A fundamental requirement for the transport of gas is to ensure the safety of our consumers and operatives engaged in construction, maintenance and repair of the network, safe control of operations when purging is a fundamental safety requirement. When commissioning gas distribution network one of the final processes is to commission the network to natural gas. Initially the network will be filled with air, displacing this with natural gas is the process of purging. During network purges there is a likelihood that a flammable mix of gas could be present inside the network. This carries a risk of ignition.

The process of direct purging of air to natural gas is understood, with safe control of operations and purging procedures in place to carry out this operation safely on networks across the UK. The purge velocities required to prevent substantial mixing of air and natural gas are known. Purging is carried out on a regular basis and is an intrinsic element of safe network operations, in particular during network construction and replacement and is carried out on a regular basis by all GDN's.

The H100 Fife project aims to deliver 100% hydrogen to domestic customers the first time. A key element of this project is a new fit for purpose 100% hydrogen distribution network.

Following the outcomes of the recently completed Hypurge project, this project is investigating the use of purge tooling for use with hydrogen.

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)

N/A

Please provide a calculation of the expected benefits the Solution

N/A

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

The research findings will be relevant to all GB gas networks.

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

The research findings will be relevant to all GB gas networks.

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 findings will be relevant to all GB gas 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)

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.

The scope has been reviewed against all existing projects and no areas of duplications have been identified.

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

Following the outcomes of the recently completed Hypurge project, this project is investigating the use of purge tooling for use with hydrogen

Relevant Foreground IPR

N/A

Data Access Details

Any relevant data can be accessed by contacting the project manager.

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

The project is carrying out research and development on an emerging technology. This technology is at a low technology readiness level and as such it is not part of the usual activities of the business.

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 NIA framework offers a robust, open framework to support this work and ensures the results are disseminated to all licenses. The commissioning and conversion of network pipes with hydrogen involves significant technical risks. The project will address all considerations and requirements to allow for the transport of hydrogen and delivery to end users, converting from existing natural gas supply.

This project has been approved by a senior member of staff

☑ Yes