FINAL DRAFT
International Standard

ISO/FDIS 14687

Hydrogen fuel quality — Product specification

Qualité du carburant hydrogène — Spécification de produit

ISO/TC **197**

Secretariat: **SCC**

Voting begins on:
2024-11-12

Voting terminates on:
2025-01-07

RECIPIENTS OF THIS DRAFT ARE INVITED TO SUBMIT, WITH THEIR COMMENTS, NOTIFICATION OF ANY RELEVANT PATENT RIGHTS OF WHICH THEY ARE AWARE AND TO PROVIDE SUPPORTING DOCUMENTATION.

IN ADDITION TO THEIR EVALUATION AS BEING ACCEPTABLE FOR INDUSTRIAL, TECHNOLOGICAL, COMMERCIAL AND USER PURPOSES, DRAFT INTERNATIONAL STANDARDS MAY ON OCCASION HAVE TO BE CONSIDERED IN THE LIGHT OF THEIR POTENTIAL TO BECOME STANDARDS TO WHICH REFERENCE MAY BE MADE IN NATIONAL REGULATIONS.

Reference number
ISO/FDIS 14687:2024(en)

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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

This second edition cancels and replaces the first edition (ISO 14687:2019), which has been technically revised.

The main changes are as follows:

— a new Grade of hydrogen quality for internal combustion engine (Grade F) applications has been added in Informative Annex F;

— rationale for each Grade D specification has been moved from ISO19880-8 to this document;

— each specification for each Grade has been modified reflecting recent research work and change in industrial needs.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

In recent years, the landscape for using hydrogen as a fuel has changed significantly in response to its potential to contribute to the reduction of greenhouse gas emissions. This shift is influenced by challenges on both the hydrogen supply side, such as production technologies and supply chain infrastructure, and also the hydrogen energy usage side, including advancements in fuel cell and combustion technology. To address these changing conditions, the hydrogen fuel specifications in this document have been updated.

The hydrogen fuel specifications for proton exchange membrane (PEM) fuel cell applications in this document are primarily based on research, development and data on the following items [2][3][4][5][6][7][8][9][10][11][12][13][14]:

— PEM fuel cell catalyst and fuel cell tolerance to hydrogen fuel impurities;

— effects/mechanisms of impurities on fuel cell power systems and components;

— impurity detection and measurement techniques for laboratory, production and in-field operations;

— fuel cell vehicle demonstration and stationary fuel cell demonstration results.

Grade D and grade E in this document are intended to apply to PEM fuel cells for road vehicles and stationary appliances, respectively. These aim to facilitate the provision of hydrogen of reliable quality balanced with acceptable lower cost for the hydrogen fuel supply.

In addition, Grades F-1 and F-2 are newly specified in this edition to apply to hydrogen internal combustion engines for use in vehicular and stationary applications respectively. The new Grades were placed in an informative annex (Annex F) to allow experience to be gained with this fuel quality prior to inclusion in the normative text.

While this document reflects the state of the art at the date of its publication, the rapid development of quality requirements for hydrogen technology applications would necessitate future revisions in response to technological progress.

Hydrogen fuel quality — Product specification

1 Scope

This document specifies the minimum quality characteristics of hydrogen fuel as distributed for utilization in residential, commercial, industrial, vehicular and stationary applications.

This document is applicable to hydrogen fuelling applications, which are listed in Table 2.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 19880-8, *Gaseous hydrogen — Fuelling stations — Part 8: Fuel Quality Control*

ISO 19880-9, *Gaseous hydrogen — Fuelling stations — Part 9: Sampling for fuel quality analysis*

ISO 21087, *Gas analysis — Analytical methods for hydrogen fuel — Proton exchange membrane (PEM) fuel cell applications for road vehicles*

3 Terms, definitions and abbreviations

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at http://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1 Terms and definitions

3.1.1
boundary point
<proton exchange membrane *fuel cell* (3.1.7) for stationary applications> point between the *hydrogen fuel supply equipment* (3.1.13) and the PEM *fuel cell power system* (3.1.9) at which the quality characteristics of the hydrogen fuel are to be determined

3.1.2
constituent
component (or compound) found within a hydrogen fuel mixture

3.1.3
contaminant
impurity that adversely affects the components within the *fuel cell system* (3.1.8), the *fuel cell power system* (3.1.9) or the hydrogen storage system

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

3.1.4
customer
<proton exchange membrane *fuel cell* (3.1.7) for stationary applications> party responsible for sourcing hydrogen fuel in order to operate the *fuel cell power system* (3.1.9)

3.1.5
detection limit
lowest quantity of a substance that can be distinguished from the absence of that substance with a stated confidence limit

3.1.6
determination limit
lowest quantity which can be measured at a given acceptable level of uncertainty

3.1.7
fuel cell
electrochemical device that converts the chemical energy of a fuel and an oxidant to electrical energy (DC power), heat and other reaction products

3.1.8
fuel cell system
<proton exchange membrane *fuel cell* (3.1.7) for road vehicle applications> power system used for the generation of electricity on a fuel cell vehicle

Note 1 to entry: The fuel cell system typically contains the following subsystems: fuel cell stack, air processing, fuel processing, thermal management and water management.

3.1.9
fuel cell power system
<proton exchange membrane *fuel cell* (3.1.7) for stationary applications> self-contained fuel cell assembly used for the generation of electricity which is fixed in place in a specific location

Note 1 to entry: The fuel cell power system typically contains the following subsystems: fuel cell stack, air processing, thermal management, water management and automatic control system. It is used in applications such as: distributed power generation, back-up power generation, remote power generation, electricity and heat co-generation for residential and commercial applications.

Note 2 to entry: For the purposes of the applications, the fuel cell power system does not contain a fuel processing system due to the location of the *boundary point* (3.1.1).

3.1.10
gaseous hydrogen
hydrogen under gaseous form

3.1.11
hydrogen-based fuel
<proton exchange membrane *fuel cell* (3.1.7) for stationary applications> gas containing a specified concentration of hydrogen used in PEM fuel cells for stationary applications

Note 1 to entry: The concentration of hydrogen in the gas is specified in tables in this document (ISO 14687).

3.1.12
hydrogen fuel index
mole fraction of a fuel mixture that is hydrogen

3.1.13
hydrogen fuel supply equipment
equipment used for the transportation or on-site generation of hydrogen fuel, and subsequently for the delivery to the *fuel cell power system* (3.1.9), including additional storage, vaporization and pressure regulation as appropriate

3.1.14
irreversible effect
effect, which results in a permanent degradation of the *fuel cell system* (3.1.8) or the *fuel cell power system* (3.1.9) performance that cannot be restored by practical changes of operational conditions and/or gas composition

3.1.15
liquid hydrogen
hydrogen that has been liquefied, i.e. brought to a liquid state

3.1.16
particulate
solid or liquid such as oil mist that can be entrained somewhere in the production, delivery, storage or transfer of the hydrogen fuel to a *fuel cell system* (3.1.8) or a *fuel cell power system* (3.1.9)

3.1.17
reversible effect
effect, which results in a temporary degradation of *the fuel cell system* (3.1.8) or the *fuel cell power system* (3.1.9) performance that can be restored by practical changes of operational conditions and/or gas composition

3.1.18
slush hydrogen
hydrogen that is a mixture of solid and liquid at the eutectic (triple-point) temperature

3.1.19
system integrator
<proton exchange membrane *fuel cell* (3.1.7) for stationary applications> integrator of equipment between the PEM *fuel cell power system* (3.1.9) and the hydrogen supply

3.2 Abbreviated terms

Table 1 — Abbreviated terms

Abbreviated term	Definition
PEM	proton exchange membrane
FCEV	fuel cell electric vehicle

4 Classification and application

4.1 Classification

Hydrogen fuel shall be classified according to the following types and grade designations:

a) Type I (grades A, B, C, D, E and F): gaseous hydrogen and hydrogen-based fuel;

b) Type II (grades C and D): liquid hydrogen;

c) Type III: slush hydrogen.

4.2 Application

Table 2 characterizes representative applications of each type and grade of hydrogen fuel.

Table 2 — Hydrogen and hydrogen-based fuel classification by application

Type	Grade	Category	Applications	Clause
I Gas	A	—	Gaseous hydrogen; residential/commercial combustion appliances (e.g. boilers, cookers and similar applications)	7
	B	—	Gaseous hydrogen; industrial fuel for power generation and heat generation except PEM fuel cell applications	7
	C	—	Gaseous hydrogen; aircraft and space-vehicle ground support systems except PEM fuel cell applications	7
	D[a,b,c]	—	Gaseous hydrogen; PEM fuel cells for road vehicles	5
	E	PEM fuel cells for stationary appliances		6
		1	Hydrogen-based fuel	
		2	Gaseous hydrogen	
	F[c]	Internal combustion engine applications		Annex F
		1	Gaseous hydrogen; internal combustion engine vehicular applications	
		2	Gaseous hydrogen; internal combustion engine stationary applications	
II Liquid	C	—	Aircraft and space-vehicle on-board propulsion and electrical energy requirements; off-road vehicles	7
	D[a,b,c]	—	PEM fuel cells for road vehicles	5
III Slush	—	—	Aircraft and space-vehicle on-board propulsion	7

[a] Grade D may be used for other fuel cell applications and internal combustion engines in vehicular and stationary applications, including on and non-road vehicles.

[b] Grade D may be used for PEM fuel cell stationary appliances alternative to grade E category 2.

[c] Fuel cells can be contaminated by lower grade hydrogen. Protection against misfuelling with Grade F is ensured by the nozzle/receptacle geometry. These geometries are specified in ISO17268-1 [15]. Care should be taken to ensure cross contamination does not occur in the supply chain nor when dispensing into vehicles or other systems.

NOTE Biological and other sources of hydrogen can contain additional constituents (e.g. siloxanes or mercury) that can affect the performance of the various applications, particularly PEM fuel cells. However, these are not included in most of the following specifications due to insufficient information.

5 Hydrogen quality requirements for PEM fuel cell road vehicle application

5.1 Fuel quality specification

The quality of hydrogen at dispenser nozzle for grade D hydrogen (see Table 2) shall meet the requirements of Table 3. The fuel specifications are not process-dependent or feed-stock-specific. Non-listed contaminants have no guarantee of being benign.

Annex A provides the rationale for the selection of the impurities specified in Table 3.

Table 3 — Fuel quality specification for PEM fuel cell road vehicle application

Constituents [a] (assay)	**Type I, Type II grade D**
Hydrogen fuel index [b] (minimum mole fraction)	99,97 %
Total non-hydrogen gases (maximum)	300 µmol/mol
Maximum concentration of individual contaminants	
Water (H_2O)[c]	5 µmol/mol
Hydrocarbons except methane [a,d] (C1 equivalent)	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)[e]	0,2 µmol/mol
Sulfur compounds [a,f] (S1 equivalent)	0,004 µmol/mol
Formaldehyde (HCHO)[e]	0,2 µmol/mol
Ammonia (NH_3)	0,1 µmol/mol
Halogenated compounds [a,g] (Halogen equivalent)	0,05 µmol/mol
Maximum particulate concentration [h]	1 mg/kg

[a] For the constituents that are grouped, such as hydrocarbons except methane, sulfur compounds and halogenated compounds, the sum of the constituents shall be less than or equal to the acceptable limit.

[b] The hydrogen fuel index is determined by subtracting the "total non-hydrogen gases" in this table, expressed in mole percent, from 100 mole percent.

[c] The allowable water content is based upon a HRS operating at 70 MPa nominal pressure and -40 °C hydrogen pre-cooling. The allowable water content may be allowed to increase to 7 µmol/mol H_2O for a station only dispensing at a nominal working pressure of 35 MPa and a precooling temperature of -26 °C or warmer. The change should be confirmed by the hydrogen quality plan as discussed in ISO 19880-8 to ensure that no water condensate can form. The potential temperatures and pressures in the FCEV should be considered.

[d] Hydrocarbons except methane include oxygenated organic species (for example, formic acid). Hydrocarbons except methane which can potentially be in the hydrogen gas should be determined by the hydrogen quality control plan discussed in ISO 19880-8. Hydrocarbons except methane shall be measured on a C1 equivalent (µmol/mol).

[e] The sum of measured CO and HCHO shall not exceed 0,2 µmol/mol.

[f] Sulfur compounds which can potentially be in the hydrogen gas (for example, H_2S, COS, CS_2 and mercaptans, which are typically found in natural gas) should be determined by the hydrogen quality control plan discussed in ISO 19880-8. Sulfur compounds shall be measured on a S1 equivalent (µmol/mol).

[g] Halogenated compounds which can potentially be in the hydrogen gas [for example, hydrogen chloride (HCl) and organic chlorides (R-Cl)], should be determined by the hydrogen quality control plan discussed in ISO 19880-8. Halogenated compounds shall be measured on a halogen equivalent (µmol/mol).

[h] Particulate includes both solid and liquid particles and may be comprised of oil mist. Large particulates can cause issues with vehicle components and should be limited by using filter as specified in.[14] No visible oil shall be found in fuel at a nozzle.

5.2 Analytical method

The analytical laboratories measuring the constituents should follow industry approved practices, such as ISO/IEC 17025. For Grade D hydrogen, the analytical methods used shall be validated according to the requirements in ISO 21087.