TECHNICAL SPECIFICATION

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Gaseous hydrogen and hydrogen blends — Land vehicle fuel tanks

Hydrogène gazeux et mélanges d'hydrogène gazeux — Réservoirs de carburant pour véhicules terrestres

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.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.

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.

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of document:

— an ISO Publicly Available Specification (ISO/PAS) represents an agreement between technical experts in an ISO working group and is accepted for publication if it is approved by more than 50 % of the members of the parent committee casting a vote;

— an ISO Technical Specification (ISO/TS) represents an agreement between the members of a technical committee and is accepted for publication if it is approved by 2/3 of the members of the committee casting a vote.

An ISO/PAS or ISO/TS is reviewed after three years in order to decide whether it will be confirmed for a further three years, revised to become an International Standard, or withdrawn. If the ISO/PAS or ISO/TS is confirmed, it is reviewed again after a further three years, at which time it must either be transformed into an International Standard or be withdrawn.

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/TS 15869 was prepared by Technical Committee ISO/TC 197, *Hydrogen technologies*, with collaboration from Technical Committee ISO/TC 22, *Road vehicles*, and Technical Committee ISO/TC 58, *Gas cylinders*, Subcommittee SC 3, *Cylinder design*.

Introduction

Fuel tanks for on-board storage of compressed gaseous hydrogen and hydrogen blends as fuels for land vehicle service are required to maintain or improve the level of safety currently existing for land vehicle applications. These requirements are achieved by:

a) specifying service conditions precisely and comprehensively as a firm basis for both fuel tank design and use;

b) using an appropriate method to assess cyclic pressure fatigue life and to establish allowable defect sizes in metal tanks or liners;

c) requiring design qualification tests;

d) requiring non-destructive testing and inspection of all production fuel tanks;

e) requiring destructive tests on fuel tanks and tank material taken from each batch of fuel tanks produced;

f) requiring manufacturers to specify the acceptable in-service damage levels for their design; and

g) requiring manufacturers to specify as part of their design, the safe service conditions for their fuel tanks.

Designs meeting the requirements of this International Standard:

a) will have a fatigue life that exceeds the expected service; and

b) will demonstrate appropriate strength and durability for expected service conditions.

Gaseous hydrogen and hydrogen blends — Land vehicle fuel tanks

1 Scope

This International Standard specifies the requirements for lightweight refillable fuel tanks intended for the on-board storage of high-pressure compressed gaseous hydrogen or hydrogen blends on land vehicles.

This International Standard is not intended as a specification for fuel tanks used for solid, liquid hydrogen or hybrid cryogenic high-pressure hydrogen storage applications.

This International Standard is applicable for fuel tanks of steel, stainless steel, aluminium or non-metallic construction material, using any design or method of manufacture suitable for its specified service conditions.

This International Standard applies to the following types of fuel tank designs:

— Type 1: metal fuel tanks;

— Type 2: hoop-wrapped composite fuel tanks with a metal liner;

— Type 3: fully wrapped composite fuel tanks with a metal liner;

— Type 4: fully wrapped composite fuel tanks with no metal liner.

2 Normative references

The following referenced documents are indispensable for the application 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 306, *Plastics — Thermoplastic materials — Determination of Vicat softening temperature (VST)*

ISO 527-2, *Plastics — Determination of tensile properties — Part 2: Test conditions for moulding and extrusion plastics*

ISO 2808, *Paints and varnishes — Determination of film thickness*

ISO 4624, *Paints and varnishes — Pull-off test for adhesion*

ISO 6506-1, *Metallic materials — Brinell hardness test — Part 1: Test method*

ISO 7225, *Gas cylinders — Precautionary labels*

ISO 7866:1999, *Gas cylinders — Refillable seamless aluminium alloy gas cylinders — Design, construction and testing*

ISO 9809-1:1999, *Gas cylinders — Refillable seamless steel gas cylinders — Design, construction and testing — Part 1: Quenched and tempered steel cylinders with tensile strength less than 1 100 MPa*

ISO 9809-2:2000, *Gas cylinders — Refillable seamless steel gas cylinders — Design, construction and testing — Part 2: Quenched and tempered steel cylinders with tensile strength greater than or equal to 1 100 MPa*

ISO 11114-4, *Transportable gas cylinders — Compatibility of cylinder and valve materials with gas contents — Part 4: Test methods for selecting metallic materials resistant to hydrogen embrittlement*

ISO 11439, *Gas cylinders — High pressure cylinders for the on-board storage of natural gas as a fuel for automotive vehicles*

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

EN 1964-3:2000, *Transportable gas cylinders — Specification for the design and construction of refillable transportable seamless steel gas cylinders of water capacities from 0,5 litre up to and including 150 litres — Part 3: Cylinders made of seamless stainless steel with an Rm value of less than 1 100 MPa*

EN 12862:2000, *Transportable gas cylinders — Specification for the design and construction of refillable transportable welded aluminium alloy gas cylinders*

EN 13322-2:2003/A1:2006, *Transportable gas cylinders — Refillable welded steel gas cylinders — Design and construction — Part 2: Stainless steel*

ASTM B 117, *Standard Practice for Operating Salt Spray (Fog) Apparatus*

ASTM D 522, *Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings*

ASTM D 1308, *Standard Test Method for Effect of Household Chemicals on Clear and Pigmented Organic Finishes*

ASTM D 2344, *Standard Test Method for Short-Beam Strength of Polymer Matrix Composite Materials and Their Laminates*

ASTM D 2794, *Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)*

ASTM D 3170, *Standard Test Method for Chipping Resistance of Coatings*

ASTM D 3418, *Standard Test Method for Transition Temperatures and Enthalpies of Fusion and Crystallization of Polymers by Differential Scanning Calorimetry*

ASTM G 154, *Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials*

3 Terms and definitions

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

3.1
auto-frettage
pressure application procedure used in manufacturing composite fuel tanks with metal liners, which strains the liner past its yield point

NOTE Auto-frettage results in the liner having compressive stresses and the fibres having tensile stresses at zero internal pressure.

3.2
auto-frettage pressure
pressure within the over-wrapped composite fuel tank at which the required distribution of stresses between the liner and the over-wrap is established

3.3
batch of composite fuel tanks
group of not more than 200 fuel tanks plus fuel tanks for destructive testing or, if greater, one shift of successive production of fuel tanks, successively produced from qualified liners having the same size, design, specified materials of construction and manufacturing process

3.4
batch of metal fuel tanks/liners
group of not more than 200 fuel tanks/liners plus fuel tanks/liners for destructive testing or, if greater, one shift of successive production of metal fuel tanks/liners, successively produced having the same nominal diameter, wall thickness, design, specified material of construction, manufacturing process, equipment for manufacturing and heat treatment, and conditions of time, temperature and atmosphere during heat treatment

3.5
batch of non-metallic liners
group of not more than 200 liners plus liners for destructive testing or, if greater, one shift of successive production of non-metallic liners, successively produced having the same nominal diameter, wall thickness, design, specified material of construction and manufacturing process

3.6
burst pressure
pressure that causes the bursting of a pressure vessel subjected to a constant increase of pressure during a destructive test

3.7
controlled tension winding
process used in manufacturing hoop-wrapped composite fuel tanks with metal liners by which compressive stresses in the liner and tensile stresses in the over-wrap at zero internal pressure are obtained by winding the reinforcing filaments under high tension

3.8
design change
change in the selection of structural materials or dimensional changes exceeding the tolerances as on the design drawings

3.9
finished fuel tanks
fuel tanks that are ready for use, typical of normal production, complete with identification marks and external coating including integral insulation specified by the manufacturer, but free from non-integral insulation or protection

3.10
fully wrapped composite fuel tank
fuel tank with an over-wrap having a filament wound reinforcement both in the circumferential and axial direction of the fuel tank

3.11
hoop-wrapped composite fuel tank
fuel tank with an over-wrap having a filament wound reinforcement in a substantially circumferential pattern over the cylindrical portion of the liner such that the filament does not carry any significant load in a direction parallel to the longitudinal axis of the fuel tank

3.12
hydrogen blend
mixture of natural gas and hydrogen

3.13
hydrogen storage system
system on a land vehicle comprised of the fuel tank and all closure devices (e.g. shut-off valves, check valves and thermally activated pressure relief devices), as well as piping that contains hydrogen at the working pressure

3.14
leakage
release of gas through a crack, pore, unbonded or similar defect

NOTE Permeation through the wall of a Type 4 fuel tank that is less than the rates described in B.16 is not considered leakage.

3.15
liner
container that is used as an inner shell, on which reinforcing fibres are filament wound to achieve the necessary strength

3.16
manufacturer
organization responsible for the design, manufacturing and testing of fuel tanks

3.17
over-wrap
reinforcement system of filament and resin applied over the liner

3.18
thermally activated pressure relief device
device that activates by temperature to release pressure and prevent a fuel tank from bursting due to fire effects and that will activate regardless of fuel tank pressure

3.19
passenger vehicles
vehicles designed and constructed primarily for the carriage of persons (e.g. cars and buses)

3.20
pre-stress
process of applying auto-frettage or controlled tension winding

3.21
service conditions
conditions that the fuel tank will experience in service and that include on-road exposure to environmental factors (road salt, acids, bases, temperature extremes) and expected usage (pressure cycles associated with filling and discharge during service and driving, static pressure associated with vehicle parking, etc.)

3.22
settled pressure
gas pressure when a given settled temperature is reached

3.23
settled temperature
uniform gas temperature after any change in temperature caused by filling has dissipated

3.24
stress ratio
stress in fibre at specified minimum burst pressure divided by stress in fibre at working pressure

3.25
test pressure
required pressure applied during a pressure test

3.26
working pressure
nominal working pressure
settled pressure of compressed gas at a uniform temperature of 15 °C in a full fuel tank

4 Service conditions

4.1 General

The specified service conditions provide the basis for the design, manufacturing, inspection, and testing of fuel tanks that are to be mounted on land vehicles and used to store compressed gaseous hydrogen or hydrogen blends at ambient temperatures for use as a fuel on these vehicles.

The specified service conditions are also intended to provide information on how fuel tanks made in accordance with this International Standard may safely be used, for

a) manufacturers of fuel tanks,

b) owners of fuel tanks,

c) designers or contractors responsible for the installation of fuel tanks,

d) designers or owners of equipment used to refuel land vehicle fuel tanks,

e) suppliers of gaseous hydrogen and hydrogen blends, and

f) regulatory authorities that have jurisdiction over fuel tank use.

The service conditions do not cover external loading that may arise from vehicle collisions, etc.

4.2 Expected service

The expected service for which fuel tanks are safe shall be specified by the fuel tank manufacturer.

4.3 Working pressure

The working pressure shall be specified by the fuel tank manufacturer for gaseous hydrogen and hydrogen blends settled at a temperature of 15 °C.

4.4 Maximum filling pressure

Fuel tanks shall be designed to be filled up to a maximum pressure not exceeding 1,25 times the working pressure, regardless of filling conditions or temperature, and which settles to a pressure of not greater than the working pressure at the settled temperature of 15 °C.

4.5 Filling cycles

4.5.1 General

Except as permitted in 4.5.2, fuel tanks shall be designed for 11 250 fill cycles, representing a 15-year life of use in commercial heavy-duty vehicles (see Annex A).

4.5.2 Reduced number of filling cycles

A reduced number of 5 500 filling cycles may be specified for the lifetime of the vehicle. Fuel tanks with the reduced number of filling cycles may be qualified according to 9.2 or 9.5. In the case of fuel tanks with a reduced number of filling cycles and qualified according to 9.2, these shall only be used in conjunction with a tamper-proof counter system that records the number of fill cycles and terminates usage of the fuel tank before the reduced number of fill cycles is exceeded.

4.6 Design temperature

Fuel tanks shall be designed to be suitable for use in the following material temperature range: –40 °C to 85 °C. Transient gas temperatures during filling and discharge may vary locally beyond these limits.

4.7 Gas composition

Fuel tanks shall be designed to be filled with compressed gaseous hydrogen and/or hydrogen blends containing more than 2 % hydrogen by volume, combined with dry natural gas. The gas composition shall comply with the following:

a) compressed hydrogen gas shall comply with the composition specified in ISO/TS 14687-2;

b) compressed natural gas (CNG) used in hydrogen blends may vary as stated in the dry gas composition limits specified in ISO 11439.

4.8 External surfaces

Fuel tank external surfaces shall be designed to withstand mechanical and chemical exposure conditions as reflected in the type tests specified in Clause 9.

4.9 Fire effects

Fuel tanks shall be protected from fire effects using non-reclosing thermally activated pressure relief devices. Non-reclosing pressure-activated pressure relief devices can only be used in parallel with thermally activated pressure relief devices. A thermally activated pressure relief device shall not under any circumstances require the operation of the pressure-activated pressure relief device in order to function.

NOTE In the selection of thermally activated pressure relief devices, the requirements of the ANSI/IAS PRD 1-1998/ Addenda PRD 1a-1999 can be used as guidance until a standard on pressure relief devices for hydrogen service is available.

The fire protection of fuel tanks may also be supplemented by the use of thermal insulation.

5 Information to be recorded

5.1 General

The fuel tank manufacturer shall keep on file the information specified herein. This information shall be retained for the intended life of the fuel tank.

5.2 Statement of service

A statement of service shall be provided to the user. This statement of service shall include the following:

a) the name and address of the fuel tank manufacturer;

b) a description of the fuel tank design, including fuel tank identification, working pressure (MPa), fuel tank type, diameter (mm), length (mm), internal volume (l), empty weight (kg) and valve thread type;

c) a statement that the fuel tank design is suitable for use in the service conditions provided in Clause 4;

d) a statement of the maximum service conditions for which the fuel tank was designed;

e) a statement of the maximum number of filling cycles for which the fuel tank was designed;

f) a statement of the working pressure for which the fuel tank was designed;

g) a specification for the fire protection system approved by the fuel tank manufacturer using non-reclosing thermally activated pressure relief devices and, if used, thermal insulation;

h) a specification for the support methods, protective coatings and any other items required, but not provided with the fuel tank;

i) any other information and instructions necessary to ensure the safe use and inspection of the fuel tank.

5.3 Design drawings and information

All fuel tank drawings and related technical data shall be kept on file by the fuel tank manufacturer and shall show the following information:

a) title, reference number, date of issue and revision numbers with dates of issue, if applicable;

b) reference to a Type 1, Type 2, Type 3 or Type 4 design;

c) dimensions complete with tolerances, including details of end closure shapes with minimum thickness and openings;

d) mass, complete with tolerance;

e) material specifications, complete with minimum mechanical and chemical properties and tolerance ranges and, for metal fuel tanks or metal liners, the specified hardness range;

f) other data such as auto-frettage pressure range, minimum test pressure, details of the fire protection system and of any exterior protective coating;

g) the gas that the fuel tank is designed to carry;

h) the working pressure of the design.

5.4 Stress analysis report

When a stress analysis is required to be carried out, the stress analysis report shall be kept on file and shall include a table summarizing the calculated stresses.

NOTE Verification of the stress ratios may be performed using strain gauges or an equivalent method. An example of an acceptable method is provided in Annex C.

5.5 Material property data

A detailed description of the materials and tolerances of the material properties used in the design shall be kept on file. Test data shall also be presented characterizing the mechanical properties and the suitability of the materials for service under the conditions specified in Clause 4.