



BSI Standards Publication

Gaseous hydrogen — Fuelling stations

Part 8: Fuel quality control

National foreword

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**Gaseous hydrogen — Fuelling
stations —**

**Part 8:
Fuel quality control**

Hydrogène gazeux — Stations de remplissage —

Partie 8: Contrôle qualité du carburant



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CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
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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 documents 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).

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A list of all parts in the ISO 19880 series can be found on the ISO website.

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

This document was developed to specify how the quality of gaseous hydrogen fuel for road vehicles which use PEM fuel cells can be assured. The document discusses hydrogen quality control approaches for routine and non-routine conditions, as well as quality assurance plans. It is based upon best practices and experience from the gaseous fuels and automotive industry. ISO 21087 describes the requirements for analytical methods to measure the level of contaminants found in the gaseous hydrogen fuel.

Gaseous hydrogen — Fuelling stations —

Part 8: Fuel quality control

1 Scope

This document specifies the protocol for ensuring the quality of the gaseous hydrogen at hydrogen distribution facilities and hydrogen fuelling stations for proton exchange membrane (PEM) fuel cells for road vehicles.

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

3 Terms and definitions

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

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1

authority having jurisdiction

AHJ

organization, office or individual responsible for approving a facility along with an equipment, an installation, or a procedure

3.2

indicator species

one or more *constituents* (3.3) in the gas stream which can signal the presence of other chemical constituents because it has the highest probability of presence in a fuel produced by a given process

3.3

constituent

component (or compound) found within a hydrogen fuel mixture

3.4

contaminant

impurity (3.9) that adversely affects the components within the *fuel cell system* (3.6) or the hydrogen storage system

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

3.5

filter

equipment to remove undesired *particulates* (3.15) from the hydrogen

3.6

fuel cell system

power system used for the generation of electricity on a *fuel cell vehicle* (3.7), typically containing the following subsystems: fuel cell stack, air processing, fuel processing, thermal management, and water management

3.7

fuel cell vehicle

FCV

vehicle which stores hydrogen on-board and uses a *fuel cell system* (3.6) to generate electricity for propulsion

3.8

fuelling station

facility for the dispensing of compressed hydrogen vehicle fuel, including the supply of hydrogen, and hydrogen compression, storage, and dispensing systems

Note 1 to entry: Fuelling station is often referred to as hydrogen fuelling station or hydrogen filling station.

3.9

impurity

non-hydrogen component in the gas stream

3.10

irreversible damage

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

3.11

monitoring

act of measuring the *constituents* (3.3) of a hydrogen stream or process controls of a hydrogen production system on a continuous or semi-continuous basis by on-site equipment

3.12

non-routine, adjective

not in accordance with established procedures

3.13

on-site supply

hydrogen fuel supplying system with a hydrogen production system in the same site

3.14

off-site supply

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

3.15

particulate

solid or liquid such as oil mist that can be entrained somewhere in the delivery, storage, or transfer of the hydrogen fuel entering a *fuel cell system* (3.6)

3.16

purifier

equipment to remove undesired *constituents* (3.3) from the hydrogen

Note 1 to entry: Hydrogen purifiers may comprise purification vessels, dryers, *filters* (3.5), and separators.

3.17

quality assurance

part of quality management focused on providing confidence that quality requirements will be fulfilled

3.18**quality control**

part of quality management focused on fulfilling quality requirements

3.19**quality plan**

documentation of quality management

3.20**reversible damage****reversible effect**

effect, which results in a non-permanent degradation of the fuel cell power system performance that can be restored by practical changes of operational conditions and/or gas composition

3.21**risk**

combination of the probability of occurrence of harm and the *severity* (3.26) of that harm, encompassing both the uncertainty about and severity of the harm

3.22**risk assessment**

determination of quantitative or qualitative value of *risk* (3.21) related to a specific situation and a recognized threat also called a hazard

3.23**risk level**

assessed magnitude of the *risk* (3.21)

3.24**routine**, adjective

in accordance with established procedures

3.25**sampling**

act of capturing a measured amount of hydrogen for chemical analysis by external equipment

3.26**severity**

measure of the possible consequences for fuel cell cars if filled with H₂ containing higher level of *impurities* (3.9) than the threshold value

4 Abbreviated terms

Abbreviated term	Definition
Halogens	total halogenated compounds
HDS	hydrodesulphurization
PEM	proton exchange membrane
PSA	pressure swing adsorption
SC	severity class
SMR	steam methane reforming
THC	total hydrocarbons
TS	total sulphur compounds
TSA	temperature swing adsorption

5 Hydrogen specifications

A1 The quality requirements of hydrogen fuel dispensed to PEM fuel cells for road vehicles are listed in Grade D of ISO 14687. **A1**

6 Quality control approaches

6.1 General

There are two common methods to control the quality of hydrogen at a fuelling station, by spot sampling and continuous monitoring. These methods can be used individually or together to ensure hydrogen quality levels.

6.2 Sampling

Spot sampling at a fuelling station 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 conform to ISO 19880-1. The advantage of spot sampling is that a more detailed laboratory analysis can be conducted on the sample. The disadvantage of spot sampling is that it is not continuous and results in a detail analysis of a single point in time.

6.3 Monitoring

A fuelling station 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 indicator 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 fuelling station, as well as be calibrated on a periodic basis. Continuous monitoring compliments spot sampling by offsetting the disadvantages.

7 Potential sources of impurities

For a given fuelling station, the contaminants listed in the hydrogen specification referred to in [Clause 5](#) 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 D](#).

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 in [Clause 8](#).

8 Hydrogen quality assurance methodology

8.1 General

A quality assurance plan for the entire supply chain shall be created to ensure that the hydrogen quality will meet the requirements listed in [Clause 5](#). The methodology used to develop the quality assurance plan can vary but shall include one of the two approaches described in this document. The general description of these two approaches are described in [8.2](#) and [8.3](#). Examples of these approaches 1) prescriptive approach and 2) risk assessment for hydrogen quality, are presented in [Annexes A, B and C](#), respectively. The quality assurance plan for the fuelling station shall include the following to ensure hydrogen quality is properly maintained:

- identification of potential impurities;

- methods to control and remove these impurities;
- sampling impurities and frequency;
- monitoring of impurities or process controls;
- description of solid and liquid particulate filters;
- cleanliness and maintenance procedures.

It is important to understand that quality should be maintained throughout the complete supply chain of the product (from production source to fuelling station nozzle), such that the impurities that are given in the specification remain below the threshold values.

Each component of the supply chain shall be investigated taking into account the already existing barriers for a given contaminant.

NOTE An effective quality control approach can further ensure the quality of the hydrogen by providing a proactive means to identify and control potential quality issues which can include sampling and monitoring. Additionally, use of quality assurance can improve the decision making if a quality problem arises.

8.2 Prescriptive methodology

The prescriptive approach to hydrogen quality assurance considers potential sources of contaminants and establishes a fixed protocol for analysing and addressing potential contaminants. The prescriptive approach can be applied for the clearly identified supply chain.

The prescriptive quality assurance plan shall be determined taking into account all hydrogen production methods, hydrogen transportation methods and non-routine procedures which exists in the area where the assurance plan is applicable.

NOTE [Annex C](#) presents Japanese hydrogen quality guidelines which is an example of a prescriptive quality assurance plan.

8.3 Risk assessment methodology

The risk assessment approach determines the probability to have each impurity above the threshold values of specifications given in [Clause 5](#) and evaluates severity of each impurity for the fuel cell vehicle (see [Annex A](#)). As an aid to clearly defining the risk(s) for risk assessment purposes, three fundamental questions are often helpful:

- What can go wrong: which event can cause the impurities to be above the threshold value?
- What is the likelihood (probability of occurrence expressed relative to the number of fuelling events) that impurities can be above the threshold value?
- What are the consequences (severity) for the fuel cell vehicle?

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. To determine the probability of the occurrence that impurities in hydrogen exceed the threshold value, [Table 1](#) defines the occurrence classes.

Table 1 — Occurrence classes for an impurity

Occurrence class	Class name	Description	Occurrence or frequency
0	Very unlikely (Practically impossible)	Contaminant above threshold never been observed for this type of source in the industry	Never

Table 1 (continued)

Occurrence class	Class name	Description	Occurrence or frequency
1	Very rare	Known to occur in the industry for the type of source/Supply chain considered	1 per 1 000 000 fuellings
2	Rare	Has occurred more than once/year in the Industry	1 per 100 000 fuellings
3	Possible	Has occurred repeatedly for this type of source at a specific location	1 out of 10 000 fuellings
4	Frequent	Occurs on a regular basis	Often

If the occurrence class is unknown, then the risk assessment shall assume the worst case. In addition, the experience of the hydrogen supplier, station manufacturer/installer should be taken into account when performing the risk analysis.

The range of severity classes (level of damage for vehicle) is defined in [Table 2](#).

Table 2 — Severity classes for an impurity

Severity class	FCV 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 — Vehicle still operates	Yes	No	No
2	— Reversible damage — Requires specific light maintenance procedure — Vehicle still operates	Yes or No	Yes	No
3	— Reversible damage — Requires specific immediate maintenance procedure — Gradual power loss that does not compromise safety	Yes	Yes	No
4 ^a	— Power loss or Vehicle Stop that compromises safety — Irreversible damage — Requires major repair procedure (e.g. stack change)	Yes	Yes	No
			No	Yes

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

The final risk is defined by the acceptability table ([Table 3](#)) which combines results from [Tables 1](#) and [2](#):

Table 3 — Combined risk assessment

Probability per one fuelling	Occurrence	Severity				
		0	1	2	3	4
Frequent: Often	4	+	*	*	*	*
Possible: 10^{-4}	3	+	o	*	*	*
Rare: 10^{-5}	2	+	+	o	*	*
Very Rare: 10^{-6}	1	+	+	+	o	*
Practically Impossible	0	+	+	+	+	+
Key	+	Acceptable risk area: Existing controls sufficient		o	Unacceptable risk; additional control or barriers required	

NOTE 1 It is possible that contamination of a vehicle at severity class 1 or 2 is not noticeable immediately, thereby making it difficult to identify the source of the contamination.

If a vehicle is found to have hydrogen with contamination that exceeds the specification in [Clause 5](#) and the source is unknown, the procedures in [Clause 11](#) shall be followed.

For each impurity of the specification and for a given fuelling station (including the supply chain of hydrogen), a risk assessment shall be applied to define the global risk.

NOTE 2 Risk control includes decision making to reduce and/or accept risks. The purpose of risk control is to reduce the risk to an acceptable level.

The amount of effort used for risk control should be proportional to the significance of the risk. Decision makers might use different processes, including benefit-cost analysis, for understanding the optimal level of risk control. Risk control can focus on the following questions:

- Is the risk above an acceptable level?
- What can be done to reduce or eliminate risks?
- What is the appropriate balance among benefits, risks and resources?

For each level of risk, a decision shall be taken in order to either refuse the risk and find mitigation or barriers to reduce it, or accept the risk level as it is. Risk reduction focuses on processes for mitigation or avoidance of quality risk when it exceeds an acceptable level (“o” or “*” zone in [Table 3](#)). Risk reduction typically includes actions taken to mitigate the severity and/or probability of occurrence. However, this document only deals with the mitigation of probability of occurrence.

8.4 Impact of impurities on fuel cell powertrain

A1 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. **A1**

A1 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. **A1**

If higher concentrations that exceed Level 1 can be reached, the severity class is given in column 6.

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 ₂ O	5	4	N/A	4
Total sulphur compounds	H ₂ S 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.

A1

9 Routine quality control

Routine analysis is performed on a periodic basis once every specified time period or once for each lot or batch. The methodology selected in the hydrogen quality assurance plan determines the type and frequency of the routine analysis. A prescriptive methodology may be used as described in 8.1 or a risk assessment methodology may be used (8.2). Information on the routine analysis for each step of the supply chain is provided in Annex E.

10 Non-routine quality control

The hydrogen quality plan shall identify any non-routine conditions and subsequent required actions. Some common non-routine conditions include the following:

- a new production system is constructed at a production site or a new fuelling station is first commissioned;