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Hydrogen fuel - Product specification and Quality assurance - Proton exchange membrane (PEM) fuel cell applications for road vehicles

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Wasserstoff als Kraftstoff - Produktfestlegung - Teil 2: Protonenaustauschmembran (PEM) - Brennstoffzellenanwendungen für Straßenfahrzeuge

Combustible à base d□hydrogène - Spécification produit et assurance qualité - Applications utilisant des piles à combustible à membrane échangeuse de protons (PEM) pour véhicules routiers

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European foreword

This document (prEN 17124:2017) has been prepared by Technical Committee CEN/TC 268 "Cryogenic vessels and specific hydrogen technologies applications", the secretariat of which is held by AFNOR.

This document is currently submitted to the CEN Enquiry.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

1 Scope

This draft European standard specifies the quality characteristics of hydrogen fuel and the corresponding quality assurance in order to ensure uniformity of the hydrogen product as dispensed for utilization in proton exchange membrane (PEM) fuel cell road vehicle systems.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 14687-2:2012, *Hydrogen fuel — Product specification — Part 2: Proton exchange membrane (PEM) fuel cell applications for road vehicles*

ISO/TS 19880-1, *Gaseous hydrogen — Fuelling stations — Part 1: General requirements*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
constituent
component (or compound) found within a hydrogen fuel mixture

3.2
contaminant
impurity that adversely affects the components within the fuel cell system or the hydrogen storage system

Note 1 to entry: An adverse effect can be reversible or irreversible.

3.3
detection limit
lowest quantity of a substance that can be distinguished from the absence of that substance with a stated confidence limit

3.4
determination limit
lowest quantity which can be measured at a given acceptable level of uncertainty

3.5
fuel cell system
power system used for the generation of electricity on a fuel cell vehicle, typically containing the following subsystems: fuel cell stack, air processing, fuel processing, thermal management and water management

3.6
hydrogen fuel index
fraction or percentage of a fuel mixture that is hydrogen

3.7
irreversible effect
effect, which results in a permanent degradation of the fuel cell power system performance that cannot be restored by practical changes of operational conditions and/or gas composition

3.8
on-site fuel supply
hydrogen fuel supplying system with a hydrogen production system in the same site

3.9
off-site fuel supply
hydrogen fuel supplying system without a hydrogen production system in the same site, receiving hydrogen fuel which is produced out of the site

3.10
particulate
solid or aerosol particle that can be entrained somewhere in the delivery, storage, or transfer of the hydrogen fuel

3.11
reversible effect
effect which results in a temporary degradation of the fuel cell power system performance that can be restored by practical changes of operational conditions and/or gas composition

4 Requirements

The fuel quality requirements at the dispenser nozzle applicable to the aforementioned grades of hydrogen fuel for PEM fuel cells in road vehicles shall meet the requirements of Table 1. The fuel specifications are not process or feed stock specific. Non-listed contaminants have no guarantee of being benign.

Table 1 — Directory of limiting characteristics

Constituent	Characteristics
Hydrogen fuel index (minimum mole fraction)[a]	99,97 %
Total non-hydrogen gases	300 µmol/mol
Maximum concentration of individual contaminants	
Water (H_2O)	5 µmol/mol
Total hydrocarbons[b] (Excluding Methane)	2 µmol/mol
Methane (CH_4)	100 µmol/mol
Oxygen (O_2)	5 µmol/mol
Helium (He)	300 µmol/mol
Nitrogen (N_2)	300 µmol/mol
Argon (Ar)	300 µmol/mol
Carbon dioxide (CO_2)	2 µmol/mol
Carbon monoxide (CO)[c]	0,2 µmol/mol
Total sulfur compounds (H_2S basis)	0,004 µmol/mol
Formaldehyde (HCHO)[c]	0,2 µmol/mol
Formic acid (HCOOH)[c]	0,2 µmol/mol
Ammonia (NH_3)	0,1 µmol/mol
Total halogenated compounds[d] (Halogenate ion basis)	0,05 µmol/mol
Maximum particulates concentration	1 mg/kg
For the constituents that are additive, such as total hydrocarbons and total sulfur compounds, the sum of the constituents shall be less than or equal to the acceptable limit.	

[a] The hydrogen fuel index is determined by substracting the “total non-hydrogen gases” in this table, expressed in mole percent, from 100 mol percent.

[b] Total hydrocarbons include oxygenated organic species. Total hydrocarbons shall be measured on a carbon basis (µmolC/mol).

[c] Total of CO, HCHO, HCOOH shall not exceed 0,2 µmol/mol

[d] Total halogenated compounds include, for example, hydrogen chloride (HCl), and organic halides (R-X). Species will be checked according Quality Assurance.

5 Hydrogen Quality Control Approaches

5.1 General requirements

Quality verification requirements for the qualification tests shall be performed at the dispenser nozzle under applicable standardized sampling and analytical methods where available. Alternatively, the quality verification requirements may be performed at other locations or under other methods acceptable to the supplier and the customer.

There are two kinds of quality control at a HRS: On line monitoring or off line analysis after sampling. These methods can be used individual or together to ensure hydrogen quality levels.

5.2 Sampling

Spot sampling at a HRS involves capturing a measured amount for chemical analysis. Sampling is used to perform an accurate and comprehensive analysis of impurities which is done externally, typically at a laboratory. Since the sampling process involves drawing a sample of gas, it is typically done on a periodic basis and requires specialized sampling equipment and personnel to operate it. Sampling procedures shall follow the requirements in ISO/TS 19880-1. Sampling procedure shall ensure and maintain the integrity of the sample.

5.3 Monitoring

A HRS can have real time monitoring of the hydrogen gas stream for one or more impurities on a continuous or semi-continuous basis. A critical impurity can be monitored to ensure it does not exceed a critical level, or monitoring of canary species are used to alert of potential issues with the hydrogen production or purification process. Monitoring equipment is installed in-line with the hydrogen gas stream and shall meet the process requirements of the HRS, as well as be calibrated on a periodic basis.

6 Hydrogen Quality Assurance Methodology

6.1 General Requirements – Potential sources of impurities

For a given HRS, the contaminants listed in the hydrogen specification referred to Clause 4 may or may not be potentially present. There are several parts of the supply chain where impurities can be introduced. The potential impurities in each step of the supply chain are described in Annex X.

When a contaminant is classified as potentially present, it shall be taken into account in the Quality Assurance methodology (risk assessment or prescriptive approach) described at Clause 8.

6.2 Prescriptive Approach for H_2 Quality Assurance

A prescriptive approach can be applied for clearly identified supply chains. An approach to conducting a quality analysis of the contaminants listed in Clause 5 is to consider the potential sources of contaminants, and establish protocol for analysing potential contaminants.

An example of such approach is given in Annex B.

Prescriptive quality assurance plan shall be determined taking into account all existing hydrogen production methods, hydrogen transportation methods and non-routine procedures.

6.3 Risk Assessment for H_2 quality Assurance

Risk assessment consists of the identification of the probability to have each impurity above the threshold values of specifications given in Clause 5 and the evaluation of severity of each impurity for the fuel cell car. As an aid to clearly defining the risk(s) for risk assessment purposes, three fundamental questions are often helpful:

— What might go wrong: which event can cause the impurities to be above the threshold value?

— What is the likelihood (probability of occurrence) that impurities can be above the threshold value?

— What are the consequences (severity) for the fuel cell car?

In doing an effective risk assessment, the robustness of the data set is important because it determines the quality of the output. Revealing assumptions and reasonable sources of uncertainty will enhance confidence in this output and/or help identify its limitations. The output of the risk assessment is a qualitative description of a range of risk. For the probability of occurrence of the event: impurities in hydrogen exceed the threshold value, the following table of occurrence classes has been defined:

Table 2 — Occurrence classes for an impurity

Occurrence class	Class name	Occurrence or frequency	Occurrence or frequency
0	**Very unlikely (Practically impossible)**	Contaminant above threshold never been onserved for this type of source in the industry	Never
1	**Very rare**	Heard in the Industry for the type of source/ Supply chain considered	1 per 1 000 000 refueling
2	**Rare**	Has happened more than once/year in the Industry	1 per 100 000 refueling
3	**Possible**	Has happened repeatedly for this type of source at a specific location	1 out of 10 000 refueling
4	**Frequent**	Happens on a regular basis	Often

The range of severity level (level of damage for vehicle) is defined by the following table:

Table 3 — Severity levels for an impurity

Severity class	FCEV Performance impact or damage	Impact categories		
		Performance impact	Hardware impact temporary	Hardware impact permanent
0	— No impact	No	No	No
1	— Minor impact — Temporary loss of power — No impact on hardware — Car still operates	Yes	No	No
2	— Reversible damage — Requires specific procedure, light maintenance — Car still operates	Yes or No	Yes	No
3	— Reversible damage — Requires specific procedure and immediate maintenance. Gradual power loss that does not compromises safety	Yes	Yes	No
4	— Irreversible damage — Requires major repair (e.g. stack change) — Power loss or Car Stop that compromises safety	Yes	Yes	Yes or No[a]

[a] Any damage, whether permanent or temporary, which compromises safety will be categorized as 4, otherwise temporary damage will be categorized as 1, 2 or 3.

The following Table 4 Severity Classes shows the summary of the concentration based impact of the impurities on the fuel cell. In the first two columns the contaminants with their chemical formulas are given. The third column gives an indication of the severity class up to the Limiting characteristics threshold value which is given in column four. The column six gives the Level 1 Value needed for the risk assessment approach to define the quality assurance. The columns five and seven indicate the severity classes for the concentration ranges from ISO 14687-2:2012 threshold value up to Level 1 Value and from Level 1 Value to infinity.