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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

(Revision of ISO/TS 15869:2009)

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Foreword

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ISO 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.*

This edition cancels and replaces ISO/TS 15869:2009, which has been technically revised.

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[1].

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 Standard applies to the following types of fuel tank designs:

— Type 1 – all - metal fuel tank;

— Type 2 – hoop wrapped fuel tank with a load sharing metal liner and composite reinforcement on the cylindrical part only;

— Type 3 – fully wrapped fuel tank with a load sharing metal liner and composite reinforcement on both the cylindrical part and dome ends;

— Type 4 – fully wrapped fuel tank with a non-load sharing liner and composite reinforcement in both the cylindrical part and dome ends.

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*

[1] The first edition of this International Standard only covers gaseous hydrogen and hydrogen blends fuel tanks for use onboard light duty four-wheel passenger road vehicles and heavy-duty road vehicles. Fuel tanks for other applications are to be added in the next editions.

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 9809-1:2010, *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 9809-2:2010, *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 14687-1, *Hydrogen fuel — Product specification —Part 1: All applications except proton exchange membrane (PEM) fuel cells for road vehicles*

ISO 14687-2[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* l *up to and including 150* l *— Part 3: Cylinders made of seamless stainless steel with an Rm value of less than 1100* 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, *Transportable gas cylinders — Refillable welded steel gas cylinders — Design and construction — Part 2: Stainless steel*

CSA HPRD-1: 2007, *Basic Requirements for Pressure Relief Devices for Compressed Hydrogen Vehicle Fuel Containers*

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*

1) To be published.

ASTM D 3418, *Standard Test Method for Transition Temperatures 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, which 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 so 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 more than 2% hydrogen by volume

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) and piping that contain hydrogen at the nominal 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 F.16 is not considered leakage.

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

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

3.17
nominal working pressure
settled pressure of compressed gas at a uniform temperature of 15 °C in a full fuel tank

3.18
over-wrap
reinforcement system of filament and resin applied over the liner

3.19
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 which will activate regardless of fuel tank pressure

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 which includes on-road exposure to environmental factors (road salt, acids, bases, temperature extremes) and expected usage (pressure cycles associated with filling and defilling 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 nominal working pressure

3.25
test pressure
required pressure applied during a pressure test

4 Categories of fuel tanks

4.1 Type of fuel

Fuel tanks shall be designated as per the type of fuel it is designed to store as follows:

H	Fuel tanks for hydrogen storage
M	Fuel tanks for hydrogen blends storage[3)]

3) The requirements for fuel tanks for hydrogen storage are covered in the main body of the standard. The specific requirements applicable to fuel tanks for hydrogen blends storage are defined in Annex A.

4.2 Nominal working pressure

Fuel tanks shall be designated by their nominal working pressure as follows:

25	Fuel tanks designed for a nominal working pressure of 25 MPa at 15 ºC
35	Fuel tanks designed for a nominal working pressure of 35 MPa at 15 ºC
70	Fuel tanks designed for a nominal working pressure of 70 MPa at 15 ºC

4.3 Type of service

Fuel tanks shall be designated for the type of service as follows:

A	fuel tanks designed for use on board light duty four-wheel passenger road vehicles
B	fuel tanks designed for use on board heavy-duty road vehicles such as buses and trucks

4.4 Designation

Fuel tanks shall be designated by this International standard number followed by a hyphen and the specified designations described in 4.1 to 4.3.

EXAMPLE A 35 MPa fuel tank for hydrogen storage designed to be used on heavy-duty vehicles is to be designated as follows: ISO 15869-H35B.

5 Service conditions

5.1 General

The specified service conditions provide the basis for the design, manufacturing, inspection, and testing of fuel tanks that are to be mounted on road 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 be qualified for use as road vehicle tanks, 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.

5.2 Maximum filling pressure

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

5.3 Filling cycles

The number of filling cycles shall be specified by the tank manufacturer in relationship with the manufacturer specified service life. In all cases, fuel tanks for service type A shall be designed for a minimum of 5500 cycles for a service life of 15 years. Fuel tanks of service type B shall be designed for a minimum of 11 250 cycles with a service life of 15 years, or a minimum of 15 000 cycles with a service life of 20 years.

NOTE Annex B provides further information on the number of filling cycles.

5.4 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.

5.5 Gas composition

Fuel tanks for fuel type H shall be designed to be filled with hydrogen that comply with the requirements of ISO 14687-1 or ISO 14687-2 as appropriate.

5.6 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 10.

5.7 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. Under no circumstances shall a thermally activated pressure relief device require the operation of the pressure-activated pressure relief device in order to function. Pressure relief devices shall meet the requirements of the CSA HPRD-1 standard.

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

6 Information to be recorded

6.1 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.

6.2 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) the designation of the tank as specified in 4.4;

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

d) a statement that the fuel tank design is suitable for use in the service conditions provided in Clause 5;

e) 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;

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

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

NOTE Annex C provides further information on the manufacturer's instructions for handling, use and inspection of tanks.

6.3 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) the designation of the tank as specified in 4.4;

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;

6.4 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 **Erreur ! Source du renvoi introuvable.**.

6.5 Material property data

The 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 5

6.6 Fire protection

The arrangement of the non-reclosing thermally activated pressure relief devices, and insulation if provided, that will protect the fuel tank from sudden rupture when exposed to the fire conditions in F.9 shall be specified by the fuel tank manufacturer.

6.7 Manufacturing data

Details of all fabrication processes, tolerances, non-destructive examinations, type tests, batch tests and production tests shall be specified and kept on file by the fuel tank manufacturer. The manufacturer shall specify the burst pressure range for the design. In no case shall the minimum specified burst pressure be less than the minimum burst pressure specified in this International Standard.

Surface finish, thread details, acceptance criteria for ultrasonic scanning (or equivalent), and maximum lot sizes for batch tests shall also be specified by the fuel tank manufacturer and kept on file.

7 Materials

7.1 Compatibility

The design shall not have incompatible materials in contact with each other. All metallic materials in contact with hydrogen shall be compatible with hydrogen per F.2.

NOTE Guidance on hydrogen compatibility can be found in the documents listed in the bibliography.

7.2 Steel

Steels for fuel tanks and liners shall conform to the materials requirements of 6.1 to 6.4 of ISO 9809-1:2010, or 6.1 to 6.3 of ISO 9809-2:2010, as appropriate. Welds shall not be permitted.

7.3 Stainless steels

Stainless steels shall conform to the materials requirements of 4.1 to 4.4 of EN 1964-3:2000. The following stainless steels shall be considered as suitable for use in hydrogen at pressures up to 100 MPa: UNS S31600 and UNS S31603 (equivalents include SUS316L, AISI316L, AISI316 and DIN1,4435). In all cases, stainless steel shall have a nickel mass fraction equal to or higher than 12 % and a volume fraction of magnetic phases of 0,1 % or less as measured by ferritiscope. Welds shall not be permitted.

7.4 Aluminium alloys

Aluminium alloys shall conform to the materials requirements of 6.1 and 6.2 of ISO 7866:1999. Welded aluminium alloys shall conform to the materials requirements of 4.2 and 4.3 of EN 12862:2000.

Aluminium alloys not covered by the materials requirements of ISO 7866:1999 may be used provided that hydrogen compatibility is demonstrated according to the method specified in F.2.

7.5 Resins

The material for impregnation may be thermosetting or thermoplastic resins. Examples of suitable matrix materials are epoxy, modified epoxy, polyester and vinylester thermosetting plastics, as well as polyethylene and polyamide thermoplastic.