INTERNATIONAL STANDARD

ISO 13985

First edition
2006-11-01

Liquid hydrogen — Land vehicle fuel tanks

Hydrogène liquide — Réservoirs de carburant pour véhicules terrestres

Reference number
ISO 13985:2006(E)

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Published in Switzerland

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Foreword

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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.

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ISO 13985 was prepared by Technical Committee ISO/TC 197, *Hydrogen technologies*.

Introduction

The fuel tanks described in this International Standard are intended to be used in conjunction with the fuelling system interface described in ISO 13984.

Liquid hydrogen — Land vehicle fuel tanks

1 Scope

This International Standard specifies the construction requirements for refillable fuel tanks for liquid hydrogen used in land vehicles as well as the testing methods required to ensure that a reasonable level of protection from loss of life and property resulting from fire and explosion is provided.

This International Standard is applicable to fuel tanks intended to be permanently attached to land vehicles.

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 188:1998, *Rubber, vulcanized or thermoplastic — Accelerated ageing and heat resistance tests*

ISO 1431-1, *Rubber, vulcanized or thermoplastic — Resistance to ozone cracking — Part 1: Static and dynamic strain testing*

ISO 2768-1, *General tolerances — Part 1: Tolerances for linear and angular dimensions without individual tolerance indications*

ISO 6957, *Copper alloys — Ammonia test for stress corrosion resistance*

ISO 9227, *Corrosion tests in artificial atmospheres — Salt spray tests*

ISO 13984, *Liquid hydrogen — Land vehicle fuelling system interface*

ISO 21010, *Cryogenic vessels — Gas/materials compatibility*

ISO 21013-3, *Cryogenic vessels — Pressure-relief accessories for cryogenic service — Part 3: Sizing and capacity determination*

ISO 21014, *Cryogenic vessels – Cryogenic insulation performance*

ISO 21028-1, *Cryogenic vessels — Toughness requirements for materials at cryogenic temperature — Part 1: Temperatures below –80 °C*

ISO 21029-1:2004, *Cryogenic vessels — Transportable vacuum insulated vessels of not more than 1 000 litres volume — Part 1: Design, fabrication, inspection and tests*

ISO 23208, *Cryogenic vessels — Cleanliness for cryogenic service*

3 Terms and definitions

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

3.1
accessory
device fixed directly to the inner tank or outer jacket of a fuel tank such as a pressure relief valve, shut-off valve, non-return valve or level gauge

3.2
boil-off management system
system that controls the boil off of gas under normal conditions

3.3
burst pressure
pressure that causes the rupture of a pressure vessel subjected to a constant increase of pressure during a destructive test

3.4
design temperature
temperature of the inner tank, the outer jacket and all other accessories to which fabrication drawings, inspections and physical measurements such as volume are referred

3.5
fuel tank
vessel used for the storage of cryogenic hydrogen

3.6
hydrogen conversion system
system designed for the consumption of hydrogen for energy transformation

3.7
impermissible fault range
pressure range within which an unwanted event is to be expected (see Annex A)

3.8
inner tank
part of the fuel tank that contains liquid hydrogen

3.9
level gauge
device that measures the level of liquid hydrogen in the fuel tank

3.10
maximum allowable working pressure
MAWP
maximum pressure to which a component is designed to be subjected to and which is the basis for determining the strength of the component under consideration

3.11
normal operating range
range planned for the process values (see Annex A)

NOTE In the case of inner tanks, the normal operating range of the inner tank pressure is from 0 MPa to the set pressure of the primary pressure relief valve, which is lower than or equal to the MAWP of the inner tank.

3.12
outer jacket
part of the fuel tank that encases the inner tank(s) and its insulation system

3.13
outer pressure
pressure acting on the outside of the inner tank or outer jacket

3.14
permissible fault range
range between the normal operating range and the impermissible fault range (see Annex A)

3.15
pressure
gauge pressure against atmospheric pressure, unless otherwise stated

3.16
thermal autonomy
time of the pressure increase in the inner tank measured from a starting pressure of 0 MPa at the corresponding boiling point of hydrogen (–253 °C) up to MAWP of the inner tank

NOTE The thermal autonomy is a measure of the quality of the insulation of the fuel tank.

4 Requirements

4.1 General requirements

The fuel tank and its accessories shall function in a correct and safe way. It shall withstand and remain gas tight when subjected to the mechanical, thermal and chemical stresses specified in this International Standard.

4.2 Mechanical stresses

4.2.1 Inner/outer pressure

4.2.1.1 Inner tank

The inner tank shall be designed to resist the following inner test pressure:

$$p_{test} = 1{,}3\ (\text{MAWP} + 0{,}2)$$

where

p_{test} is the test pressure, expressed in megapascals (MPa);

MAWP is the maximum allowable working pressure of the inner tank, expressed in megapascals (MPa).

The inner tank and its accessories shall be designed to resist an outer pressure of 0,2 MPa.

4.2.1.2 Outer jacket

The outer jacket shall be designed to resist an outer pressure of 0,2 MPa.

4.2.2 Accelerations

4.2.2.1 General

The fuel tank and its accessories shall be mounted and protected so that the accelerations shown in Table 1 can be absorbed without structural damage to the fuel tank and its accessories. No uncontrolled release of hydrogen is permitted.

Table 1 — Accelerations

Vehicle categories	Accelerations
Vehicles of categories M_1 and N_1	20 g in the direction of travel 8 g horizontally perpendicular to the direction of travel
Vehicles of categories M_2 and N_2	10 g in the direction of travel 5 g horizontally perpendicular to the direction of travel
Vehicles of categories M_3 and N_3	6,6 g in the direction of travel 10 g horizontally perpendicular to the direction of travel

The vehicle categories include the following:

— Category M_1: Vehicles used for the transportation of passengers and comprising not more than eight seats in addition to the driver's seat.

— Category M_2: Vehicles used for the transportation of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum mass that does not exceed 5 000 kg.

— Category M_3: Vehicles used for the transportation of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum mass exceeding 5 000 kg.

— Category N_1: Vehicles used for the transportation of goods and having a maximum mass that does not exceed 3 500 kg.

— Category N_2: Vehicles used for the transportation of goods and having a maximum mass exceeding 3 500 kg, but not exceeding 12 000 kg.

— Category N_3: Vehicles used for the transportation of goods and having a maximum mass exceeding 12 000 kg.

4.2.2.2 Inner and outer support

When exposed to the accelerations described in Table 1, the stress in the support elements shall not exceed 50 % of the minimum ultimate tensile strength of the material (R_m, calculated according with the linear stress model).

The allowable stress in the support elements may not have to be calculated if it can be demonstrated that the fuel tank supports the accelerations given in Table 1 without any structural damage to the inner tank or its supports.

4.3 Thermal stresses

4.3.1 Design temperature

The design temperature of the inner tank, the outer jacket and the accessories shall be 20 °C. In addition, the inner tank, the outer jacket and the accessories shall be designed to withstand a temperature range from the lowest to the highest possible operating temperatures that will be encountered in service.

4.3.2 Ambient temperature

The fuel tank shall be designed to withstand ambient temperatures ranging from –40 °C to 85 °C. If the fuel tank is to be installed in areas of internal heat sources such as the internal combustion engine compartment of a vehicle, the fuel tank shall be designed for an ambient temperature of 120 °C, or a lower value if substantiated by calculations.

4.3.3 Operating temperature

The thermal stresses produced by the operating conditions shall be considered. The inner vessel and the other components that may be in contact with liquid hydrogen shall be designed to operate at –253 °C.

4.4 Materials

The materials of the fuel tank and its accessories shall be compatible, as applicable, with:

a) hydrogen;

b) other media and fluids found in a land vehicle environment, such as coolants and battery acid.

NOTE Recommendations for lowering the susceptibility to hydrogen embrittlement are given in Annex B.

Materials used at low temperatures shall meet the toughness requirements of ISO 21028-1. For non-metallic materials, low temperature suitability shall be validated by an experimental method, taking into account the service conditions.

The materials used for the outer jacket shall ensure the integrity of the insulation system, and their elongation at fracture, at the temperature of liquid nitrogen, shall be at least 12 %.

A corrosion allowance does not need to be added for the inner tank. A corrosion allowance does not need to be added on other surfaces, if they are protected against corrosion.

For welded vessels, welds shall have properties equivalent to those specified for the parent material for all temperatures that the material may encounter.

4.5 Design

4.5.1 Design validation

The design of the fuel tank shall be validated in accordance with the design options specified in 10.1 of ISO 21029-1:2004.

4.5.2 Inner tank and outer jacket

Unless the design is validated as per option 10.1.3 of ISO 21029-1:2004, the design of the inner tank and the outer jacket shall meet all the design rules specified in 10.3 of ISO 21029-1:2004. If the design is validated as per option 10.1.3 of ISO 21029-1:2004, the exceptions specified in 10.1.3 of ISO 21029-1:2004 shall apply.

Unless indicated otherwise, the general tolerances of ISO 2768-1 shall apply.

4.6 Insulation

4.6.1 General requirements

The insulation system installed on a fuel tank shall meet the requirements of ISO 21014.

Except in the vicinity of the pressure relief valves, no ice shall form on the outer wall of the fuel tank under normal operating conditions.

When exposed to fire as per 5.3, the thermal autonomy of the fuel tank, equipped with vacuum insulation and fire protection measures (if present), shall be at least 5 min.

The insulation of the accessories shall prevent liquefaction of the air in contact with the outer surfaces, unless a system is to be provided for collecting and vaporizing the liquefied air. If such a system is to be used, the materials of accessories shall be compatible with an atmosphere enriched with oxygen according to ISO 21010.