POSITION PAPER
3 September 2021

Hydrogen – a potential future fuel gas

Hydrogen is a clean and renewable energy source, in plentiful supply and more efficient than other sources of energy. It is not a new fuel gas, but in the current climate-aware environment, is being closely studied as a possible replacement for natural gas in domestic heating and industrial use as it can in theory be handled by the current gas distribution infrastructure. This reasonably assumes that plastic materials, in particular polyethylene and PVC systems that have been classified for pressure applications, will be suitable for use with hydrogen fuel gases. Hydrogen is a biodegradable, renewable energy resource providing opportunities to move away from fossil fuels. It is also volatile, difficult to store and can be corrosive to some materials. The use of hydrogen would therefore represent a change for many European nations from the status quo, and would require careful assessment on a localised basis.

Hydrogen has been present in fuel gas since discoveries made in the 1790s which preceded gas street lighting in the early 1800s and the heating of homes which then followed. Gases in this period were manufactured from coal ('town gas') and the major constituents were hydrogen, methane, carbon dioxide and monoxide. For many Western European nations this was the dominant fuel gas used until the discovery of, and conversion to, natural gas from the 1950s onwards. This means that many European countries do not have experience of running hydrogen-based fuel gases with plastic pipe gas networks which were established from 1969 onwards.

Teppfa aisbl
Avenue de Cortenbergh 71 t: +32 2 736 24 06 71
B-1000 Brussels, Belgium e: info@teppfa.eu

There are networks elsewhere in the world that still use ‘town gas’ today. One internationally recognised example is the Hong Kong & China Gas company. It supplies gas made from naphtha, natural and landfill gas sources. The major constituent of this gas [i] is hydrogen which forms 46.3% to 51.8% of the gas supplied by volume. Hong Kong as a territory started using polyethylene pipe systems in 1987 and has an extensive network from 32 to 400mm, operating at pressures to 4 bar. This, on one of the most densely populated regions of the planet, a city with extensive underground building levels and pipes buried in close proximity. It is a network with an exemplary safety record. So hydrogen in plastic pipes is not new, it’s an experience which for some asset operators extends over more than 30 years.

SSSCCC/Shutterstock.com

In Western Europe, many networks are now taking the first steps of reintroducing hydrogen as a blend with natural gas components to reduce carbon emissions. This tends to be low concentrations of hydrogen, eg. up to 30%, not because of a safety consideration with the pipeline but for the reason that appliances operated by end users do not need modification of the combustion systems. This allows a change to be made which at the first step delivers an incremental benefit but is largely invisible and without impact to wider society. The objective of such schemes is to regain confidence in moving to a new fuel gas source prior to later, and larger, changes such as full conversion to 100% hydrogen gas supply.

There are several successful examples of such schemes in countries like the Netherlands, Denmark and the United Kingdom. The Netherlands is making extensive use of PVC pipes for the distribution of natural gas since the mid-1960s. A first project named ‘Hydrogen in natural gas on Ameland’ [ii] has notably been launched as soon as in 2007 to investigate the impact of injection of up to 20% hydrogen in the natural gas grid supplying 14 homes of the Noorderlicht apartment complex on the Amerland Island. No visible or measurable degradation of the pipes has been found after exposure to the hydrogen mixture for four years. In the United Kingdom, a case study is the ‘HyDeploy’ [iii] project to convert Keele University estate to run on a hydrogen-methane blend. This example features polyethylene pipes laid from the early 1970s onwards. It also features the range of jointing systems to be found including hot iron, butt and electro-fusion welding techniques. A safety case was successfully developed with the national regulator for conversion of the plastic pipe network to start use with hydrogen in the gas supply.

Gordine N/Shutterstock.com

©Wavin

Examples also exist of countries taking the next steps, which is to consider conversion of existing networks, or construction of new networks, for the distribution of hydrogen gas alone. A well-known example of an early study is that by the Danish Gas Technology Institute [iv]. In this example, polyethylene pipes up to 20 years old were removed from existing methane based natural gas installations. These pipes, along with new pipes, were then installed to a test network running with 100% hydrogen gas volumes. And the evidence from this test network is clear. Even with increased concentration of hydrogen no new failure modes are created, nor any acceleration of wear out characteristics, after monitoring for a period in excess of 10 years. Other evidence is provided by the Dutch 'Future-proof Gas Distribution Networks' research project [v]. This research concluded that the existing Dutch distribution network (125,000 km including PVC-U and PVC-Hi and PE pipes) is suitable for a 100% hydrogen gas supply, provided the gas is dry. This study highlights that the same transport capacity can be maintained if the flowrate is tripled vs. natural gas.

Newer materials are perhaps easier to perform a full validation prior to building networks and many studies have been done to look at pipe and fitting performance, alongside construction practices to employ. An example is the development of green hydrogen refuelling infrastructure for vehicles in the Groningen region of the Netherlands. A published study on the properties and suitability of polyethylene materials [vi] supports the case that risk is no higher than with methane gas. Indeed, the evidence from other studies such as the H100 project in the UK [vii] is that some risks actually reduce with hydrogen.

In another variation, many countries are considering the longer-term goal of converting existing gas distribution networks to either a hydrogen-methane blend, or a pure hydrogen option. The scale of this means that hydrogen production will come from two different sources, either ‘blue’ hydrogen from the reaction of natural gas in steam methane reforming processes, or ‘green’ hydrogen from renewable sources. The hydrogen is the same in either case, it is potentially a 100% clean gas for distribution to homes and industry for use in heating or power generation processes. And it should be made clear, polyethylene and PVC pipe materials laid in the past, as much as what could be laid in the future, will in principle be suitable for the distribution of these gases.

There has been much work performed on the suitability of hydrogen for use with plastic piping systems. Whilst polyethylene materials are under consideration due to their extensive use in European gas networks, PVC pipes have also been assessed [[viii]]. Pan European collaborative research projects have been completed to assist in developing evidence of the genuine concerns and issues that arise from converting older networks, as much as for building new ones. Examples of such evidence can be found from participants to the ‘NaturalHy’ [[ix, x, xi]] project. This is an evidential approach to demonstrating the suitability of the materials for hydrogen. It also helps differentiate what are economic issues (permeability of materials) from safety concerns.

It is clear, and the informed position of TEPPFA, that PE and PVC pipe systems can be considered for use with hydrogen-methane based blends, and with pure hydrogen gases. Indeed, for modern materials, the industry standards such as ISO 4437, EN 1555 and ISO 6993 already anticipate this in their scope for compatible fuel gases for polymer piping systems. Additionally, older generation materials that have been subject to classification and characterisation of their properties can also be considered. The final decision on suitability will ultimately rest with asset owners who understand the construction and operating conditions of their pipelines; which have also to be considered. And this reflects the approach being consistently taken through all of the European markets in which TEPPFA member companies are working.

© PE100+ Association

©Wavin

Observations and brief summary:

1. This position statement applies to polyethylene and PVC pressure pipe materials. Such materials will have been characterised in relation to time, temperature and stress, for example using EN ISO 9080, to give predictable lifetime performance. Such pipe systems were manufactured to pressure pipe application standards.

2. The performance of fitting systems made of the same materials, for example hot iron fittings, electrofusion and butt-welded polyethylene fittings, socket PVC fittings with rubber ring seals, with known assembly methods, can work with hydrogen.

3. Users' attention is drawn to mechanical sealing systems in particular, and seals generally to assess leak tightness with hydrogen, which being a smaller molecule than methane may give rise to some economic leakage on network conversions.

4. The industry standards applicable today, such as ISO 4437, and EN 1555 for polyethylene, and ISO 6993 for PVC, by default, include hydrogen in the definition of suitable (dry) gaseous forms for distribution using these materials.

5. The national or local application practice of gas plastic piping networks must be taken into consideration, factors such as earlier construction specifics and operating characteristics of installations must be taken into account prior to conversion to ensure a safe system.

References

[i] www.towngas.com/en/About-Us/Hong-Kong-Gas-Business/Gas-Production
[ii] Management summary available in English on https://www.netbeheernederland.nl/_upload/Files/Waterstof_56_7c0ff368de.pdf
[iii] https://hydeploy.co.uk/hydrogen/hydeploy-at-keele-live-pilot/
[iv] Iskov H et al; Danish Gas Technology Centre, "Field test of hydrogen gas network", WHEC 2010, Germany
[v] Report Summary available in English on https://www.netbeheernederland.nl/_upload/Files/Waterstof_56_8ad725a5d3.pdf
[vi] Hermkens R et al; KIWA; "The suitability of PE pipes for transport of hydrogen", Plastic Pipes in Infrastructure AMI Conference Proceedings, 2018, London
[vii] Muckle D et al; "Integrity of PE Pipe Systems – 100% Hydrogen Fuel Gas Source", May 2020, OFGEM NIA, UK
[viii] Management summary available in English on https://www.netbeheernederland.nl/_upload/Files/Waterstof_56_7c0ff368de.pdf
[ix] Foulc MP et al; "Durability and transport properties of polyethylene pipes for distributing mixtures of hydrogen and natural gas", NaturalHy Project, WHEC June 2006, France
[x] Nony et al.; "Study of hydrogen ageing of ductile PVC pipes (Impact resistance and tensile tests)", Naturalhy Project WP-3, January 2010, France
[xi] Klopffer MH et al; "Development of Innovating Materials for Distributing Mixtures of Hydrogen and Natural Gas. Study of the Barrier Properties and Durability of Polymer Pipes", Oil & Gas Science & Technology, Vol 70, pp305-315, 2015

About TEPPFA

TEPPFA is The European Plastic Pipe and Fittings Association founded in 1992 with headquarters in Brussels. TEPPFA's multinational company members and national associations across Europe represent 350 companies that manufacture plastic pipes and fittings. TEPPFA's members have an annual production volume of 3 million tonnes directly employing 40,000 people with €12 billion combined annual sales. TEPPFA positions itself as polymer neutral. Its final products are subdivided into 3 application groups: 1. Building (above ground systems for hot & cold-water supply, surface heating & cooling, waste water discharge and rainwater drainage); 2. Civils (below ground pipe systems for sewers, stormwater management and sub soil drainage); 3. Utilities (below ground pipe systems for distribution of drinking water, gas, energy and telecommunications).