

CASE NOTE

Energy Division – Gas, Pipelines, Wind & Marine Energy

Health & Safety Executive

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Date:	27 th May 2021	cc:	

Case Title: BEIS/Arup+ Hy4heat Case for Safety Project

Hy4Heat: HSE Conclusions Memo – May 2021

1. Background / Introduction

Hydrogen provides a zero carbon alternative to natural gas. Hydrogen has been identified by the government within its ten point plan to deliver the UK's legal obligation to achieve net zero carbon emissions by 2050.

A number of projects are being considered to trial the use of hydrogen for domestic, commercial and industrial use by supplying hydrogen through either a new hydrogen supply system or by converting parts of the existing natural gas supply system to convey hydrogen.

These trials are generally being undertaken by the existing Gas Distribution Networks (GDNs) who are currently responsible for the gas supply pipe system upstream to the emergency control valve (ECV) at a consumer's premise. The focus of the GDNs is therefore on management of the risks associated with the new or repurposed gas pipe systems, the overall safety of the use of hydrogen must however cover all aspects of the supply and use of hydrogen.

The BEIS/Arup+ Hy4heat Project was developed to look specifically at the hydrogen infrastructure downstream of the ECV with the aim of determining if it is technically possible, safe, and convenient to replace natural gas with hydrogen gas in residential and commercial buildings.

The Hy4heat project is split in to 10 work packages as listed in appendix 1. HSE was engaged by BEIS to undertake a review of work package 7 "Safety Assessment".

The Hy4heat project has looked at the potential use of 100% hydrogen rather than a blend of hydrogen and natural gas. Unlike previous trials using a blend of hydrogen and natural gas, should a 100% hydrogen trial proceed, the Gas Safety (Management) Regulations 1996, GS(M)R, will not apply as these regulations only apply to networks which mainly convey methane. GS(M)R requires that no person shall convey gas in a network until they have prepared a safety case and that safety case has been accepted by HSE. There is no requirement to prepare a safety case for a 100% hydrogen network.

2. Work package 7 – Safety Assessment and Output

The Hy4heat Project “*mission is to establish if it is technically possible, safe and convenient to replace natural gas (methane) with hydrogen in residential and commercial buildings and gas appliances. This will enable the government to determine whether to proceed to community trial*”. The approach taken included assessing whether the use of 100% hydrogen in a specific range of settings poses a greater safety risk than the current existing natural gas safety risk.

The assessment process involved the Project collecting data and undertaking experimental testing to review: the potential for hydrogen leakage, dispersion of any loss of containment of hydrogen, likelihood of ignition and consequences of any ignition, and to identify appropriate risk reduction measures (controls). The output from this work was used to complete a quantified risk assessment (QRA) to compare the risks of using hydrogen gas and natural gas.

The output of work package 7 comprises a large body of documentation. A precis document was prepared to summarise the work.

The Project also produced “*Annex to Site Specific Safety Case for Hydrogen Community Demonstration – downstream of the ECV*” (annex). The annex specifically describes the risk reduction measures to be applied downstream of the ECV where 100% hydrogen is supplied. These risk reduction measures underpin the QRA.

The annex was prepared so that it can be added to a GDN’s trial specific safety demonstration suite of documents to ensure that the downstream safety considerations are taken in to account in a consistent way without the need for duplication of effort in each trial.

All documentation is to be available to those undertaking trials via the IGEM Knowledge Centre, or other suitable method.

3. HSE Review Process

There was no formal agreed process for completing the review. The existing GS(M)R assessment criteria are unsuitable as the basis for the review as they relate to upstream gas conveyor activities and not downstream gas use.

The review has been undertaken by HSE’s Science Division (SD) fire, explosion and risk assessment specialists and Energy Division’s (ED) pipeline specialist inspectors.

The SD team of fire and explosion and risk assessment specialists undertook the bulk of the assessment. This included detailed review of the QRA and the evidence that underpinned it. The SD team have raised a number of challenges regarding the submitted documents over a period of approximately 12 months which the BEIS/Arup+ team have responded to with appropriate revised demonstrations.

The review has determined that the risks from hydrogen gas are no greater than those for natural gas in the limited range of scenarios described within the annex where the additional risk control measures specified in the annex are in place.

ED have reviewed the annex with input from SD who were able to confirm that the conditions described therein were representative of the submitted demonstration.

The ED review included the use of the “*HSE Safety Assurance Protocol : Hydrogen for Heat : Safety Demonstration : Considerations for Trials*” question set.

The review was limited to the types of buildings described within the annex. Should trials be proposed which contain buildings that fall outside the scope of the annex or without implementing the risk control measures described in it, there would be a need for such a trial to produce additional safety demonstrations for those circumstances.

4. Use of the Hy4heat safety demonstration / Annex

The annex relates solely to downstream hydrogen gas supply safety. In isolation it is not the safety demonstration for a 100% hydrogen trial but can be used to support a site specific risk assessment for the trial as a whole.

A site specific risk assessment will have to consider three broad areas.

1. Ensuring that the specific requirements of the annex are complied with for the trial.
2. Providing evidence that the general requirements of the annex are complied with for the trial.
3. Demonstrating safety for the wider (upstream) trial.

4.1 Ensuring that the specific requirements of the annex are complied with

The site specific assessment will need to demonstrate that the assumptions of the annex are accurate for that specific trial and how the mitigation measures described within the annex will be implemented before hydrogen gas is conveyed.

These requirements are described fully in the annex and supporting documentation and in brief include:

- properties within scope of the annex are limited to two storey masonry built residential properties or commercial properties that are similar to domestic properties (e.g. corner shops, small restaurants) including boilers up to 100kW, and those where the service pipe maximum operating pressure does not exceed 75mbarg
- each property considered within the trial shall be assessed for its suitability to accept hydrogen
- hydrogen appliances must be new appliances (domestic or commercial), certified for hydrogen use by a Notified Body
- pipework downstream of the ECV shall be visually inspected where this can be done without disturbance to the fabric of the property and remedial work undertaken where it does not comply with current natural gas standards
- a tightness test of the installation downstream of the ECV shall be undertaken
- meters must be new hydrogen smart gas meters containing an integrated Excess Flow Valve to limit the flow rate to below 20m³/hr or lower
- additionally, an Excess Flow Valve shall be installed either in the service pipe or immediately after ECV to limit the flow rate to below 20m³/hr or lower
- Hydrogen gas meters should be installed outside of the property
- properties are compliant (or made to be compliant) with current Building Regulations regarding ventilation and installation of appliances. Additionally, rooms with gas appliances or substantial pipework installed should have vents with equivalent area of 10,000 mm², located as close to the ceiling level as possible and no more than 500 mm below ceiling level. Compliance with appropriate product ventilation standards is also required and/or manufacturers installation instructions

- the hydrogen is odorised, and that the hydrogen odorant chemical is that currently used for natural gas providing the same distinctive odour.

4.2 Providing evidence that the annex's general requirements are complied with

The annex contains important requirements which are less prescriptive and which individual trials may approach differently. Typically, implementation of these requirements may vary due to the size and complexity of the trial area. In all cases the site specific demonstration will have to demonstrate how these requirements will be provided and assured.

Again, these are described fully within the annex and supporting documentation and include:

- ensuring suitable competent resources are available for the trial, including for installation, testing, commissioning, inspection, and maintenance of the downstream installation and appliances
- ensuring suitable competent resources are available for responding to hydrogen escapes and emergency situations that may arise
- installing hydrogen detection alarms where residents are unable to smell the gas odorant or request such a device
- If larger 'light' commercial properties are to be included in the trial area (up to 100kW, i.e. where demand is in excess of 20m³/hr), then a conventional interlock (AIV – automatic isolation valve) system shall be installed which shall cut off the supply to these buildings in the event of a leak being detected
- Arrangements for monitoring the health and safety performance of the trial should be developed both for ensuring safety throughout the trial and to enable further refinement of the Hy4heat safety assessment.

4.3 Demonstrating safety for the wider (upstream) trial

The annex applies to the use of hydrogen gas downstream of the ECV and does not address risks associated with the wider upstream safety management of a trial. The use of the "*HSE Safety Assurance Protocol*" identified many areas that were not addressed by the Hy4heat work as they were out of scope of the Hy4heat Project.

The following is a list of the areas that are not addressed by the Hy4heat work but would need to be considered in a site specific safety demonstration:

- overall emergency arrangements, including how escapes should be reported and responded to
- rights of entry arrangements for emergencies
- suitability of the trial area and supply network, including the materials and components that will convey hydrogen
- risks directly associated with operation of the upstream system (e.g. from leakage)
- the capacity of the system to convey hydrogen, both in terms of volume and minimum pressures
- arrangements to prevent the system exceeding its safe operating limits, e.g. over pressure of the network

- system resilience to ensure security of supply
- access to and provision of suitable instrumentation and ancillary Equipment (e.g. hydrogen monitors for those working on the network)
- gas (hydrogen) quality management
- training and competence of personnel, including procedures and written instructions as necessary
- how change will be managed, including any conversion process
- public awareness
- inspection, monitoring and data collection to support safety.

Note: this is not an exhaustive list

5. Outcome of Assessment

All issues and clarifications raised throughout the HSE review process have been satisfactorily closed.

The review concludes that the annex is suitable to be used as the basis for the safety demonstration for the downstream use of a 100% hydrogen gas trial, subject to the site specific assessment ensuring that all the requirements described within are implemented and assured.

6. Recommendation

It is recommended that HSE issue a *letter of assistance* to BEIS confirming that the Safety Case annex, relating to the risks from the supply of 100% hydrogen gas downstream of the ECV, and supporting documentation provides an adequate basis, if applied appropriately by the relevant duty holder, for:

- Designing the scope of future hydrogen trials,
- Assessment of the risks arising from those trials, and
- Management of those risks in accordance with a suitable and sufficient risk assessment for those trials

Appendix 1

Hy4heat Work Packages:

- WP1 Programme Management
- WP2 Hydrogen Quality Standard
- WP3 Appliance Certification
- WP4 Domestic Appliances
- WP5 Commercial Appliances
- WP6 Industrial Appliances
- WP7 Safety Assessment
- WP8 Demonstration Facilities
- WP9 Community Trial Preparation
- WP10 Developing Hydrogen Gas Meters

Appendix 2 - Glossary and supporting notes

Gas Network

A connected network of pipes for the conveyance of natural gas from terminals and storage sites to the end user / consumer. These pipes are often referred to as mains and services. The network ends at the Emergency Control Valve. This description is based on the definition in Regulation 2 of the Gas Safety (Management) Regulations.

Hydrogen Network

Similar to a gas network but for the purpose of conveying hydrogen. A hydrogen network may be purpose built for hydrogen or a repurposed natural gas network. There is no legal definition for a hydrogen network, for consistency it is considered to be the same as for a gas network. This approach is also consistent with the Gas Safety (Installation and Use) Regulations.

Gas Distribution Network Operator / Independent Gas Transporter

These are the companies who operate the gas networks. To undertake this role the company must hold a license issued by Ofgem.

Distribution Mains

A generic term for the network pipes that supply gas to consumers.

Service Pipes (Services)

A generic term for the network pipes that connect the gas main to the emergency control valve at a property.

Installation pipework

The pipes after the emergency control valve which connect the gas network to a consumer's appliances. These pipes are not part of the gas network. They are owned and the responsibility of the building owner. Any work on these pipelines should be undertaken by a Gas Safe Registered person.

Emergency Control Valve

A valve found at the end of a gas service. This valve must be accessible to a consumer to allow the gas supply to be isolated in case of a gas escape. This valve is the end of the gas network, pipes after this valve are installation pipework.

Upstream / Downstream

Industry terms to distinguish between the gas network and the consumers installations. Upstream refers to the gas supply system up to and including the emergency control valve (mains and services etc.). Downstream refers to the gas supply system after the emergency control valve (installation pipework, appliances, meters etc.).

Gas Safety (Management) Regulations

Regulations which relate to the safe management of gas networks. These require any person operating a gas network to prepare a safety case and have it accepted by HSE prior to starting operating. The regulations also place duties on operators in relation to dealing with gas escapes and to co-operating with others involved in the supply of gas. The Regulations only apply to networks conveying gas "which consists wholly or mainly of methane". Natural gas networks, and those with hydrogen blends below 50%, therefore come under these regulations; 100% hydrogen network do not fall within the scope of the regulations.

Gas Safety (Installation and Use) Regulations

Regulations which deal with the safe installation, maintenance and use of gas systems, including gas fittings, appliances and flues, in domestic and commercial premises downstream of the emergency control valve. These regulations relate to both natural gas and hydrogen in domestic premises but not hydrogen in commercial/industrial premises.

Safety Case

A document required by the Gas (Safety) Management Regulations. The safety case must describe how the operator will ensure its gas network is safely managed. The safety case must be provided to HSE, and HSE must accept the safety case before the network is operated. The safety case is a living document and must be regularly updated. A formal review of the ongoing suitability must be completed at least every 3 years and the findings of this review sent to HSE. The safety case does not include the safety of the downstream installation other than how gas escapes will be managed.

Site Specific Safety Case (S3C)

A term used by the Hy4heat Project which relates to a safety demonstration document prepared by the operator of a 100% trial. Although there is no legal requirement to prepare a "safety case", the operator of a trial will be required to demonstrate that people are protected to risks to their health and safety during the trial. HSE envisage that this demonstration will contain similar information to that normally found in a "safety case". The **annex** provides the additional safety demonstration for the downstream installation which would not normally be included in a "safety case" but will be required for a 100% hydrogen trial. There is no requirement for HSE to accept a "site specific safety case".