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TECHNICAL REPORT FOR FUNCTIONAL SPECIFICATION FOR HYDROGEN BLENDING INFRASTRUCTURE PROJECT: ODORISATION

1 INTRODUCTION

A consortium of GB gas transporters comprising Cadent Gas, National Grid Gas, Northern Gas Networks, SGN, and Wales and the West Utilities has engaged the services of Dave Lander Consulting Ltd and Thyson Technology Ltd to develop and test a functional specification for blending of hydrogen into natural gas networks. The functional specification will set out the required equipment functionality to achieve acceptable blending of hydrogen into gas transmission or distribution systems, based on consideration of both regulatory and engineering requirements. A "sister" project[1] is considering the commercial requirements for successful blending.

The functional specification will consider a number of key principles and this technical report summarises the odorisation requirements of hydrogen-natural gas blends and the implications for the functional specification.

2 LEGAL RESPONSIBILITY AND ODORISATION POLICY

In the interests of public safety natural gases generally require odorisation, i.e., a substance is added to it so as to impart a distinctive and characteristic smell. Ensuring that gas has a distinctive odour aids leak detection by members of the public and mitigates the risk of such leaks leading to build-up of flammable atmospheres and subsequent explosion.

UK gas transporters have a legal obligation regarding odorisation that is set out in the Gas Safety (Management) Regulations 1996 (the GSMR). Regulation 8 of the GSMR requires gas transporters, under normal conditions, to convey only gas that complies with the requirements set out in Part I of Schedule 3. In the context of odorisation the following requirement applies:

> *The gas shall have been treated with a suitable stenching agent to ensure that it has a distinctive and characteristic odour which shall remain distinctive and characteristic when the gas is mixed with gas which has not been so treated, except that this paragraph shall not apply where the gas is at a pressure of above 7 barg. (GSMR, Part 1 Schedule 3, paragraph 2.)*

In general, the GSMR are not prescriptive in terms of specific requirements and do not define the term "distinctive and characteristic". As a result, the gas transporters have historically asserted in their safety cases that the requirement to be "distinctive and characteristic" is met as follows:

a) A characteristic odour is achieved by selection of an appropriate odorant that imparts an odour that is generally recognisable by members of the public as "gassy" and less likely to be confused with other smells such as drains or sewers etc. The current odorant employed by GTs in the United Kingdom for NG is odorant NB, a blend of t-butyl mercaptan and dimethyl sulphide.
b) A distinctive odour is achieved by selection of an appropriate concentration of odorant in the supplied gas. Addition of odorant so as to achieve, for a gas concentration in air that corresponds to around 20% of the Lower Flammability Limit (LFL), an odour intensity of 2 olfactory degrees on the Sales scale is widely accepted as achieving this requirement. This enables a leak to be detected well before the gas concentration in air reaches the LFL.

The above interpretation is included in the draft Third Edition of IGEM/SR/16 – Odorisation, which is expected to be published for Industry comment this year.

Gas transporters in the UK employ odorant NB[2] for odorisation and a concentration of odorant NB in natural gases of 6 mg/m^3 is generally agreed to ensure an Odour Intensity (OI) of 2° on the Sales scale at 20% LFL. The justification for this, together with the technical background to odorisation, is contained in a Measurement Process Report MPR/074 – Odorisation of UK gas[3], originally produced in 2008 by the Network Policy group of the

[1] "Enabling Hydrogen Blending from Industrial Clusters". Frontier Economics.

[2] A blend of t-butyl mercaptan (78 % by weight) and dimethyl sulphide (22% by weight).

[3] D.F. Lander MPR074 – Odorisation of UK gas. (2011 – Issue A)

then National Grid Transco. The document was produced at around the time of the partial sale by National Grid of its distribution system. During the development of the Third Edition of IGEM/SR/16, it was agreed with National Grid that MPR074 would be updated and provided to NGN, SGN and WWU.

3 CONCENTRATION OF ODORANT NB FOR HYDROGEN – NG BLENDS

Odorant NB was adopted for use with UK natural gas in 1997[4] and the appropriate concentration to achieve an OI of 2° was determined from the OI curve for odorant NB. The OI curve is a plot of OI against odorant concentration and was determined from experiments performed in the LRS Odour Chamber at the Transco Technical Services Area Laboratory in Hertford. Based on these experiments, together with a field trial of use of odorant NB injected into Feeder 3 at Bacton (with OI assessed at Roudham Heath AGI) it was decided that an odorant NB concentration of 6 mg/m^3 of natural gas would achieve an OI of 2° for a 1% gas in air (GIA) concentration. 1% GIA is generally taken to approximate 20% of the lower flammability limit (LFL) for natural gas (approximately 5% GIA).

In practice, UK natural gases vary in composition and so LFL also varies and in turn, the concentration of odorant NB in natural gas to achieve an OI of 2° at 20% LFL will vary. Table 1 below lists a typical range of LFLs of UK natural gases, together with the OI that would be expected at 20% LFL if they were odorised at a concentration of 6 mg/m^3. The expected OI is based on the OI equation taken from MPR074 (odorimeter OI equation):

$$OI = 3{,}4030 + 0.4943 \cdot ln(c) \qquad (1)$$

Where *c* is the concentration of odorant in mg/m3 of natural gas.

The OI of UK natural gases is therefore expected to vary between 1.97 and 2.01, assuming that an odorant injection rate of 6 mg/m^3 were applied across all odorant injection facilities. In practice, GDNs have the option to increase or decrease injection rates in response to local conditions and assessment of actual OI locally by trained rhinologists.

Also shown in Table 1 is the OI at 20% LFL, for blends of 20% hydrogen in each of these gases if an odorant injection rate of 6 mg/m^3 were practiced. The OI would be expected to vary between 1.95 and 1.99. Because the OI is related to the logarithm of odorant concentration the OI is not significantly lower for a 20% hydrogen blend and would probably not be distinguishable by a trained rhinologist. However, if GDN policy is to be strictly observed then an increase in odorant injection rate from 6 to 6.25 mg/m^3 would restore the range of OIs currently achieved for natural gases. This is shown in the final row of OIs in Table 1.

4 ACHIEVING THE REQUIRED ODORANT CONCENTRATION IN THE BLEND

Irrespective of whether a target concentration of 6 or 6.25 mg/m^3 is chosen for a 20% blend, this target concentration can be achieved either by:

- Odorising the hydrogen directly either at the hydrogen supply point or at the hydrogen blending and grid entry unit (HBGEU)
- Odorising indirectly, by simply increasing the natural gas odorant injection rate to compensate for unodorised hydrogen being injected

If hydrogen were to be odorised directly, then an odorant concentration of 7.3 mg/m3 would be required, because 100% hydrogen has a significantly lower LFL than natural gas (4.0 % GIA). Odorising hydrogen directly prior to blending would also automatically adjust the final odorant concentration to the appropriate level for the given proportion of hydrogen in the blend.

If indirect odorisation were practiced, then the odorant injection rate would have to be adjusted to compensate for the unodorised hydrogen. This has the added complication that odorant flowrate delivered by the odorant injection system is based on the prevailing natural gas flowrate. If unodorised hydrogen is blended, then – depending on the strategy for controlling natural gas flow – the natural gas flowrate could either stay the same (volumetric control) or decrease (demand control). These situations would require different injection rate (expressed in terms of mg per m^3 of natural gas). In practice indirect odorisation would require odorant injection

[4] The change to odorant NB was forced by supply difficulties with components of the previously employed odorant – odorant "BE".

rate to be computed based on the sum of natural gas and hydrogen flowrates, so a suitable modification of the existing odorant injection system would be required.

Note that for the HyDeploy and HyDeploy 2 field trials of hydrogen blending, unodorised hydrogen was injected without compensation further upstream at the NTS offtakes serving Keele University (HyDeploy) or Winlaton (HyDeploy2). This decision was taken based on an assessment of likely OI and actual assessment of OI during the trials by Cadent and NGN rhinologists, which meant that, although compensation was an option, it was not required in practice. However, the field trials were relatively short term activities and subject to increased surveillance, so simply injecting unodorised hydrogen without compensation is not recommended for more widespread, enduring, hydrogen blending.

5 FUNCTIONALITY REQUIREMENTS ARISING FROM ODORISATION CONSIDERATIONS

a) Hydrogen – natural gas blends require a slightly increased odorant concentration than their natural gas counterparts. Typically, for blends containing 20% hydrogen an increase from 6 to 6.25 mg/m^3 is recommended.

b) Achieving this odorant concentration can be either

- Directly, by odorising hydrogen at an injection rate of 7.3 mg/m^3 prior to blending with natural gas, or
- Indirectly, by increasing the odorant injection rate of the existing natural gas odorant injection system if present.

The choice of direct or indirect odorisation will depend on the chosen location of the hydrogen blending and grid entry unit.

Table 1: Lower Flammability Limits and Odour intensities of natural gases and hydrogen blends

	NG1	NG2	NG3	NG4	NG5	NG6	NG7	GQ2011 - min LFL	GQ2011 - max LFL	OI range
Natural gases:										
LFL, % GIA	4.76	4.58	4.72	4.85	4.55	4.73	4.73	4.69	4.98	
OI (6 mg/m^3)	1.99	1.97	1.98	2.00	1.97	1.98	1.98	1.98	2.01	1.97 - 2.01
NG-hydrogen blends (20%):										
LFL, % GIA	4.59	4.45	4.55	4.65	4.43	4.56	4.56	4.53	4.75	
OI (6 mg/m^3)	1.97	1.95	1.97	1.98	1.95	1.97	1.97	1.96	1.99	1.95 - 1.99
OI (6.25 mg/m^3)	1.99	1.98	1.99	2.00	1.97	1.99	1.99	1.98	2.01	1.97 - 2.01

Note: GQ2011 refers to a database of UK gas compositions gathered from UK NTS offtakes in the year 2011.