INTERNATIONAL STANDARD

ISO 14687-2

First edition
2012-12-01

Hydrogen fuel — Product specification —

Part 2:
Proton exchange membrane (PEM) fuel cell applications for road vehicles

Carburant hydrogène — Spécification de produit —

Partie 2: Applications des piles à combustible à membrane à échange de protons (MEP) pour les véhicules routiers

Reference number
ISO 14687-2:2012(E)

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 14687-2 was prepared by Technical Committee ISO/TC 197, *Hydrogen technologies.*

This first edition of ISO 14687-2 cancels and replaces the first edition of ISO/TS 14687-2:2008.

ISO 14687 consists of the following parts, under the general title *Hydrogen fuel — Product specification*:

— *Part 1: All applications except proton exchange membrane (PEM) fuel cell for road vehicles*

— *Part 2: Proton exchange membrane (PEM) fuel cell applications for road vehicles*

— *Part 3: Proton exchange membrane (PEM) fuel cell applications for stationary appliances*

Introduction

This part of ISO 14687 specifies two grades of hydrogen fuel, “Type I, grade D” and — Type II, grade D. These grades are intended to apply to the interim stage of proton exchange membrane (PEM) fuel cells for road vehicles (FCV) on a limited production scale.

It is also noted that this part of ISO 14687 has been prepared based on the research and development focusing on the following items:

— PEM catalyst and fuel cell components tolerance to hydrogen fuel contaminants;

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

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

— onboard hydrogen storage technology;

— vehicle demonstration results.

Since the FCV and related technology are developing rapidly, this part of ISO 14687 needs to be revised according to technological progress as necessary. Technical Committee ISO/TC 197, *Hydrogen Technologies*, will monitor this technology trend.

Hydrogen fuel — Product specification —

Part 2:
Proton exchange membrane (PEM) fuel cell applications for road vehicles

1 Scope

This part of ISO 14687 specifies the quality characteristics of hydrogen fuel 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 6145 (all parts), *Gas analysis — Preparation of calibration gas mixtures using dynamic volumetric methods*

ISO 14687-1, *Hydrogen fuel — Product specification — Part 1: All applications except proton exchange membrane (PEM) fuel cell for road vehicles*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 14687-1 and the following 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 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

4.1 Classification

Hydrogen fuel for PEM fuel cell applications for road vehicles shall be classified according to the following types and grade designations:

a) Type I (grade D): Gaseous hydrogen

b) Type II (grade D): Liquid hydrogen

4.2 Applications

The following information characterizes representative applications of each type and grade of hydrogen fuel. It is noted that suppliers commonly transport hydrogen of a higher quality than some users may require.

Type I (grade D) Gaseous hydrogen fuel for PEM fuel cell road vehicle systems

Type II (grade D) Liquid hydrogen fuel for PEM fuel cell road vehicle systems

NOTE 1 Type I, grade A, B, C, Type II, grade C and Type III, which are applicable for all applications except PEM fuel cells applications, are defined in ISO 14687-1.

NOTE 2 There is no equivalent grade A and B for Type II fuels.

NOTE 3 Hydrogen fuel specifications applicable to PEM fuel cell applications for stationary appliances are addressed in ISO 14687-3.

4.3 Limiting characteristics

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.

NOTE Annex A provides the rationale for the selection of the impurities specified in Table 1.

Table 1 — Directory of limiting characteristics

Characteristics (assay)	**Type I, Type II** **Grade D**
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] (Methane basis)	2 µmol/mol
Oxygen (O_2)	5 µmol/mol
Helium (He)	300 µmol/mol
Total Nitrogen (N_2) and Argon (Ar)[b]	100 µmol/mol
Carbon dioxide (CO_2)	2 µmol/mol
Carbon monoxide (CO)	0,2 µmol/mol
Total sulfur compounds[c] (H_2S basis)	0,004 µmol/mol
Formaldehyde (HCHO)	0,01 µmol/mol
Formic acid (HCOOH)	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 are to be less than or equal to the acceptable limit.

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

b Total hydrocarbons include oxygenated organic species. Total hydrocarbons shall be measured on a carbon basis (µmolC/mol). Total hydrocarbons may exceed 2 µmol/mol due only to the presence of methane, in which case the summation of methane, nitrogen and argon shall not exceed 100 µmol/mol.

c As a minimum, total sulphur compounds include H_2S, COS, CS_2 and mercaptans, which are typically found in natural gas.

d Total halogenated compounds include, for example, hydrogen bromide (HBr), hydrogen chloride (HCl), chlorine (Cl2), and organic halides (R-X).

5 Hydrogen fuel qualification test

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.

5.2 Report results

The detection and determination limits for analytical methods and instruments used shall be reported along with the results of each test as well as the employed analytical method, the employed sampling method and the amount of sample gas.

6 Sampling

6.1 Sample size

The quantity of hydrogen in a single sample container should be sufficient to perform the analyses for the limiting characteristics specified in Table 1. If a single sample does not contain a sufficient quantity of hydrogen to perform all of the analyses required to assess the quality level, additional samples from the same lot shall be taken under similar conditions.

6.2 Gaseous hydrogen

Gaseous hydrogen samples shall be representative of the dispensed hydrogen. The sampling location shall be in accordance with 5.1.

A sample from the dispenser nozzle shall be withdrawn through a suitable connection that does not contaminate the sample or compromise safety. Attention shall be paid to ensure that the sampled hydrogen is not contaminated with residual gases inside the sample container by repeated purge cycles. A validated sampling method should be used (see Annex B for guidance).

Clause 9 provides guidance relative to managing hazards associated with withdrawing samples from the high pressure hydrogen system.

6.3 Particulates in gaseous hydrogen

Particulates in hydrogen should be sampled from a dispenser nozzle. Samples shall be collected in a manner that does not compromise safety. Appropriate measures should be taken for the sample gas not to be contaminated by particulates coming from the connection device and/or the ambient air. When using a filter, samples should be collected if possible under the same conditions (pressure and flow rate) as employed in the actual refuelling operation. To avoid trapping particles or contaminating the sample, no regulator should be used between the dispenser nozzle and the particulate filter.

6.4 Liquid hydrogen

Vaporized liquid samples shall be representative of the liquid hydrogen supply. Samples shall be obtained in a manner that does not compromise safety. For example, one of the following procedures can be used to obtain samples:

a) vaporizing, in the sampling line, liquid hydrogen from the supply container;

b) flowing liquid hydrogen from the supply container into or through a suitable container in which a representative sample is collected and then vaporized.

7 Analytical methods

7.1 General

The analytical methods suitable for measuring characteristics listed in Table 1 are described below. Other analytical methods are acceptable if their performances, including safety of use are equivalent to those of the methods listed below.

7.2 Parameters of analysis

The parameters for analytical techniques contained in this clause are

a) mole fraction, expressed as a percentage (%),

b) number of micromoles per mole (µmol/mol), and

c) number of milligrams per kilogram of hydrogen (mg/kg) (particulate concentration only).

The determination limits for the analytical methods listed should be less than or equal to the limiting characteristics of hydrogen for all constituents listed in Table 1.

If calibration gas standards which contain the applicable gaseous components at applicable concentrations and standardized dilution procedures are used to calibrate the analytical instruments used to determine the limiting characteristics of hydrogen, calibration gas mixtures shall be prepared in accordance with ISO 6145.

The calibration of measuring equipment should be traceable to a primary standard.

Analytical equipment shall be operated in accordance with the manufacturer's instructions and validated.

7.3 Water content

The water content can be determined using one of the following instruments:

a) an electrostatic capacity type moisture meter;

b) a fourier transform infrared spectrometer (FTIR) with suitable cell path length, scan wavelength and detector;

c) a gas chromatograph-mass spectrometer (GC-MS) and jet pulse injection;

d) a vibrating quartz analyser.

Alternatively, water content may be determined with a dew point analyser in which the temperature of a viewed surface is measured at the time moisture first begins to form.

7.4 Total hydrocarbon content

The total (volatile) hydrocarbon content (as methane) can be determined using one of the following instruments:

a) a gas chromatograph with a flame ionization detector (GC/FID);

b) a flame ionization detector (FID) based total hydrocarbon analyser;

c) a fourier transform infrared spectrometer (FTIR) with suitable cell path length, scan wavelength and detectorp;

d) a gas chromatograph-mass spectrometer (GC-MS) with a concentrating device.

7.5 Oxygen content

The oxygen content can be determined using one of the following instruments:

a) a galvanic cell type oxygen analyser;

b) a gas chromatograph-mass spectrometer (GC-MS) and jet pulse injection;

c) a gas chromatograph with thermal conductivity detector (GC/TCD).