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Date: 22 August 2025

Origin: International

Latest date for receipt of comments: 15 October 2025

Project No. 2022/02994

Responsible committee: GSE/6

Interested committees:

Title: Draft BS ISO 13985 Liquid hydrogen — Land vehicle fuel storage system.

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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

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Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



DRAFT International Standard

ISO/DIS 13985

Liquid hydrogen — Land vehicle fuel storage system

ICS: 43.060.40; 27.075

ISO/TC 197

Secretariat: **SCC**

Voting begins on:
2025-08-22

Voting terminates on:
2025-11-14

This document is circulated as received from the committee secretariat.

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Published in Switzerland

Contents

Page

Foreword	v
Introduction	vi
1 Scope	1
2 Normative references	1
3 Terms and definitions	2
4 General requirements	5
5 Service conditions	7
5.1 Mechanical loads	7
5.1.1 Inner container	7
5.1.2 Vacuum jacket	8
5.1.3 Accelerations	8
5.1.4 Vibrations	8
5.2 Thermal conditions	8
5.2.1 Ambient temperature	8
5.2.2 Liquid hydrogen temperature	9
5.3 Vehicle environmental conditions	9
6 Material requirements	9
6.1 Metallic materials	9
7 Design requirements	9
7.1 LHSS design	9
7.2 Inner container design	10
7.3 Vacuum jacket	10
7.4 Insulation	10
7.4.1 Getters/adsorbents	10
7.5 LHSS functions related to closure components	10
7.5.1 Inner container primary closure valves	11
7.5.2 Consideration of LH2 induced thermo-mechanical stress	12
7.5.3 Pressure maintaining system	12
7.5.4 Protection of the vacuum jacket	12
7.6 Manufacturing and assembly	12
8 Design qualification tests	12
8.1 LHSS functional performance test sequence	13
8.2 LHSS fire test	13
8.3 LHSC performance durability test	13
8.4 Reduced design qualification tests for changes of design	13
8.5 LHSS fuel system component type tests	15
9 Production and inspection tests	15
9.1 General	15
9.2 Proof pressure test	15
9.3 Leakage test	16
9.4 Destructive and non-destructive tests of welded joints	16
9.5 Visual inspection	16
9.6 Repairs and repetition of tests	16
9.7 Documentation of production tests	16
10 Marking and labelling	16
10.1 Marking method	16
10.2 LHSS markings	16
10.3 Temporary markings for first filling	17
Annex A (normative) LHSS operating ranges	18
Annex B (informative) Hydrogen compatibility	20

Annex C (normative) LHSS design qualification tests.....	21
Bibliography.....	38

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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 197, Hydrogen Technologies.

This second edition cancels and replaces the first edition (ISO 13985:2006), which has been technically revised.

The main changes are as follows:

- General revision harmonizing with other standard and regulatory documents as appropriate
- Applying newest state of the art and research results on LH2 safety
- Adding dedicated type of LH2 containers designed the LH2 fuelling process defined in ISO 13984:2026

A list of all parts in the ISO 13985 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The fuel storage systems described in this International Standard are intended to be used in conjunction with the fuelling protocols described in ISO 13984 and the fuelling connector shall comply with an applicable LH2 connector standard and have an appropriate MAWP for the application. If no such a standard is available, the latest state of the art shall be considered.

Parts of this document are based on UN GTR 13^[1] liquid part and further parts are based on UN GTR 13^[1] gaseous part with appropriate modifications.

Liquid hydrogen — Land vehicle fuel storage system

1 Scope

This document contains requirements for the design, testing, inspection and marking of serially produced, refillable storage systems intended only for liquid hydrogen for land vehicle operation. These storage systems

- a) are permanently attached to the vehicle,
- b) are vacuum insulated,
- c) have a hydrogen pressure retaining structure and vacuum enclosure consisting of metallic materials.

The scope of this document is limited to fuel storage systems containing fuel cell grade hydrogen according to ISO 14687 type II grade D. The content is mainly focused on heavy duty vehicles for road operation but may also be applied to on-board fuel storage systems for other road vehicles, industrial and other land vehicles with due consideration of appropriate service conditions.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 188:2011, *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 4126-1, *Safety devices for protection against excessive pressure — Part 1: Safety valves*

ISO 4126-10, *Safety devices for protection against excessive pressure — Part 10: Sizing of safety valves and bursting discs for gas/liquid two-phase flow*

ISO 6270-2:2017, *Paints and varnishes — Determination of resistance to humidity*

ISO 9001, *Quality management systems — Requirements*

ISO/TR 15916, *Basic considerations for the safety of hydrogen systems*

ISO 16750, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment*

ISO 13984, *Liquid hydrogen — Land vehicle fuelling protocols*

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

ISO 21013-1, *Cryogenic vessels — Pressure-relief accessories for cryogenic service — Part 1: Reclosable pressure-relief valves*

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 21029-1:2019, *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.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

automatic shut-off valve

ASOV

actuated valve between inner container and the remaining vehicle fuel system that must default to stop the flow of hydrogen from the inner container when not connected to a power source

3.2

boil-off valve

BOV

valve that vents the excess hydrogen gas pressure (boil-off gas) at a setting below the container's first pressure relief valve setting

3.3

boil-off converter

BOC

system that converts boil-off hydrogen to water and heat to prevent hydrogen discharge and associated risks of generating flammable atmospheres around the vehicle

3.4

burst disc

non-reclosing operating part of a pressure relief device which, when installed in the device, is designed to burst at a predetermined pressure to permit the discharge of hydrogen

3.5

burst pressure

highest pressure reached in an inner container during a burst test

3.6

check valve

valve which allows fluid to flow in only one direction

3.7

commissioning and recommissioning

procedures to prepare a liquid hydrogen storage system before entering or returning to operation

3.8

date of manufacture

date (month and year) of the final inspection test carried out by the manufacturer

3.9

discharge line

components attached to the exhaust port of pressure relief devices or pressure relief valves or other devices releasing gas

3.10

external leakage

leakage from any pressure-retaining chamber to atmosphere, or to any chamber venting to atmosphere

3.11

fuel system components

components of a liquid hydrogen storage system that are fixed directly to the inner container or vacuum jacket such as a pressure relief valve, shut-off valve or non-return valve

3.12

getter material

a reversible or non-reversible, gas and /or moisture adsorbent

3.13

holding time of a liquid hydrogen storage system

time elapsed, for a specified degree of filling of a liquid hydrogen storage system, from establishing the initial filling condition until the pressure has risen, due to heat leak, to the set pressure of the lowest set pressure-limiting device

Note 1 to entry: The holding time is a measure of the insulation performance of the liquid hydrogen storage system.

3.14

hydrogen concentration

percentage of the hydrogen moles (or molecules) within the mixture of hydrogen and air (equivalent to the partial volume of hydrogen gas).

3.15

hydrogen conversion system

Power conversion system that creates mechanical energy, electric energy or heat by oxidizing the hydrogen to water or water vapor (e.g., hydrogen powertrain, power take-off or cabin heating).

Note 1 to entry: Hydrogen conversion systems do not include boil-off converters.

3.16

initial burst pressure

burst pressure (3.5) at the beginning of the LHSS life

3.17

inner container

component of the LHSC that stores the primary volume of liquid hydrogen in a single chamber or multiple interconnected chambers

3.18

internal leakage

leakage from one pressure-retaining chamber to another, where both are intended to contain pressure during normal operation

3.19

liquid hydrogen storage container

LHSC

vacuum insulated container used for the storage of cryogenic hydrogen including inner container, vacuum jacket, insulation materials and getter materials

3.20

liquid hydrogen storage system

LHSS

system that stores the liquid hydrogen, allows its fuelling from a dispenser, allows its feeding to a hydrogen conversion system and maintains integrity and safety. It is composed of the liquid hydrogen storage container(s), pressure relief devices, shut-off devices, check-valves, boil-off valve, interconnection piping and fittings between the above components, on-board a vehicle

3.21

manual shut-off valve

an on-off valve that is operated by a person to start, control, and stop flow of a gas or fluid

3.22

maximum allowable working pressure

MAWP

is the highest pressure to which a component or liquefied hydrogen storage system is permitted to operate

3.23

maximum fuelling pressure

MFP

maximum pressure expected during a normal (fault-free) vehicle fuelling

3.24

maximum operating pressure

MOP

highest pressure that is expected for a component or system during normal operation including anticipated transients

3.25

minimum supply pressure

lowest pressure within the inner container during supply to the consumer

3.26

nozzle

device connected to a fuel dispensing system, which permits the quick connect and disconnect of fuel supply to the vehicle or storage system

3.27

overpressure

pressure increase over the set pressure

Note 1 to entry: Overpressure is usually expressed as a percentage of the set pressure.

[SOURCE: ISO 4126-1:2013, 3.7]

3.28

pressure

gauge pressure against atmospheric pressure, unless otherwise stated

3.29

pressure cycle

change of pressure from minimum supply pressure to the boil-off valve set-pressure and back to minimum supply representing pressure changes due to refuelling and during parking over the service life

3.30

pressure relief device

PRD

reclosable or non-reclosable safety device that releases gases or liquids above a specified pressure value in cases of emergency or abnormal conditions

3.31

pressure relief valve

PRV

reclosing type of pressure relief device that opens to relieve pressure at a pre-determined upstream pressure

3.32

primary closure valve

any device that separates the inner container from the remaining of the liquefied hydrogen vehicle fuel system or external environment

3.33

receptacle

device from the vehicle fuel system which receives the nozzle

3.34

relieving pressure

pressure used for the sizing of a safety valve which is greater than or equal to the set pressure plus overpressure

[SOURCE: ISO 4126-1:2013, 3.10]

3.35

residual burst pressure

burst pressure ([3.5](#)) at the end of the LHSS life or after a performance durability test sequence

3.36

rupture / burst

Structural failure of a shell resulting in a sudden release of stored energy.

3.37

service life

indicates the time frame during which service (usage) is authorized.

3.38

set pressure

predetermined pressure at which a safety valve under operating conditions commences to open

Note 1 to entry: It is the gauge pressure measured at the valve inlet at which the pressure forces tending to open the valve for the specific service conditions are in equilibrium with the forces retaining the valve disc on its seat.

[SOURCE: ISO 4126-1:2013, 3.5]

3.39

thermal insulation

vacuum interspace between the inner container and the vacuum jacket

Note 1 to entry: The space may or may not be filled with material to reduce the heat transfer between the inner container and the vacuum jacket.

3.40

vacuum jacket

gas-tight enclosure that contains the inner container and enables the vacuum to be established

3.41

vehicle fuel system

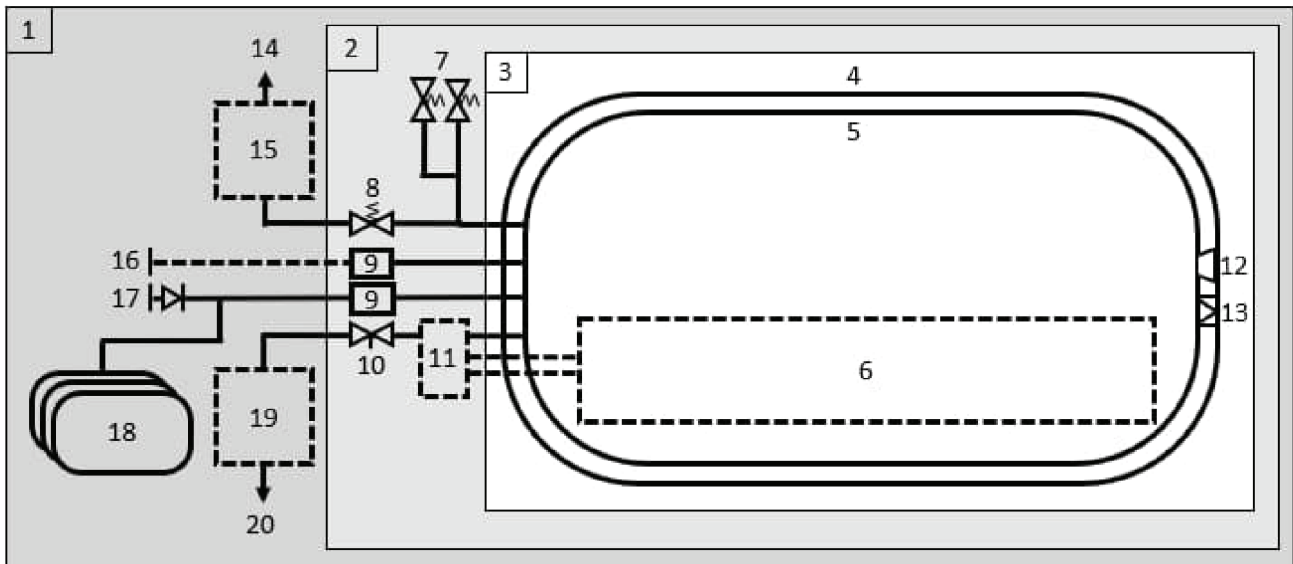
VFS

complete LH2 storage system in the vehicle consisting of one or more LHSS, receptacle, inlet and outlet valves, interconnecting lines, control system and additional safety devices.

Note 1 to entry: The system boundary to the hydrogen conversion system is individually defined by the vehicle manufacturer.

4 General requirements

The LHSS consists of the LHSC and all primary closure devices, which define the boundaries of the LHSS. The LHSC consists of the inner container assembled with the vacuum jacket. All components within the LHSS are subject to this International Standard. [Figure 1](#) shows a typical LHSS, including a LHSC and different types of primary closures, embedded in a typical VFS. Actual LHSS and VFS will differ in their configurations and included type and number components, hence [figure 1](#) is not intended to limit any other system design option.

**Key**

1	vehicle fuel system (VFS)	11	additional external fuel system components
2	liquid hydrogen storage system (LHSS)	12	vacuum plug
3	liquid hydrogen storage container (LHSC)	13	vacuum pressure relief device
4	vacuum jacket	14	to discharge
5	inner container	15	boil-off converter (BOC; optional)
6	additional internal fuel system components	16	fuelling return line
7	pressure relief devices (PRD)	17	fuelling receptacle
8	boil-off valve (BOV)	18	other LHSS
9	primary closure valve ¹	19	other valves
10	automatic shut-off valve (ASOV)	20	to hydrogen conversion systems

Footnotes:

⁽¹⁾ Primary closure valve type depending on fuelling process and manufacturer definition.

Figure 1 — Typical LHSS as part of a VFS

The primary closure devices have a function to insulate the primary volume of stored liquid hydrogen to remainder of the VFS and the environment and shall only allow flow of hydrogen from the inner container according to their specific functions. The LHSS shall include the following primary closure devices:

- Automatic shut-off valve (ASOV),
- Check valve (CV),
- Boil-off valve (BOV),
- First pressure relief valve (PRV),
- Second pressure relief device (PRD).

The functions of a), b) and/or c) may be combined in one or more primary closure devices. The functions of the first PRV d) and second PRD e) shall each be provided in fully separate devices and none of the PRD functions shall be combined with the functions a), b, or c).

A boil-off converter may be installed in the VFS depending on the vehicle type, operational requirements and regional legislative requirements.