Hy4Heat Competence Framework

Energy & Utility Skills

1.1 Comparative Analysis Report – 29 June 2020

1.0 Introduction

This report is the first in a series of outputs that together provide a pathway for the development of a comprehensive Competence Framework for personnel intending to carry out work on an installation fuelled by 100% Hydrogen. The final framework will consist of:

i. a recognised, and IGEM/IG/1 approved, Training Course that meets the requirements of an industry agreed specification,
ii. a competence assessment that enables a candidate to demonstrate the necessary skills, knowledge and understanding required, and
iii. an agreed route to Gas Safe Register recognition in an additional bespoke hydrogen category.

It is intended that attendance and completion of the framework will be restricted to existing Gas Safe Registered personnel holding appropriate defined existing categories of gas related work.

This “version 1” follows consultation with gas industry representatives and other stakeholders with an interest or role in the potential extended use of hydrogen as a replacement fuel. Feedback and comment on the initial draft has been incorporated within the relevant section of this document. Additional comments and information, either not covered in the initial draft or relating to matters arising from extended hydrogen utilisation are included in a revised section 5.

Feedback on this revised draft is welcome and all comments will be taken into account during the next stage of the framework development, which is a skills matrix that provides the content and rationale for the additional skills, knowledge and understanding required by personnel working with hydrogen in a gas utilisation context.

2.0 Scope

Gas Safe Registered personnel eligible for progression through the Hydrogen Competence Framework, will need to have previously achieved the necessary qualification criteria required to carry out work on either domestic and/or non-domestic installations. In addition, by statute, their competence in the specific

matters of gas safety relating to the work categories they hold, will have been maintained as current, and valid with Gas Safe Registration, through one of the recognised routes to re-registration (either the Accredited Certification Scheme (ACS) or the Group Competence Scheme (GCS)). Maintenance of Gas Safe Registration depends, in both cases, on evidence of current competence being provided every five years, either via an independent assessment at the end of the five year period (in the case of ACS) or a continuous portfolio of evidence gathered by the individual's employer (for GCS). This is a robust mechanism that ensures that an individual's competence relating to matters of gas safety is maintained, and updated where necessitated by changes to legislation, regulations, or other considerations such as new technology or equipment.

While the previous paragraph provides assurance of competence relating to work on traditional hydrocarbon fuels, notably natural gas (methane) and LPG (butane and propane), the utilisation of hydrogen is new and for most registered installation and maintenance operatives, its utilisation will be unfamiliar to them.

It is important to recognise that the use of either a blended mix of hydrogen and natural gas, or 100% hydrogen will create a need for the extension of skills, knowledge and understanding for installation and maintenance operatives and emergency response personnel. That said, much of their existing capability will still apply, as will most of the equipment and many of the tools currently in use.

This report, therefore, concentrates on the fundamental differences and challenges that working with hydrogen presents. The properties of hydrogen are clearly significantly different from the range of hydrocarbons and it is primarily these differences that create the need for additional awareness, knowledge and understanding and, for some aspects, changes in work practice. There is no shortage of valuable scientific research and documentation relating to the merits of hydrogen as a heating fuel source, and other learned papers relating to hydrogen as a valuable component of the drive to a zero-carbon economy. There is also extensive literature about the use of hydrogen at high pressure in other contexts such as the space, nuclear and chemical industries, as well as its use in transport. Specialised training already exists for operatives working in many of these contexts. However, this report deliberately limits its scope to addressing the use of hydrogen at lower pressures from distribution systems associated with the utilisation of that gas in a defined domestic and commercial arena only.

It is currently anticipated that the first use of the final hydrogen Competence Framework will be for a limited number of installation and maintenance operatives, within a limited geographic community trial. That said, the framework will be designed to be easily scaled up to national level should this be required at a later

date. The Training Specification and Assessment mechanism will be developed and produced with that scalability as a key consideration.

3.0 Report Format

The report outlines the range of significant aspects of gas utilisation activities that are impacted by the use of hydrogen. Many of these aspects have been the subject of extensive research, test exercises and safety considerations by a number of agencies including the HSE Lab, Kiwa Gastec, GDNs and others, resulting in a positive move to the next stage, expected to be a ring-fenced community trial.

The aspects covered in this report are listed below, with a commentary provided for each. The commentary has been sourced from a number of available documents and from engagement with individual members of a hydrogen stakeholder group, established to facilitate consultation and sign off of elements of the Competence Framework. The hydrogen stakeholder group comprises of over 70 experienced industry practitioners with a wide range of knowledge of gas utilisation and the impact of hydrogen. Future documentation and outputs produced for this project will also seek feedback from this group and others, as part of the industry consultation. It is also clear that this report will remain a "work in progress" as the Competence Framework is developed, as clarification on some technical issues relating to the use of hydrogen is not yet available where it is currently under review .

All recipients of this report and subsequent material, are invited to forward it to other colleagues with expertise, or an interest in the subject.

4.0 Aspects included

- **Properties of gas**
- **Combustion**
- **Legislation, Regulations and Standards**
- **Existing Installation infrastructure**
- **Metering**
- **Installation of Appliances**
- **Tightness testing**
- **Purging**
- **Commissioning and handover**
- **Maintenance**
- **Consumer engagement**
- **Reported gas escapes**
- **Unsafe situations**

4.1 Properties of Hydrogen

The fundamental differences between hydrogen and the hydrocarbon gases currently in use, impact on every aspect of gas utilisation work. Hydrogen contains no carbon and therefore its combustion produces no carbon dioxide and poses no risk of carbon monoxide. Based on volume and compared to methane, the calorific value of Hydrogen is one third the current methane value and therefore greater volumes of hydrogen are needed to achieve a comparable energy output for consumers.

The combustion characteristics are also significantly different than those for natural gas or LPG. The air required for combustion is less and the burning velocity higher. Ignition is much easier to achieve and the flammable range considerably wider at between 4% and 75%[1]. Resulting flame temperatures and flue gas composition are also different and can have an effect on NOx production. Some of these different characteristics will impact on certain operatives more than others, but it will be essential that anyone carrying out work on a hydrogen installation has a full understanding of hydrogen gas behaviour.

4.1.1 Combustion

Complete combustion of hydrogen, in comparison with methane, requires approximately 22% less oxygen and produces no carbon dioxide. Combustion of hydrogen is expected to produce a greater volume of water vapour which in turn will produce an increased amount of condensate. A hydrogen boiler condensate discharge of approximately 1.5 times that of a natural gas boiler is typical. The combustion of hydrogen may also produce trace amounts of NOx and the design of appliances to limit this is a key consideration.

4.1.2 Observations

Thorough knowledge and understanding of the fundamental differences in the composition and characteristics of hydrogen, as compared with familiar hydrocarbons will be a critical component of the hydrogen training and assessment specification. Some of the specific technical considerations, such as burner temperature and flame speed, will be of crucial importance for manufacturers involved in burner and appliance development. For installation and maintenance personnel however, having a comprehensive grip on aspects like the dispersion of gas, flammability and ignition point of hydrogen will be essential elements.

4.2 Legislation, Regulations and Standards

The gas industry is rightly covered by a plethora of legislative and regulatory requirements, supplemented in many areas by industry developed and recognised

[1] IGEM/H/1

Technical Standards that protect the excellent industry safety record. Eminent Standards bodies including the Institute of Gas Engineers and Managers (IGEM) and the British Standards Institute (BSI) have long track records in the development and production of standards, with many of these being adopted in other countries as well as for the UK. Many of the Statutory/Regulatory requirements and Standards will cover the application of hydrogen without the need for changes to existing text. Some however, may need to have supplementary sections added to cover the use of hydrogen, and some aspects may require new standards altogether.

While amending the current Gas Safety (Installation & Use) Regulations [GS(I&U)R] to include hydrogen in a domestic context may be relatively straightforward, extending the scope to include and allow hydrogen to be used in a non-domestic context will require a more significant change, as hydrogen, although defined as a gas in the GS(I&U)R, does not include gas consisting wholly or mainly of hydrogen used in non-domestic premises.

IGEM have developed a new Reference Standard for low pressure hydrogen utilisation (IGEM/H/1) and BSI have recently published guidance on the development and construction of hydrogen fired gas appliances (PAS4444). These documents provide useful information that may be incorporated into any hydrogen awareness or training programmes.

4.2.1 Observations

While the two hydrogen specific documents listed above are valuable in their own right, to enable Gas Safe registered installation and maintenance operatives to carry out future work in consumers premises, a more comprehensive suite of Standards is likely to be required. Some of the existing familiar Standards such as BS6891 (Installation of low pressure gas pipe work up to 28mm), BS5440:1/2 (Flues and Ventilation requirements for appliances not exceeding 70kW) and BS6798 (Installation of gas fired boilers of rated input up to 70kW) may just require additional text or amendments to ensure they incorporate hydrogen as the fuel source. The IGEM Reference Standard will require additional work to produce a comprehensive standard that explains in detail, the mandatory requirements and work practice requirements for working with hydrogen. It must be emphasised that the Standards referred to in this report are examples only and not a comprehensive list. There are several non-domestic standards that will also require attention at an appropriate stage.

While a controlled trial project may be safely managed without a full suite of standards in place, it is recommended that these be produced prior to any larger scale expansion of hydrogen utilisation.

4.3 Existing Installation Infrastructure

Although extensive research has been carried out on the suitability of types of pipework, jointing and other materials involved in hydrogen containing networks, much of this pertains to high pressure systems. As such much of this research is of limited use for low pressure, primarily in a domestic context, as the materials used differ significantly. While some unknowns still exist at this time, most current domestic and light commercial installations will have been installed using materials currently considered suitable for hydrogen use. It will, however, be important for installation and maintenance operatives to have the correct knowledge and understanding of materials and components that are unsuitable for use with hydrogen. Therefore, it will be important for installation and maintenance operatives to be competent to assess any work by an initial survey and inspection of work involving a hydrogen supply.

4.3.1 Observations

The IGEM/H/1 Reference Standard highlights one sealant, in common and widespread use in gas utilisation for many years, as being potentially unsuitable for use with hydrogen due to an identified chemical reaction. This highlights the need for definitive information to be available for installation and maintenance operatives, to enable existing installations to be checked prior to work commencing, and for new pipework and appliances to be installed using only approved materials.

4.4 Metering

As part of the Hy4Heat project, two companies, Fiorentini and Metersit have been appointed by BEIS (in December 2019) to develop smart meters to measure hydrogen. These meters will be compatible with the hydrogen meeting ISO 14687 Type A, which will be used for the conversion of existing gas networks for use in community consumer installations.

The meters being developed must also fit within existing meter boxes and brackets, meeting BS8499:2017 and so the physical installation and replacement of meters is not expected to require significant relocation work. Acceptable meter locations are expected to be specified by the GDNs, to satisfy safety considerations.

There is also an additional safety feature required as an integral component of a hydrogen meter, in the form of a type of “Excess Flow Valve” designed to prevent accumulations of hydrogen. Prototypes of these meters will be subject to further testing, and clarification of how the excess flow valve would operate, and in what circumstances it will need to be understood by all personnel involved in utilisation activities.

Hydrogen meters will need to be clearly labelled to facilitate their use with hydrogen systems. A meter that may be used for both natural gas and hydrogen is a possibility but, in any event, gas personnel must be able to identify that the correct meter is fitted for either natural gas, or hydrogen fuelled installations.

4.4.1 Observations

The meter installation and ECV are often the first components of any installation that an installer accesses, either to apply an initial tightness test, or to turn off the supply. Therefore, ensuring that hydrogen meters are clearly different from natural gas meters would provide a clear prompt that this installation is fuelled by hydrogen and not natural gas.

4.5 Installation of Appliances

The installation of appliances involves a series of familiar steps to any existing Gas Safe Registered Installer before any work commences. Preliminary steps include

i. engagement with the property owner or occupier to determine installation expectations and requirements
ii. examination of the existing building fabric and proposed appliance location, to determine suitability
iii. checks on the existing pipework to determine size suitability for the additional appliance load
iv. check that the correct source pressure is available, and
v. reference to the appliance manufacturers instructions to clarify specific installation points such as ventilation and flue products requirements.

Although the appliances will be fuelled by hydrogen, these preliminary steps will remain unchanged. Due to the different properties and characteristics of hydrogen fuelled appliances there will inevitably be specific requirements in the manufacturer's instructions relating to the need to handle the increased volume of condensate. There may also be a need for some network reinforcement work by the GDNO prior to any gas utilisation installation work being done.

4.5.1 Observations

The actual installation of appliances remains relatively unaffected by the gas being used as the fuel. There may be specific criteria set out by the appliance manufacturer relating to the appliance location, the ventilation requirements, dealing with the products of combustion etc. but these are already common aspects that differ between, for example natural gas and LPG appliances. The necessary changes to work practices that follow the installation itself are more significant and will impact on the way they are carried out.

4.6 Tightness testing

The need to establish that an installation of pipework, meter and appliances containing flammable gas does not leak is obvious and essential. Existing work practice is well established and requires a tightness test to be carried out prior to any interruption to the installation (to facilitate appliance installation for example) followed by a further tightness test once the additional work has been completed. This enables the installer to ensure that any acceptable pressure loss (only allowed for existing installations) remains the same as before. The acceptable Maximum Permitted Leakage Rate (MPLR) for any gas is dependent upon a number of factors including the viscosity of the gas and the standing pressure of the installation. For the current hydrocarbon gases in common use the acceptable pressure losses over a defined test period, are set out in a suite of four IGEM Standards (IGEM UP/1, UP/1A, UP/1B and UP/1C) that cover various types of installation. None of these standards currently include hydrogen and this situation will need to be addressed urgently, given the critical importance of tightness testing.

Given that the transition to hydrogen is very likely to involve the installation of a new appliance(s) using existing pipework infrastructure, the classification of the resulting installation as either new", or "existing" will be important in any determination of an acceptable MPLR. In consideration all installations concerning hydrogen will be considered as 'new' in which case no perceptible gas leaks will be allowed.

4.6.1 Observations

It is envisaged that the process of tightness testing is unlikely to change in any material sense. Changes for hydrogen installations may involve different manometers, pressures, stabilisation periods, test period and acceptable pressure drop over a defined time period (which may be zero) but provided that these requirements are clearly established in a standard, they are unlikely to create major issues for the competent Installation and maintenance operative .

The odourant applied to methane is expected to be applied to hydrogen as the current odourant is perceived and recognised by the public as a gas escape. The chemical composition may be altered to deliver a specified outcome, but the resulting gas odour is likely to seem the same to installation and maintenance operatives and consumers alike.

4.7 Purging

The approach to purging in hydrogen installations is more complex, as replacing the content of an existing installation will either involve the expulsion of air, replaced by hydrogen, or the expulsion of natural gas to be replaced by hydrogen. Given that it is undesirable for mixing of gases within the installation to occur, work practices and methods to avoid this are likely to be more stringent and will have to be clear and well understood. In a domestic setting, direct purging into a ventilated room will be prohibited and the purging must be to outside, with the usual safeguards for such a

procedure required. For some installations, i.e. those covered by UP/1 and UP/1A, it may be necessary for an inert gas (usually nitrogen) to be used to ensure that a potentially hazardous mixing cannot occur. It should be noted that the use of nitrogen can pose an unacceptable asphyxiation risk in domestic situations.

There are also differences in how venting may be carried out, and changes required in the type of detection and flame arresting equipment to be used and other safety considerations necessitated by the need to avoid any sources of ignition.

4.7.1 Observations

Often seen as two sides of the same coin, the testing and purging requirements for hydrogen systems both need additional clarification with the resulting requirements set out in a Standard. The IGEM/UP/1B may offer a basis for appropriate procedures and a final agreed set of requirements are essential prior to any training of installation and maintenance operatives.

4.8 Commissioning and Handover

Existing work practices require the Installer to commission any appliance in accordance with the requirements set out in the manufacturer's instructions. The recent BSI document PAS4444 provides manufacturers with guidance on the development and construction of hydrogen fired appliances and it is envisaged that the information needed by installation and maintenance operatives will be include in any hydrogen appliance installation instructions.

The installer, as is the case with current appliances, must leave the manufacturers' user instructions with the owner or occupier of the premises where the appliance is installed. Any new or markedly different aspects, specific to a hydrogen appliance will need to be highlighted to the owner of occupier to avoid unnecessary calls querying specific situations e.g. pluming of combustion products in certain conditions.

4.8.1 Observations

Provided that the specific requirements relating to the commissioning of appliances is included in manufacturer's instructions, the existing work practices are expected to remain the same. These including the standard checking of pressure, appliance component operation, flame picture, flue operation, condensate drainage and hot water temperature.

Given that the combustion of hydrogen produces no CO_2, any flue gas analyser must be able to measure direct levels of Oxygen, conforming to BS EN 50379-1: 2004, BS EN 50379-2:2004, BS EN 50379-3:2004. This may require the Installer to adapt to new equipment, or at least be competent in the setting and operation of an analyser appropriately.

4.9 Maintenance

Maintenance procedures are likely to remain relatively unchanged, although it will be essential for installation and maintenance operatives undertaking maintenance work to recognise that the installation is fuelled by hydrogen. A check of the meter should provide clarity on that and, provided that the Installer has achieved the additional Gas Safe Registration recognition as being competent to work on hydrogen systems, the existing approach to maintenance will remain appropriate.

4.9.1 Observations

The hydrogen Training Specification will be the key document to ensure that all the necessary skills, knowledge and understanding elements are included in any course. An individual successfully passing the associated assessment must be competent to carry out the range of installation, maintenance and repair activities associated in domestic and light commercial settings.

4.10 Consumer engagement

Hydrogen conversion will be new to consumers and personnel working in the gas sector, who are likely to need to respond to a range of questions from consumers. As is always the case, some consumers will be positive and enthusiastic, while others may be sceptical and negative. It is essential that installation and maintenance operatives are knowledgeable enough to answer consumer questions and to reassure them about the use of hydrogen, particularly with regard to safety. Research carried out recently by Leeds Becket University for NGN as part of the Leeds H21 project, shows that many customers trust the gas industry and would accept hydrogen on the basis that it is just as safe. It will be essential that personnel involved in hydrogen installation work are able to reinforce that trust through what they say, and what they do.

Keeping gas appliances and installations safe depends on a day to day basis, on the consumer using them correctly in accordance with the manufacturer's users' instructions. It is therefore important that installation and maintenance operatives have the communication skills and knowledge necessary to explain any specific requirements when the installation is handed over.

4.10.1 Observations

Incorporating this message and the soft skills required to achieve effective positive customer communication into the hydrogen training will be crucial. Conversion offers an excellent opportunity for future sustainability of the industry and keeping customers "on side" will be essential.

4.11 Reported gas escapes

All the aspects covered in this paper apply to personnel responding to a public reported escape (PRE). The identification of the hydrogen installation, applying a

tightness test to the correct standard and implementing procedures with a good understanding of the properties of the gas involved will be critical.

There may need to be some change to the leak detection equipment used as the equipment currently in common use does not detect hydrogen. However, the procedure for using an electronic detector is unlikely to differ significantly so any changes are likely to be related to dealing with the characteristics of hydrogen such as the increased flammability range, lower ignition point and the buoyancy and dispersal features of the gas itself.

4.11.1 Observations

Although the knowledge and understanding of hydrogen needed by First Call Operatives is the same as that for installation and maintenance operatives, there are additional aspects that will need to be covered for those responding to a PRE, including:

i. detection of external leaks
ii. evacuation criteria and
iii. third party liaison with police and fire brigade etc.

4.12 Unsafe situations

As has been noted in relation to the relevant Standards, the existing Unsafe Situations handbook will need to be expanded to incorporate hydrogen issues and procedures.

5.0 Additional issues raised during consultation

A number of tangential issues were highlighted during the consultation process and these are noted in this section. While these issues clearly have a relevance to a transition to hydrogen, they are not within the specific scope of the hydrogen Competence Framework Programme. A brief outline of the issues raised follows:

5.1 The competence of other personnel

Raised as a risk to the overall safe roll out of hydrogen, a number of concerns were raised about the potential lack of a competence framework for other workers not covered by GS(I&U)R. Mitigation is currently under consideration by BEIS.

5.2 Network Planning and Reinforcement

Related to the work activities needed by GDNs to facilitate the establishment of a viable hydrogen supply to each property within the designated network.

5.3 Availability of appliances other than boilers

The impact on consumer support if no suitable hydrogen fuelled appliances are available to replace those burning natural gas i.e. space heaters, ovens etc.

Summary

From the range of documented information considered to date, there are clearly fundamental differences between hydrogen and the existing hydrocarbon gases used in the UK gas industry. Although significant in nature, there are also many aspects of gas utilisation work that will remain largely the same following a transition to hydrogen fired appliances. This report has sought to highlight those aspects likely to be most affected by this change, thereby helping to facilitate the next stage in the development of the Hydrogen Competence Framework. That stage is the production of a detailed Skills Matrix to document the range and scope of additional skills needed by an installer, together with the added range and depth of knowledge and understanding required.

6.0 Consultation and Feedback

To ensure that the final Competence Framework is based upon solid foundations, it is important that the content of this report, remains subject to additional clarification and revision. In addition to the actual topic areas, it will also be necessary to consider both the breadth and depth of each aspect, to ensure that any resulting Training Specification achieves its objectives and is “fit for purpose”.

The comments and feedback provided to date have been extremely useful in establishing the basis for a hydrogen Skills Matrix. Energy & Utility Skills proposes to now commence work on that next output, which will be available for consultation and feedback by the end of July.