EASEE-gas

European Association for the Streamlining of Energy Exchange - gas

Common Business Practice

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Subject: Hydrogen Quality Specification

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Summary

This CBP defines the hydrogen quality specification for dedicated hydrogen pipelines.

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About EASEE-gas

https://easee-gas.eu/about-easee-gas

Version List

Number/ Version	Approved	Implementation date
(2022-001)/01		Already in place

Reference List

Reference	Document name	Version
	EASEE-gas Reference CBP Hydrogen Quality Specification	V 1.0*

Common Business Practice 2022-001/01 "Hydrogen Quality Specification"

1.1 APPLICATION AREA

This CBP defines the recommended quality specification for hydrogen (non-blended with natural gas, see Note 1) flowing through dedicated systems, meaning networks that were originally designed and used for natural gas transmission and after a safety and reliability assessment (see Note 2) found suited for conveying hydrogen and newly built hydrogen pipeline systems. The CBP is valid for both the entry as well as the exit points of these dedicated systems.

Note 1: This CBP is not applicable to blends of hydrogen and natural gas.

Note 2: This CBP only specifies the recommended hydrogen specification. Before hydrogen can be transmitted through existing European natural gas grids, safety and reliability assessments need to be carried out to prove the suitability of the given grid for the transmission of hydrogen.

Note 3: After the pipeline is switched over from natural gas to hydrogen there is a period in which the hydrogen composition can be influenced by natural gas residues still present in the pipeline system. This period is referred to by the term 'transition period'.

This CBP focusses on 'industrial grade' hydrogen because it is expected that in the coming years, the large-scale production of hydrogen, necessary to operate a pipeline system, will partly take place by chemical conversion of hydrocarbons. In contrast to electrolysis, these processes do not deliver inherent fuel cell quality hydrogen. Possibilities for large scale production of hydrogen via electrolysis are not expected before 2030. Another reason to focus on 'industrial grade' hydrogen is the observation from market forecasts that the industry will take the lion part of the total hydrogen production. Only in the period after 2030, there is a possibility for large scale demand for fuel cell and/or energy production grade hydrogen. Last but not least, no hands-on experience is available on the possible effects of residues in the pipeline resulting from the previous exposure to natural gas on the hydrogen transmitted through such a pipeline. The risk that small amounts of a particular contaminant result in an off-specification at the exit increases with an increase of the minimum hydrogen purity.

Depending on the developments in the hydrogen production and advances in the market, i.e. large market for fuel cells, it is recommended to evaluate the current specification after a period of 3 years or earlier if necessary. An additional advantage after the specification being in place for a number of years is that more information will be available on the effect of the residues in the pipeline on the hydrogen quality during the transition phase.

1.2 HYDROGEN QUALITY SPECIFICATION

The basis for the parameters and their limit values in this CBP is based on an internal analysis carried out by EASEE-gas in which the end user requirements, the market shares, the hydrogen quality obtained by the various production techniques and the contribution of the pipeline were taken into account and a common denominator was defined.

Note 4: It is acknowledged that this specification will not meet the specific requirements of some of the industrial (feedstock) users and therefore needs on-site pre-treatment. Especially the strict requirements regarding sulphur components requires in most cases on-site desulphurisation. Furthermore, it is noted that the oxygen limitations in some of the industrial processes are more strict i.e. a maximum 24 hour moving average value of 5 ppm (molar basis) oxygen (O_2) and a maximum hourly value of 25 ppm (molar basis) oxygen (O_2).

The parameters and limit values that have been agreed upon for this CBP and are given in the table below. A short explanation for some of the parameters and their limit values can be found in the explanatory notes section.

Parameter	Unit	Min	Max
Hydrogen	mol-%	98,0	-
Carbon monoxide	ppm	-	20
Total sulphur content[1]	mg S/m^3(n)[2]	-	21[(3)]
Carbon dioxide	ppm		20
Hydrocarbons (including Methane)	mol-%	-	1,5[(3)]
Inerts (Nitrogen, Argon, Helium)	mol-%	-	2,0
Oxygen	ppm (mol)	-	10[(4,5)]
Total halogenated compounds	ppm (mol)	-	0,05
Water dewpoint	°C at 70 bar(a)	-	- 8
Hydrocarbon dewpoint[3]	°C at 1-70 bar(a)	-	- 2[(3)]

[1]) Non-odorised hydrogen
[2]) normal conditions (1.01325 bar(a), 0 °C)
[3]) During the transition period, where the hydrogen composition can be influenced by natural gas residues present in the pipeline system (see Note 5)
[4]) Expressed as expressed as a moving 24-hour average
[5]) Where the hydrogen can be demonstrated not to flow to installations or end-user applications sensitive to higher levels of oxygen, (e.g. feed stock users or hydrogen storages), a higher limit of up to 1000 ppm may be applied.

Note 5: It is acknowledged that the presence of residues in the pipeline as a result of natural gas transmission, makes it necessary to relax the specification for the total sulphur content, to allow for higher hydrocarbons to be present and to introduce a temporary specification for the hydrocarbon dewpoint.

The gas shall not contain constituents other than listed in the table above at levels that prevent its transportation, storage and/or utilization without quality adjustment or treatment.

1.3 EXPLANATORY NOTES

1.3.1 EXISTING SPECIFICATIONS

Although a number of specifications for various grades of 'pure' hydrogen exist, none of these specifications for 'pure' hydrogen are suitable as a general specification for hydrogen flowing through a former natural gas network without modifications.

The specification for a hydrogen grade used for Proton exchange membranes refers to hydrogen with a very high purity (minimum 99,97 mol-% H_2). This very high purity hydrogen can neither be guaranteed in a 'former' natural gas network nor is it necessary for the larger part of the hydrogen end consumers. On the other hand, the lower grade hydrogen specifications don't contain the necessary limit values for parameters normally encountered in natural gas like for example the water dewpoint and are therefore not suitable.

1.3.2 HYDROGEN CONTENT

Based on the inventory carried out by EASEE-gas a hydrogen concentration equal or higher than 98 mol-% is proposed. This is in agreement with the hydrogen purity stated for Grade A in ISO 14687:2019 standard.

1.3.3 CHOICE OF TRACE COMPONENTS IN THE SPECIFICATION

Depending on the hydrogen production technique used and the condition of the network, a large number of trace components can in principle be present in the hydrogen. EASEE-gas has chosen to only specify critical components.

1.3.4 CARBON MONOXIDE

If the production of hydrogen gas takes place by reforming, carbon monoxide is one of the constituents present. The requirements regarding the carbon monoxide content for the various industrial processes and appliances show a wide range of values but most of them are in the ppm range. A value of 20 ppm is a compromise between the hydrogen production and the usability by the various end user categories. In the Hy4Heat study (1), which was the basis for the BSI PAS 4444 standard, a similar conclusion was drawn.

1.3.5 SULPHUR COMPONENTS

A source of sulphur components, like hydrogen sulphide and mercaptans, is the (natural) gas used in a reforming process. Since sulphur components are poisoning the catalysts used in the various types of reforming processes, the sulphur components will be removed from the (natural) gas before the actual reforming process takes place and thus the resulting hydrogen is almost free of sulphur components.

Another source of sulphur components could be the residue left in the pipeline. During the transition period, which ends for sulphur at the moment no sulphur components are released anymore from the pipeline debrides, the total sulphur shall not be more than 21 mg S/m^3 (n). This value corresponds to the specification mentioned in European EN 16726 standard for H-gas.

After the transition period, the maximum amount of total sulphur is expected to be much lower since most of the existing hydrogen production processes are known to produce virtual no sulphur components. However, since no accurate data is available at the moment no maximum value for the total sulphur content after the transition phase is specified.

1.3.6 CARBON DIOXIDE

If the production of hydrogen gas takes place by reforming, carbon dioxide is also one of the constituents present. Like for carbon monoxide, the requirements regarding the carbon dioxide content for the various industrial processes and appliances show a wide range of values but most of them are in the ppm range. The value of 20 ppm is for carbon dioxide also a good compromise between the hydrogen production costs and the usability of the hydrogen by the end users.

1.3.7 HYDROCARBONS INCLUDING METHANE

Methane will be mostly present in the hydrogen gas if a chemical conversion process is used for its production. In most of the industrial feedstock applications, methane does not take part in the chemical reaction and is considered as an inert. However, the presence of a higher concentration of methane in the hydrogen feedstock can result for processes in which part of the feed stream is recycled to larger recycle- and vent streams and thus to higher costs. On the other hand a higher hydrocarbon (methane) specification facilitates the use of methanation as a purification method for hydrogen production. The methanation step converts carbon monoxide and carbon dioxide into methane.

During chemical conversion most of the other hydrocarbon species present in the (natural) gas will be converted into hydrogen resulting apart from methane in the absence of other hydrocarbon species in the product stream.

Hydrocarbons can also originate from the residue present in the pipeline.

The amount of hydrocarbons shall not be more than 1,5 mol-%. Various end users prefer to have separate specifications for the maximum allowed amount of methane and the other (heavier) hydrocarbons because of the different effects on their processes. Since no accurate data is available at the moment it is not possible to come up with a proposal for such a split.

1.3.8 HYDROCARBON DEWPOINT (DURING TRANSITION PERIOD)

During the transition process of a pipeline system from (natural) gas to hydrogen, it cannot be fully excluded that in the beginning hydrocarbons from the pipeline residue are taken up by the hydrogen passing along. To limit the maximum allowable concentration hydrocarbons, during this transition, a hydrocarbon dewpoint specification is in force. The specification of ≤ -2 °C at any pressures between 1 and 70 bar(a) is taken from the European standard EN 16726 for natural gas.

1.3.9 INERTS

The fraction inerts consists of argon, helium and nitrogen. The specification (≤ 2 mol-%) is complementary to the hydrogen specification (≥ 98 mol-%). Argon can be found as a constituent in the produced hydrogen if it is produced via an Auto Thermal Reforming or Partial Oxidation reforming process. Some natural gases contain nitrogen and/or helium and therefore nitrogen and/or helium can be found as a constituent in the produced hydrogen gas via a reforming process. Argon and helium are noble gases and do not take part in any chemical reaction. Apart from the ammonia production, nitrogen does not take part in the chemical reaction and is therefore also categorised as an inert. Like with the hydrocarbons, large amounts of inerts can result for processes in which part of the feed stream is recycled to larger recycle- and vent streams and thus to higher costs. On the other hand, a higher maximum allowed concentration of inerts avoids the use of Pressure Swing Adsorption as a purification method for hydrogen production by reforming.

1.3.10 OXYGEN

For (natural) gas, according to the European standard EN 16726, a maximum level of 10 ppm, expressed as a moving 24-hour average, is specified for sensitive users. The production of hydrogen, both by reforming as well as electrolysis can fulfil this requirement without requiring complex process steps and thus high costs. Especially industrial feedstock users require an oxygen content in the lower ppm range because oxygen can poison the catalysts used in those chemical processes. However, where the hydrogen can be demonstrated not to flow to installations or end-user applications sensitive to higher levels of oxygen, , e.g. feed stock users or hydrogen storages, a higher limit of up to 1000 ppm may be applied.

1.3.11 HALOGENATED COMPOUNDS

Halogenated compounds can be present in the hydrogen gas if produced by electrolysis of a sodium chloride solution or theoretically by reforming of gas originating from a landfill. However, the latter is not very realistic because this requires an extensive cleaning of the gas before it can be used in a reformer.

Furthermore, in the required purification step, which is probably based on pressure swing adsorption, halogenates will preferable be trapped. This specification is taken from the requirement stated in ISO 14687:2019 for Grade D and Grade E.

1.3.12 WATER

The current specification for natural gas (EN 16726) specifies a water dewpoint of -8 °C at a pressure of 70 bar(a) which matches a water content of 48 ppm (v) for hydrogen. This limiting value does not fulfil the requirements for fuel cells (< 5 ppm) and the production of hydrogen peroxide (< 10 ppm). However, since these two applications require a higher hydrogen concentration as specified in this CBP, the water dewpoint specification of -8 °C at a pressure of 70 bar(a) is maintained in the CBP.

1.3.13 WOBBE INDEX

A Wobbe-range is not taken into account in this specification because the sum of all components with the exception of hydrogen can only reach a maximum value of 2 mol-%. The largest difference in Wobbe index occurs for a composition existing of 98 mol-% hydrogen and 2 mol-% nitrogen and using ISO 6976 results in a maximum shift of 6,1 MJ/m^3 (n), or equivalently, in a maximum reduction in Wobbe Index of 12,6 %.