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INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

Gaseous hydrogen and hydrogen blends — Land vehicule fuel tanks —

Part 5:
Particular requirements for fully wrapped composite tanks with non-metallic liner (Type 4)

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

Partie 5: Exigences particulières pour les réservoirs composites entièrement bobinés avec liner non métallique (Type 4)

ICS 43.060.40; 71.100.20

Member bodies are reminded to consult relevant national interests in each of the technical fields concerned [*Hidrogen technologies* (ISO/TC 197), *Gas cylinder* (ISO/TC 58/SC 3) and *Road vehicles* (ISO/TC 22) and before returning their ballot to the Central Secretariat.

To expedite distribution, this document is circulated as received from the committee secretariat. ISO Central Secretariat work of editing and text composition will be undertaken at publication stage.

In accordance with the provisions of Council Resolution 15/1993 this document is circulated in the English language only.

Conformément aux dispositions de la Résolution du Conseil 15/1993, ce document est distribué en version anglaise seulement.

Contents

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.

International Standard ISO 15869-5 was prepared by Technical Committee ISO/TC 197, *Hydrogen technologies*, and Technical Committee ISO/TC 58 Subcommittee SC 3, *Gas cylinder design*.

This is the first edition.

ISO 15869 consists of the following parts, under the general title *Gaseous hydrogen and hydrogen blends — Land vehicle fuel tanks*:

— *Part 1: General requirements*

— *Part 2: Particular requirements for metal tanks (type 1)*

— *Part 3: Particular requirements for hoop wrapped composite tanks with a metal liner (type 2)*

— *Part 4: Particular requirements for fully wrapped composite tanks with a metal liner (type 3)*

— *Part 5: Particular requirements for fully wrapped composite tanks with a non-metallic liner (type 4)*

Gaseous hydrogen and hydrogen blends — Land vehicle fuel tanks —

Part 5:
Particular requirements for fully wrapped composite tanks with non-metallic liner (Type 4)

1 Scope

This part of ISO 15869 defines the specific aspects of fully wrapped composite fuel tanks with a non-metallic liner used for the on-board storage of high pressure compressed gaseous hydrogen or hydrogen blends. It modifies or supplements the common aspects that are defined in ISO 15869-1.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 15869. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 15869 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 15869-1: *Gaseous hydrogen and hydrogen blends — Land vehicle fuel tanks — Part 1: General requirements*

3 Terms and definitions

For the purposes of this part of ISO 15869, the terms and definitions given in ISO 15869-1 apply.

4 General requirements

Tanks conforming to this part of ISO 15869 shall meet the general requirements specified in ISO 15869-1. Should there be a conflict between this part of ISO 15869 and ISO 15869-1, the requirements specified in this part of ISO 15869 shall prevail.

5 Materials

5.1 General

Materials used shall be suitable for the service conditions specified in ISO 15869-1, clause 4. The design shall not have incompatible materials in contact.

5.2 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 material.

The glass transition temperature of the resin material shall be determined in accordance with ASTM D 3418-97.

5.3 Fibres

Structural reinforcing filament material types shall be glass fibre, aramid fibre or carbon fibre. If carbon fibre reinforcement is used, the design shall incorporate means to prevent galvanic corrosion of metallic components of the tank.

The tank manufacturer shall keep on file for the intended life of the tank design the published specifications for composite materials, the material manufacturer's recommendations for storage, conditions and shelf life. The tank manufacturer shall keep on file, for the intended life of each batch of tanks, the fibre manufacturer's certification that each shipment conforms to the manufacturer's specifications for the product.

5.4 Plastic liners

The polymeric material shall be compatible with the service conditions specified in ISO 15869-1, clause 4.

5.5 Metal end bosses

The metal end bosses connected to the non-metallic liner shall be of a material compatible with the service conditions specified in ISO 15869-1, clause 4.

6 Design requirements

6.1 General

The design shall ensure a «leakage before break» failure mode under feasible degradation of pressure parts during normal service.

NOTE This part of ISO 15869 does not provide design formulas nor permissible stresses or strains, but requires the adequacy of the design to be established by appropriate calculations and demonstrated by tanks being capable of consistently passing the materials, prototype and batch tests as well as the tests on every tank specified in this part of ISO 15869.

6.2 Test pressure

The minimum test pressure used in manufacture shall be 1,5 times working pressure.

6.3 Burst pressure and fibre stress ratio

The minimum actual burst pressure shall not be less than the values given in Table 1. The composite over-wrap shall be designed for high reliability under sustained loading and cyclic loading. This reliability shall be achieved by meeting or exceeding the composite reinforcement stress ratio values given in Table 1.

For designs conforming to this part of ISO 15869, the stress ratio is equal to the burst ratio.

Verification of the stress ratios may also be performed using strain gauges. An acceptable method is outlined in ISO 15869-1, Annex A.

When analyzing tanks with hybrid reinforcement (two or more different fibres), consideration shall be given to the load share between the different fibres based on the different elastic modulii of the fibres. The stress ratio requirements for each individual fibre type shall be in accordance with the values given in Table 1.

Table 1 — Minimum actual burst pressure and stress ratios

Fibre type	Stress ratio	Burst pressure
Glass	3,65	3,65 times working pressure[a]
Aramid	3.10	3,10 times working pressure
Carbon	2,35	2,35 times working pressure
Hybrid	[b]	

[a] Minimum actual burst pressure. In addition, calculations shall be performed in accordance with 6.3 to confirm that the minimum stress ratio requirements are also met.

[b] Stress ratios and burst pressures shall be calculated in accordance with 6.3.

6.4 Stress analysis

A stress analysis shall be performed to justify the minimum design wall thickness. It shall include the determination of the stresses in fibres of composite designs.

The stresses in the composite shall be calculated in the tangential and longitudinal direction of the tank. The pressures used for these calculations shall be zero pressure, working pressure, test pressure and design burst pressure. The calculations shall use suitable analysis techniques to establish stress distribution throughout the tank.

6.5 Fire protection

The tank, its materials, pressure relief devices and any added insulation or protective material shall be designed collectively to ensure adequate safety during fire conditions in the test specified in 8.1.5. A manufacturer may specify alternative pressure relief device locations for specific land vehicle installations to optimize safety considerations.

7 Construction and workmanship

7.1 General

The composite tank shall be fabricated from a liner over-wrapped with continuous filament windings. Fibre winding operations shall be computer or mechanically controlled. The fibres shall be applied under controlled tension during winding. After winding is complete, thermosetting resins shall be cured by heating, using a predetermined and controlled time-temperature profile.

7.2 Neck threads

Threads shall be clean cut, even, without surface discontinuities, to gauge, and conform to international standards.

7.3 Curing of thermosetting resins

The curing temperature for thermosetting resins shall be at least 10 °C below the softening temperature of the plastic liner. During the curing, the curing cycle (i.e. the time-temperature profile) shall be documented and retained by the tank manufacturer for the intended life of each batch of tanks.

7.4 Exterior environmental protection

The exterior of tanks shall meet the requirements of the chemical exposure test of ISO 15869-1, clause C.10. Exterior protection may be provided by using any of the following:

a) a surface finish giving adequate protection (e.g. metal sprayed on aluminium, anodizing); or

b) the use of a suitable fibre and matrix material (e.g. carbon fibre in resin); or

c) a protective coating (e.g. organic coating, paint). If exterior coating is part of the design, the requirements of ISO 15869-1, clause C.7 shall be met; or

d) a covering impervious to the chemicals of ISO 15869-1, clause C.10.

Any coatings applied to tanks shall be such that the application process does not adversely affect the mechanical properties of the tank. The coating shall be designed to facilitate subsequent in-service inspection and the manufacturer shall provide guidance on coating treatment during such inspection to ensure the continued integrity of the tank.

8 Prototype testing

8.1 Qualification testing of new designs

8.1.1 Material tests for plastic liners

One liner shall be subjected to the following tests:

a) The tensile yield strength and ultimate elongation shall be determined in accordance with ISO 15869-1, clause C.21 and shall meet the requirements therein.

b) The softening temperature shall be determined in accordance with ISO 15869-1, clause C.20 and shall meet the requirements therein.

8.1.2 Hydrostatic burst pressure test

Three tanks shall be hydrostatically pressurized to failure in accordance with ISO 15869-1, clause C.14. The tank burst pressure shall exceed the specified minimum burst pressure specified in Table 1, and in no case be less than the value necessary to meet the stress ratio requirements of 6.3.

8.1.3 Ambient temperature pressure cycling test

Two tanks shall be pressure cycle tested at ambient temperature in accordance with ISO 15869-1, clause C.2 and meet the requirements therein.

8.1.4 Leak-Before-Break (LBB) test

Three tanks shall be tested in accordance with ISO 15869-1, clause C.15 and shall meet the requirements therein.

8.1.5 Bonfire test

One or two tanks as appropriate shall be tested in accordance with ISO 15869-1, clause C.3 and meet the requirements therein.

8.1.6 Penetration test

One tank shall be tested in accordance with ISO 15869-1, clause C.17 and meet the requirements therein.

8.1.7 Chemical exposure test

One tank shall be tested in accordance with ISO 15869-1, clause C.10 and meet the requirements therein.

8.1.8 Composite flaw tolerance test

One tank shall be tested in accordance with ISO 15869-1, clause C.8 and meet the requirements therein.

8.1.9 Accelerated stress rupture test

One tank shall be tested in accordance with ISO 15869-1, clause C.1 and meet the requirements therein.

8.1.10 Extreme temperature pressure cycling

One tank shall be tested in accordance with ISO 15869-1, clause C.11 and meet the requirements therein.

8.1.11 Resin shear strength

One sample coupon representative of the composite overwrap shall be tested in accordance with ISO 15869--1, clause C.19**.** Resin materials shall meet the requirements therein.

8.1.12 Drop test

One (or more) finished tanks shall be drop tested in accordance with ISO 15869-1, clause C.9 and meet the requirements therein.

8.1.13 Boss torque test

One tank shall be tested in accordance with ISO 15869-1, clause C.4 and meet the requirements therein.

8.1.14 Permeation test

One tank shall be tested for permeation in accordance with ISO 15869-1, clause C.18 and meet the requirements therein.

8.1.15 Hydrogen gas cycling test

One tank shall be tested in accordance with ISO 15869-1, clause C.13 and meet the requirements therein.

8.2 Minor design changes

Minor design changes may be qualified through the reduced test program specified in Annex A.

9 Batch tests

9.1 General requirements

Batch tests shall be carried out on each batch of tanks.