Netbeheer Nederland

GT-200157
03 February 2021

An exploration for hydrogen specifications

Entry and exit specifications for the gas distribution network

DNV·GL

kiwa

Trust
Quality
Progress

GT-200157
03 February 2021

An exploration for hydrogen specifications

Entry and exit specifications for the gas distribution network

Colofon

Titel An exploration for hydrogen specifications: Entry and exit specifications for the gas distribution network

Project number	004P001881
Project manager	E.A. Polman
Principal	Netbeheer Nederland
Quality assurance	M. van Rij (Kiwa), H.B. Levinsky (DNV GL)
Authors	E.A. Polman (Kiwa), H. Vlap, P. Visser, A. van den Noort (all DNV GL)

This report was commissioned by Netbeheer Nederland. It is available to Netbeheer Nederland, the network operators affiliated with Netbeheer Nederland and the companies associated with these network operators.

Kiwa Technology B.V.
Wilmersdorf 50
Postbus 137
7300 AC Apeldoorn

Tel. 088 998 33 93
Fax 088 998 34 94
www.kiwatechnology.nl

19/190125

Summary

This report describes the design specifications for hydrogen in the gas distribution network, which aim at a safe and efficient use of both the gas distribution network and the hydrogen applications. The specifications concern the entry specifications, the specifications at the point where the hydrogen enters the distribution network, and the exit specifications, at the point at which the gas leaves the distribution network at a delivery point. This report does not include specifications for the transport of hydrogen in the national gas transport network.
These specifications are intended as a first exploration and point of departure before agreeing on national regulations for the quality of hydrogen in distribution networks together with the relevant stakeholders.

For safe operation of the gas network, it is expected that odorization will be necessary, with the consequence that additional cleaning will be necessary for specific applications such as fuel cells. At the request of the client, odorization (choice of odorant / non-odorant, type of odorant and dosage) has been kept outside the scope of this study.

On the basis of the research carried out by Kiwa and DNV, it is clear that, at the time of writing this report, there was still little insight into the possible future development of hydrogen turbines that could be used in the distribution networks. Engines are often set up in greenhouses, where use is also made of the exhaust gases for CO_2 tests. The research indicates that the loss of CO_2 in hydrogen must first be addressed before a fuel specification can be issued. The stakeholders also expect that fuel cells will be connected to hydrogen that are specifically intended for this application or that will always have additives. For these reasons, the following proposed specifications are therefore only valid for combustion equipment for the purpose of heat production (central heating boilers, hot water boilers, heaters, gas stoves and cooking appliances).

It is known that in some low pressure distribution networks (especially gray cast iron and asbestos cement pipes) water leaks can occur. Even with low pressure PVC pipes with sliding sleeves, groundwater leakage can occur and wet networks cannot therefore always be prevented. The effect of water vapor on the Wobbe index in a hydrogen network is roughly a factor five higher than for natural gas. To avoid large variations in the Wobbe, it is recommended not to use such networks for the distribution of hydrogen. A plan has been drawn up by all regional network operators for the replacement of gray cast iron and asbestos cement gas pipes for the year 2032 because of the sensitivity to ground movements. This plan has been coordinated with the regulator SodM (State Supervision of Mines), which supervises the safety of, among other things, the gas networks on behalf of the national government. After implementation of this plan, significantly fewer “wet networks” will occur.

A minimum hydrogen quality of 98 mol% has been chosen, with a limitation on the absolute variation of the Wobbe index of 4 MJ/m^3(n). By limiting the Wobbe band, it is prevented that there is any need to compensate for the loss of efficiency, such as the use of devices with a higher capacity. With regard to these gas quality aspects, the proposal is also in line with the PAS4444, which is expected to be adopted in many European countries and avoids the need to develop specific appliances for the Dutch market.
As far as possible, the quality aspects for feed-in and delivery to a connection will be linked to the gas quality aspects that currently apply to the Ministerial Regulation on Gas Quality (MR) for natural gas.
The Wobbe index specified in the MR is based on hourly mean values, with room for under- and exceeding of these values due to the control inaccuracy. The absolute limit values for green gas are also specified at 0.5 MJ/m^3(n) below the lower (hourly average) Wobbe limit value and 0.5 MJ/m^3(n) above the upper (hourly average) Wobbe limit value. Due to the broad support for the MR, it is recommended to use the same method for hydrogen. It should be noted here that control space only needs to be provided at the bottom, because the upper limit (Wobbe index at 100% hydrogen) can never be exceeded. This is because there are no

gaseous components that can result in a higher Wobbe index when added. This results in a Wobbe variation on the hourly mean value of 3.5 MJ/m^3(n), with an absolute lower limit of 44.35 MJ/m^3(n).

For components that are listed in the MR for natural gas, but will not occur in hydrogen, no limit values are stated, in order to avoid that control measurements of an unnecessarily large number of parameters will be required, without this leading to a lower risk. For the other trace components it is suggested to use the limit values specified in the MR for natural gas because this specification is suitable for combustion appliances. Depending on the source and method of production, hydrogen may contain other trace components not specified in the MR. Because there is currently no insight into the impact of these components on the distribution network and / or gas appliances, a disclaimer is used for the time being that excludes the presence of gaseous compounds that are harmful to the distribution and use of hydrogen.

The considerations discussed in this report have led to the following specifications.
It is noted here that the Wobbe index is defined as the amount of energy released during the complete combustion of gas in air, when the components present after combustion are returned to the initial conditions of temperature and pressure, being 298.15 K and an absolute pressure of 1.01325 bar and where the water vapor formed during combustion is condensed, divided by the square root of the relative density, converted to normal conditions (273.15 K and 1.01325 bar).

Table A: Specifications for hydrogen when fed into a connection

Component/Physical property	Limit value		Unit
	Hydrogen	MR natural gas	
Wobbe-index	44.85-48.35 A,B)	43.46-44.41 A,H,I)	MJ/m³(n)
Higher hydrocarbons	C)	≤ 5	mole% propane equivalent
Gas condensate	≤ 80	≤ 80	mg/m³(n) at -3 °C
Water dewpoint	≤ -10	≤ -10	°C (at 8 bar(a))
Temperature	5-20 D)	5-20 D)	°C
Oxygen	≤ 0,2	≤ 0.5	mole%
Carbon dioxide	C)	≤ 10.3 J)	mole%
Hydrogen	≥ 98	≤ 0,5	mole%
Chlorine based on organochlorine compounds	E)	≤ 5	mg Cl/m³(n)
Fluorine based on organofluorine compounds	E)	≤ 5	mg F/m³(n)
Carbon monoxide	≤ 2900 K)	≤ 2900	mg/m³(n)
Pathogenic microbes	E)	≤ 500	number/m³(n)
Dust particles (> 5 μm)	≤ 100	≤ 100	mg/m³(n)
Sulphur content based on inorganically bound sulphur	≤ 5	≤ 5	mg S/m³(n)
Sulphur content based on alkyl thiols	≤ 6	≤ 6	mg S/m³(n)
Total sulphur (for odorization) peak value	≤ 20	≤ 20	mg S/m³(n)
Total sulphur (before odorisation) annual average	≤ 5.5	≤ 5.5	mg S/m³(n)
Total sulphur (after odorisation) peak value	F)	≤ 31	mg S/m³(n)
Total sulphur (after odorization) annual average	F)	≤ 16.5	mg S/m³(n)
THT-content	F)	10-40	mg THT/m³(n)
Silicon components	E)	≤ 0.1	mg Si/m³(n)
Non specified components	G)		

A. The Wobbe index of the gas injected must be above the lower limit for at least 50% of the time. There may be a maximum of 200 hours per rolling year in which an undershoot (a value below the lower limit) between 0.2 and 0.3 MJ/m³ occurs, while such an hour may not occur more than once every 12 hours. There may be a maximum of 10 times per rolling year an hour in which an undershoot of more than 0.3 MJ/m³ occurs, while such an hour may not occur more than once every 60 hours. The values for the Wobbe index are hourly averages.
B. The values for the Wobbe index must always be above the absolute lower limit of 44.35 MJ/m³ (n), regardless of the measurement frequency.
C. The maximum concentration is limited by the Wobbe index
D. A different feed in temperature is accepted if the hydrogen producer demonstrates that the materials used in the pipes can withstand the deviating temperature and the gas in the connecting pipe of the hydrogen producer will heat up or cool down so that the gas at the valve of the connection point with the network of the grid operator has reached a temperature between 5 and 20 ° C. This can be calculated using the method from the KIWA report "Requirements for green gas inlet temperature" of 2 August 2012.
E. This parameter does not occur in hydrogen and is therefore not specified
F. Is outside the scope of this study
G. The hydrogen can not contain any solid particles, liquids or gaseous components that could affect the integrity of the gas network or the gas application

H. The values for the Wobbe index must always be above the absolute lower limit of 42.96 MJ/m^3(n) and below the absolute upper limit of 44.91 MJ/m^3 (n), regardless of the measurement frequency. These absolute limits apply to gases containing at least 99 mole% CH_4, CO_2, N_2 and O_2.

I. Exceedances (a value above the upper limit) are allowed if they lie within a distribution around the limit value with a standard deviation of not more than 0.1 MJ/m_3(n).The following restriction applies to the CO_2 content for gases that consist of at least 99 mole% of CH_4, CO_2, N_2 and O_2 and consist of more than 6 mole% of CO_2. 10.32 - 0.72 * N_2 content - 0.87 * O_2 content, and 10.56 - 0.746 * N_2 content - 1.01 * O_2 content, where the contents are expressed in mole%. In RTL pipes that end at border points, gas may contain a maximum of 3% CO_2. When fed into connections where the gas is distributed via parts of the RNB network where groundwater ends up in the gas, gas may contain a maximum of 3% CO_2.

J. The eight-hour time-weighted average limit value (TTG 8 hours) for CO was lowered from 29 to 23 mg / m^3 (n) on 21 August 2018, assuming a gas exposure at 20% LEL (1% gas in air), this means a limit value of 2300 mg/m^3(n) for the distribution gas in the event that an employee or connected party would be exposed for 8 hours to a gas leak that is just not detectable. It is recommended to adjust the limit value.

Table B: Specifications hydrogen at delivery to a connection

Component/physical property	Limit value		Unit
	Hydrogen	MR natural gas	
Wobbe-index	44.85-48.35 A)	43.46-44.41 F)	MJ/m³(n)
Higher hydrocarbons	B)	≤ 5	mole% PE
Gas condensate	≤ 80	≤ 80 G)	mg/m³(n) bij -3 °C
Water dewpoint	≤ -10 H)	≤ -10 H)	°C (8 bar(a))
Temperature	0-35	0-35	°C
Oxygen	≤ 0,5	≤ 0,5	mol%
Carbon dioxide	B)	≤ 10.3 I)	mol%
Hydrogen	≥ 98	≤ 0.5	mol%
Chlorine based on organochlorine compounds	C)	≤ 5	mg Cl/m³(n)
Fluorine based on organofluorine compounds	C)	≤ 5	mg Fl/m³(n)
Carbon monoxide	≤ 2900 J)	≤ 2900	mg/m³(n)
Pathogenic microbes	C)	≤ 500	number/m³(n)
Dust particles (> 5 µm)	≤ 100	≤ 100	mg/m³(n)
Sulphur content based on inorganically bound sulphur	≤ 5	≤ 5	mg S/m³(n)
Sulphur content based on alkyl thiols	≤ 6	≤ 6	mg S/m³(n)
Total sulphur (for odorization) peak value	≤ 20	≤ 20	mg S/m³(n)
Total sulphur (before odorisation) annual average	≤ 5.5	≤ 5.5	mg S/m³(n)
Total sulphur (after odorisation) peak value	D)	≤ 31	mg S/m³(n)
Total sulphur (after odorization) annual average	D)	≤ 16.5	mg S/m³(n)
THT-content	D)	10-40	mg THT/m³(n)
Silicon components	C)	≤ 0.1	mg Si/m³(n)
Non specified components	E)		

A. The Wobbe index may deviate on the basis of the permitted variations in the feed, as included in the footnotes A and B of table A.
B. The maximum concentration is limited by the Wobbe index.
C. This parameter does not exist in hydrogen and is therefore not specified.
D. Is outside the scope of this study.
E. The hydrogen must not contain any solid particles, liquids or gaseous components that could affect the integrity of the gas network or the gas application.
F. The Wobbe index may deviate on the basis of the permitted variations in the input as included in footnotes 1 and 2 to appendix 2 of the MR.
G. Insofar as the network operator manages the connection.
H. With the exception of networks with a pressure lower than or equal to 200 mbar (o).
I. The following restriction applies to the content of CO_2 if the gas consists of at least 99 mol% of CH_4, CO_2, N_2 and O_2 and consists of more than 6 mol% of CO_2. CO_2 content is as a maximum the minimum of 10.32 - 0.72 * N_2 content - 0.87 * O_2 content, and 10.56 - 0.746 * N_2 content - 1.01 * O_2 content, in which the contents are expressed in mole%
J. The eight-hour time-weighted average limit value (TTG 8 hours) for CO has been lowered from 29 to 23 mg/m³ (n) on 21 August 2018, Assuming a gas exposure at 20% LEL (1% gas in air) means this is a limit value of 2300 mg/m³ (n) for the distribution gas in the event that an employee or connected party would be exposed for 8 hours to a gas leak that is just not detectable. It is recommended to adjust the limit value.