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Gaseous hydrogen — Fuelling stations —

Part 8: Fuel quality control

AMENDMENT 1: Alignment with Grade D of ISO 14687

Hydrogène gazeux — Stations de remplissage —

Partie 8: Contrôle qualité du carburant

AMENDEMENT 1: Alignement avec le Grade D de l'ISO 14687

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This document was prepared by Technical Committee TC 197, *Hydrogen technologies*.

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Gaseous hydrogen — Fuelling stations —

Part 8:
Fuel quality control

AMENDMENT 1: Alignment with Grade D of ISO 14687

Clause 5, first paragraph

Replace the paragraph with the following:

> The quality requirements of hydrogen fuel dispensed to PEM fuel cells for road vehicles are listed in Grade D of ISO 14687.

8.4, first paragraph

Replace the paragraph with the following:

> It is necessary to evaluate the possible consequences on a fuel cell vehicle if any impurity exceeds the threshold value of ISO 14687 Grade D.

8.4, second paragraph

Replace the paragraph with the following:

> An estimation of the concentration above the ISO 14687 Grade D threshold values at which the severity increases (if applicable) is named “Level 1” and is given in column 5 for each impurity where the “severity class” is not already 4.

Table 4

Replace Table 4 with the following table:

Table 4 — Impact of impurities on fuel cell powertrain

Impurity		ISO 14687 Grade D threshold value[a] [µmol/mol]	Severity class (from ISO 14687 Grade D threshold value to Level 1)	Level 1 value [µmol/mol]	Severity class (greater than Level 1 threshold)
Total non-H_2 gases		300	UD [b]	UD [b]	4
Helium	He	300	UD [b]	UD [b]	4
Nitrogen	N_2	300	UD [b]	UD [b]	4
Argon	Ar	300	UD [b]	UD [b]	4
Oxygen	O_2	5	UD [c]	UD [c]	4
Carbon dioxide	CO_2	2	1	3	4
Carbon monoxide	CO	0,2	2-3[d]	1	4
Methane	CH_4	100	1	300	4
Water	H_2O	5	4	N/A	4
Total sulphur compounds	H_2S basis	0,004	4	N/A	4
Ammonia	NH_3	0,1	4	N/A	4
Total hydrocarbons except methane	CH_4 basis	2	1-4[d]	N/A	4
Formaldehyde	HCHO	0,2	2-3[d]	1	4
Formic acid	HCOOH	0,2	2-3[d]	1	4
Halogens		0,05	4	N/A	4
Maximum particulate concentration (liquid and solid)[e]		1 mg/kg	4	N/A	4

Key

UD: undetermined

N/A: not applicable

[a] The threshold value is according to hydrogen specification of Grade D of ISO 14687.

[b] The severity class (from ISO 14687 Grade D threshold value to Level 1) and Level 1 value for this impurity is undetermined because no specific study has been conducted yet in alignment with the new threshold value. It needs to be covered in the next edition of this document.

[c] The severity class (from ISO 14687 Grade D threshold value to Level 1) and Level 1 value for oxygen are undetermined because data are lacking to confirm those values. It needs to be covered in the next edition of this document.

[d] A higher value is to be considered for risk assessment approach until more specific data is available.

[e] Particulates are based upon mass density mg/kg.

A.15 first paragraph

Replace "ISO 14687-2" with "Grade D of ISO 14687" in the second last sentence.

Table B.1

Replace Table B.1 with the following table:

Table B.1 — Probability of occurrence for off-site SMR

Impurity	Threshold µmol/mol	Possible causes For the source studied	Typical barriers employed in this process	Probability with barriers
Inert gas N_2	300	Present in natural gas and syngas PSA malfunction	— PSA — Double analysis PSA outlet <100 µmol/mol	UD [a]
Inert gas Ar	300	Only ATR and POx present in O_2 typical 0,6 % in syngas from ATR	— PSA. Not sized to remove Ar. Ar content may be higher if H_2 comes from ATR, POX or feeds with high Ar content	UD [a]
O_2	5	Not present in syngas. O_2 is unstable in the condition of reforming and shift reactions. Combines with H_2, CO, and CH_4	— PSA cannot be used with significant O_2 content for safety reasons	0
CO_2	2	Present in syngas (%)	— PSA adsorption strength of MS, activated carbon, silicagel higher for CO_2 than CO. A CO content lower than 10µmol/mol insures a CO_2 content lower than 2 µmol/mol	0
CO	0,2	Normal operation below threshold. Occasional peaks at µmol/mol level	— Double analysis at the PSA outlet + trip if the CO>1-10 µmol/mol at PSA outlet	4
CH_4	100	Present in syngas at % level	— In most cases CO is sizing the PSA, therefore CO<10 µmol/mol ==> C H_4 < 100 µmol/mol depending on users' specification (Europe pipeline 2 µmol/mol).	2
H_2O	5	Syngas saturated in H_2O	— PSA adsorbed in alumina and MS adsorption strength higher than CO_2. A CO content lower than 10 µmol/mol insures a H_2O content lower than 5 µmol/mol.	0

Key

UD: undetermined

[a] The probability of occurrence for this impurity is undetermined because no specific study has been conducted yet.

Table B.1 *(continued)*

Impurity	Threshold µmol/mol	Possible causes For the source studied	Typical barriers employed in this process	Probability with barriers
TS	0,004	TS from natural gas	— Desulphuration upstream reformer (typical values: normal < 10 ppb, maximum < 20 ppb, guarantee < 50 ppb) — Typical dilution factor 2,5 (1 mole natural gas produces 2,5 mole H_2) — Pre-reformer catalyst poisoning by sulphur is irreversible. Sulphur trapped at this stage. In case of breakthrough, process condition cannot be achieved — Reformer catalyst poisoning by sulphur is irreversible. Sulphur trapped at this stage. In case of breakthrough, process condition cannot be achieved — Shift catalyst poisoning by sulphur is irreversible. Sulphur trapped at this stage. In case of breakthrough, process condition cannot be achieved — PSA adsorption of H_2S before CO, CO_2, species — H_2S adsorption in pipe and vessels. Strong affinity with steel	0
NH_3	0,1	Traces present in syngas	— PSA adsorption strength of alumina and molecular sieve higher than CO. A CO content lower than 10µmol/mol insures a NH_3 content lower than 0,1 µmol/mol	0
THC	2	Traces of C2+ after reforming reaction	— PSA C2 C3, C4, C5+adsorbed by activated carbon layer. A CO content lower than 10 µmol/mol insures a THC (CH_4 excluded) content lower than 2 µmol/mol	0
HCHO	0,2	May be present in syngas. essentially liquid	— PSA. Formaldehyde adsorption strength of alumina and molecular sieve higher than CO. A CO content lower than 10 µmol/mol insures a HCHO content lower than 0,1 µmol/mol. To guarantee 0,01 µmol/mol require more experience of measuring at those levels	UD [a]
HCOOH	0,2	May be present in syngas essentially liquid	— PSA. Formic adsorption strength of alumina and molecular sieve higher than CO. A CO content lower than 10 µmol/mol insures a HCOOH content lower than 0,2 µmol/mol	0

Key

UD: undetermined

[a] The probability of occurrence for this impurity is undetermined because no specific study has been conducted yet.

Table B.1 *(continued)*

Impurity	**Threshold** µmol/mol	**Possible causes For the source studied**	**Typical barriers employed in this process**	**Probability with barriers**
Halogens	0,05	Present in natural gas	— Any Cl present in natural gas would be stopped by HDS — Pre-reformer catalyst poisoning by Cl irreversible Cl trapped at this stage. If breakthrough, process condition cannot be achieved — Reformer catalyst poisoning by Cl irreversible. Cl trapped at this stage I break through, process condition cannot be achieved — Shift catalyst poisoning by Cl irreversible. Cl trapped at this stage. I break through, process condition cannot be achieved — PSA adsorption of Cl before CO, CO_2, species	0
He	300	Not present in natural gas in N Europe (<10 µmol/mol). Passes through the whole process. Dilution factor 2,5		0

Key

UD: undetermined

[a] The probability of occurrence for this impurity is undetermined because no specific study has been conducted yet.

Table B.2

Replace Table B.2 with the following table:

Table B.2 — Probability of occurrence for pipeline

Impurity	Threshold µmol/mol	Causes possible For the item studied	Typical barriers employed in this process	Probability with barriers
Inert gas N_2	300	Air intake if some areas are at negative pressure From seal gas or purge gas Wrong purging after maintenance	Inlet pressure PSL trip on compressors	UD [a]
Inert gas Ar	300	No potential	1 % Ar in the air. 100 µmol/mol would mean 1 % air in the pipe Never been observed	UD [a]
O_2	5	Air intake if some areas are at negative pressure	Inlet pressure PSL trip on compressors	1
CO_2	2	From Air: CO_2 at 400 µmol/mol in the air	2 µmol/mol of C O_2 would mean 0,5 % air in the pipe Never been observed	0
CO	0,2	No potential		0
CH_4	100	No potential		0
H_2O	5	Wrong drying after pressure hydraulic test	H_2 > 40 bar ==> leak from H_2O to H_2 unlikely during operation.	0
TS	0,004	No potential		0
NH_3	0,1	No potential		0
THC	2	No potential		0
HCHO	0,2	No potential		UD [a]
HCOOH	0,2	No potential		0
Halogens	0,05	From cleaning material after maintenance		1
He	300	No potential		0

Key

UD: undetermined

[a] The probability of occurrence for this impurity is undetermined because no specific study has been conducted yet. It needs to be covered in the next edition of this document.

Table B.3

Replace Table B.3 with the following table:

Table B.3 — Probability of occurrence for fuelling station to be source of impurities

Impurity	Threshold µmol/mol	Causes possible For the source studied	Existing barriers	Probability
Inert gas N_2	300	N_2 purging operation, air intake during normal operation or maintenance		UD [a]
Inert gas Ar	300	Air intake during normal operation or maintenance	1 % Ar in the air. 100 µmol/mol would mean 1 % air in the fuelling station Never been observed	UD [a]
O_2	5	Air intake during normal operation or maintenance		2
CO_2	2	Air intake during normal operation or maintenance	2 µmol/mol CO_2 would mean 0,5 % air in the fuelling station. Never been observed	0
CO	0,2	No potential at fuelling station level		0
CH_4	100	No potential at fuelling station level		0
H_2O	5	Maintenance, leaks from compressor exchangers, improper pressure vessel drying after periodic inspection, H_2O coming from the vent in case of check valve malfunction, depending on fuelling station/compressor technology		2
TS	0,004	Materials gaskets, valve seats and tubing	Material specifications	1
NH_3	0,1	No potential		0
THC	2	Oil carryover from compressor (depending on compressor technology)		2
HCHO	0,2	No potential		UD [a]
HCOOH	0,2	No potential		0
Halogens	0,05	From degreasing material		1
He	300	No potential at fuelling station level	If pure He is not used for maintenance	0

Key

UD: undetermined

[a] The probability of occurrence for this impurity is undetermined because no specific study has been conducted yet. It will be covered in the next edition of this document.

Table B.4

Replace Table B.4 with the following table:

Table B.4 — Combined risk assessment

ISO specification		Supply chain probability			Compounded probability	Severity	Criticality	Additional risk reduction measures	Residual			
Impurity	Threshold µmol/mol	Production SMR	Pipeline distribution	Fuelling station					Severity reduction measures	Probability	Severity	Criticality
Inert gas N_2	300	UD [a]	UD [a]	UD [a]	**UD** [a]	**UD** [a]	**UD** [a]	Systematic N_2 analysis after shutdown before resuming operation or specific purging procedure	None	UD [a]	UD [a]	**UD** [a]
Inert gas Ar	300	UD [a]	UD [a]	UD [a]	**UD** [a]	**UD** [a]	**UD** [a]		None	UD [a]	UD [a]	**UD** [a]
O_2	5	0	1	2	**2**	**UD** [b]	**UD** [b]		None	2	**UD** [b]	**UD** [b]
CO_2	2	0	0	0	**0**	**1**	+		None	0	1	+
CO	0,2	4	0	0	**4**	**2**	*	CO absorber at fuelling station design margin 100 % + operation procedure for replacement when H_2 quantity purified = 50 % of design capacity.	None	1	2	+
CH_4	100	2	0	0	**2**	**1**	+		None	2	1	+
H_2O	5	0	0	1	**1**	**4**	*	Check H_2O at commissioning and after maintenance involving opening of vessels or piping. Measurement shall be done at appropriate location downstream of the considered vessel or piping	None	0	4	+
TS	0,004	0	0	1	**1**	**4**	*	Check TS at commissioning and after maintenance involving parts modification (piping, valves, seals, gaskets). Not required for part replaced by identical component	None	0	4	+
NH_3	0,1	0	0	0	**0**	**4**	+		None	0	4	+

Key

UD: undetermined

[a] The probability of occurrence, the severity and the criticality for this impurity are undetermined because no specific study has been conducted yet. It needs to be covered in the next edition of this document.

[b] The severity and the criticality for oxygen are undetermined because data are lacking to confirm those values.

Table B.4 *(continued)*

ISO specification		Supply chain probability							Residual			
Impurity	**Threshold** µmol/mol	**Production SMR**	**Pipeline distribution**	**Fuelling station**	**Compounded probability**	**Severity**	**Criticality**	**Additional risk reduction measures**	**Severity reduction measures**	**Probability**	**Severity**	**Criticality**
THC	2	0	0	2	**2**	**4**	**+**	Oil/grease cleaning at commissioning and after maintenance. Compressor surveillance depending on compressor technology (coalescing filter) THC analysis or commissioning and after maintenance	None	0	4	**+**
HCHO	0,2	UD [a]	UD [a]	UD [a]	UD [a]	UD [a]	UD [a]		None	UD [a]	UD [a]	**UD** [a]
HCOOH	0,2	0	0	0	**0**	**2**	**+**		None	0	2	**+**
Halogens	0,05	0	0	1	**1**	**4**	*	Halogenated analysis at commissioning (species shall be defined) or after maintenance	None	0	4	**+**
He	300	0	0	0	**0**	**4**	**+**		None	0	4	+
Key				+ Acceptable risk area: existing controls sufficient				o Further investigation is needed: existing barriers or control may not be enough	* Unacceptable risk; additional control or barriers required			

Key

UD: undetermined

[a] The probability of occurrence, the severity and the criticality for this impurity are undetermined because no specific study has been conducted yet. It needs to be covered in the next edition of this document.

[b] The severity and the criticality for oxygen are undetermined because data are lacking to confirm those values.

Table B.5

Replace Table B.5 with the following table:

Table B.5 — Probability of occurrence for alkaline electrolysis

Impurity	Threshold µmol/mol	Possible causes For the source studied	Typical barriers employed in this process	Probability
Inert gas N_2	300	Insufficient purging after shutdown	Electrolyser process control	UD [a]
Inert gas Ar	300	Insufficient purging after shutdown	If N_2 below 1 %, Ar < 100 µmol/mol	UD [a]
O_2	5	Insufficient purging after shutdown (does not apply to all systems) O_2 permeation through the membrane	Process control Deoxo O_2 sensor	2
CO_2	2			0
CO	0,2			0
CH_4	100			0
H_2O	5	H_2 from electrolyser is saturated.	Dryer plus water sensor downstream of electrolyser	2
TS	0,004			0
NH_3	0,1			0
THC (excluding CH_4)	2			0
HCHO	0,2			UD [a]
HCOOH	0,2			0
Halogens	0,05	Cl from water?	Any trace of halogenated compounds would be trapped in the dryer which has a stronger adsorption capacity for Cl than for H_2O	0
He	300			0

Key

UD: undetermined

[a] The probability of occurrence for this impurity is undetermined because no specific study has been conducted yet in alignment with the new threshold value. It needs to be covered in the next edition of this document.

C.2 first paragraph

Replace “ISO 14687-2” with “Grade D of ISO 14687”.

C.10 first paragraph

Replace “ISO 14687-2” with “Grade D of ISO 14687”.

Table C.4

Replace Table C.4 with the following table:

Table C.4 — Routine analysis work

Category: Distribution				
Facility type	**Sampling/ Monitoring point**	**Contaminant**	**Threshold** (µmol/mol)	**Reduced frequency**
Production of hydrogen from hydrocarbons utilizing steam reforming, catalytic reforming, partial oxidation, or ATR, purification using refining equipment, and distribution	Downstream of the purifier	TS[a]	0,004	Annual[b]
		THC as C1	2	Annual[b]
		CO	0,2	Annual[b]
		N_2	300	Annual[b, c]
		Ar	300	Annual[b, c]
		H_2O	5	Annual[b]
		O_2	5	Annual[b, c]
Electrolysis of NaCl for hydrogen, purification, and distribution	Downstream of the purifier	Halogens	0,05	Annual[b]
		N_2	300	Annual[b]
		Ar	300	Annual[b]
		H_2O	5	Annual[b]
		O_2	5	Annual[b]
Purification of coke-oven gas, and distribution	Downstream of the purifier	TS	0,004	Annual[b]
		THC as C1	2	Annual[b]
		CO	0,2	Annual[b]
		Halogens	0,05	Annual[b]
		N_2	300	Annual[b]
		Ar	300	Annual[b]
		H_2O	5	Annual[b]
		O_2	5	Annual[b]
		NH_3	0,1	Annual[b]
		HCHO	0,2	Annual[b]
		HCOOH	0,2	Annual[b]
Purification of by-product hydrogen from ethylene plants, and distribution	Downstream of the purifier	TS	0,004	Annual[b]
		THC as C1	2	Annual[b]
		CO	0,2	Annual[b]
		N_2	300	Annual[b]
		Ar	300	Annual[b]
		H_2O	5	Annual[b]
		O_2	5	Annual[b]

[a] Since sulfur in steam reforming is mostly found as hydrogen sulfide (H_2S), H_2S analysis may be performed in lieu of total sulfur analysis.

[b] The minimum frequency of the analysis is premised on the combination of continuous analysis of the indicator species (CO for hydrocarbon cracking and O_2/H_2O for water electrolysis) and proper operation controls to make sure no mixing of impurities will occur. If that premise is not satisfied, the analysis shall be carried out once a day.

[c] If a container or piping maintenance has not been opened to air or purged since the last hydrogen analysis, it is not necessary for analysis

[d] If the 5 ppm (dew point of -66 °C or less) are satisfied by routine management, there is no need for analysis.

[e] If the hydrogen on a pipeline contains odorant, the odorant shall be analysed with minimum frequency of once a year.

[f] The batch analysis once a year is needed even if a continuous analysis is performed.

Table C.4 *(continued)*

Category: Fuelling station				
Facility type	**Sampling/ Monitoring point**	**Contaminant**	**Threshold** (μmol/mol)	**Reduced frequency**
With off-site supply of transported compressed or liquid hydrogen	End of nozzle	Those not analysed by the distributor		Annual[b]
		N_2	300	Annual[b, c]
		Ar	300	Annual[b, c]
		H_2O	5	Annual[b, d]
		O_2	5	Annual[b, c]
With off-site supply from hydrogen pipelines	Downstream of the deodorant equipment	(Those listed for the odorant)		Annual[b, e]
	End of nozzle	Those not analysed by the distributor		Annual[b]
		N_2	300	Annual[b, c]
		Ar	300	Annual[b, c]
		H_2O	5	Annual[b, d]
		O_2	5	Annual[b, c]
With on-site supply of hydrogen produced from hydrocarbons utilizing steam reforming, catalytic reforming, partial oxidation, or ATR and purification using refining equipment	Downstream of the purifier	CO	0,2	Continuous and Annual[b, f]
	End of nozzle	TS[a]	0,004	Annual[b]
		THC as C1	2	Annual[b]
		CO	0,2	Annual[b]
		N_2	300	Annual[b, c]
		Ar	300	Annual[b, c]
		H_2O	5	Annual[b, d]
		O_2	5	Annual[b, c]
With on-site supply from hydroelectrolysis and purification using refining equipment	Downstream of the purifier	N_2	300	Annual[b, c]
		Ar	300	Annual[b, c]
		H_2O	5	Continuous and Annual[b, f]
		O_2	5	Continuous and Annual[b, f]
	End of nozzle	Halogens	0,05	Annual[b]
		N_2	300	Annual[b]
		Ar	300	Annual[b, c]
		H_2O	5	Annual[b]
		O_2	5	Annual[b]

[a] Since sulfur in steam reforming is mostly found as hydrogen sulfide (H_2S), H_2S analysis may be performed in lieu of total sulfur analysis.

[b] The minimum frequency of the analysis is premised on the combination of continuous analysis of the indicator species (CO for hydrocarbon cracking and O_2/H_2O for water electrolysis) and proper operation controls to make sure no mixing of impurities will occur. If that premise is not satisfied, the analysis shall be carried out once a day.

[c] If a container or piping maintenance has not been opened to air or purged since the last hydrogen analysis, it is not necessary for analysis

[d] If the 5 ppm (dew point of -66 °C or less) are satisfied by routine management, there is no need for analysis.

[e] If the hydrogen on a pipeline contains odorant, the odorant shall be analysed with minimum frequency of once a year.

[f] The batch analysis once a year is needed even if a continuous analysis is performed.