International Standard

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Second edition
2026-03

Liquid hydrogen — Land vehicle fuelling protocol

Hydrogène liquide — Protocole des systèmes de remplissage pour véhicules terrestres

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Foreword

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

This second edition cancels and replaces the first edition (ISO 13984:1999), which has been technically revised.

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The main changes are as follows:

— updated scope;

— updated normative references and definitions;

— alignment with common ISO 19880-1 requirements;

— technical requirements moved to annexes;

— introduction of fuelling process and protocol details;

— addition of supporting annexes.

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.

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Introduction

While the focus of this document is liquid hydrogen fuelling protocols, some technical requirements for the dispensing system and the fuelling station are also included. This is done to ensure:

a) the fuelling protocols can be implemented safely and with adequate equipment;

b) the content of the previous edition of this document (ISO 13984:1999) has been reviewed and adapted when relevant.

This document has been prepared in coordination with the revision of ISO 13985[1)]. The fuelling protocols described in this document and the liquid hydrogen storage systems built according to ISO 13985 are thus intended to work together.

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1) Stage at the time of publication: ISO/DIS 13985:2025.

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Liquid hydrogen — Land vehicle fuelling protocol

1 Scope

This document specifies fuelling protocols for liquid hydrogen (LH_2), defining the minimum design, installation and operation requirements for a safe, as well as fast, efficient and interoperable hydrogen transfer from the fuelling station to the vehicle fuel system.

This document applies to land vehicles of all types equipped with a liquid hydrogen storage system in accordance with ISO 13985. The protocols described in this document are currently limited to vehicles with storage system total internal volume equal to or comprised between 0,6 m^3 and 4 m^3. The requirements specified in this document are also applicable to further hydrogen applications, however, further specific requirements that can be necessary for the safe operation of such fuelling are not addressed in this document.

This document specifies the requirements for liquid hydrogen fuelling and dispensing systems, fuelling station - vehicle interface and vehicle storage system in order to minimise the risk of fire, explosion or any other hydrogen adverse effects to an acceptable level, especially during and after the fuelling process.

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.

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ISO 7369, *Pipework — Metal hoses and hose assemblies — Vocabulary*

ISO 10286, *Gas cylinders — Vocabulary*

ISO 10893-4, *Non-destructive testing of steel tubes — Part 4: Liquid penetrant inspection of seamless and welded steel tubes for the detection of surface imperfections*

ISO 10893-6, *Non-destructive testing of steel tubes — Part 6: Radiographic testing of the weld seam of welded steel tubes for the detection of imperfections*

ISO 10893-7, *Non-destructive testing of steel tubes — Part 7: Digital radiographic testing of the weld seam of welded steel tubes for the detection of imperfections*

ISO 10893-8, *Non-destructive testing of steel tubes — Part 8: Automated ultrasonic testing of seamless and welded steel tubes for the detection of laminar imperfections*

ISO 10893-10, *Non-destructive testing of steel tubes — Part 10: Automated full peripheral ultrasonic testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of longitudinal and/or transverse imperfections*

ISO 11484, *Steel products — Employer's qualification system for non-destructive testing (NDT) personnel*

ISO/DIS 13985:2025, *Liquid hydrogen — Land vehicle fuel tanks*

ISO 14687, *Hydrogen fuel quality — Product specification*

ISO 17636 (all parts), *Non destructive testing of welds — Radiographic testing*

ISO 19880-1:2020, *Gaseous hydrogen — Fuelling stations — Part 1: General requirements*

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

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ISO 21013-2, *Cryogenic vessels — Pressure-relief accessories for cryogenic service — Part 2: Non-reclosable pressure-relief devices*

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

IEC 60079-14, *Explosive atmospheres - Part 14: Electrical installations design, selection and erection*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 7369 and ISO 10286 and the following 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
ambient temperature
unregulated temperature of the air

3.2
backgas
gaseous hydrogen flowing back from the vehicle to the *fuelling station* (3.19) during the *fuelling process* (3.17)

3.3
breakaway device
device on the *fuelling hose* (3.15) that disconnects the hose from the *dispenser* (3.7) or the vehicle when a tension, load, stress or displacement limit is exceeded and blocks the flow of hydrogen from the dispenser, e.g. if the vehicle moves away with the fuelling hose connected to the vehicle

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3.4
check-valve
valve which allows fluid to flow in only one direction

3.5
control valve
valve electronically or pneumatically controlled that enables and disables the hydrogen flow

Note 1 to entry: The control system provides necessary inputs and signals to the valve.

3.6
connector
matching parts (such as male and female parts) that can be put together to form a “connection” which permits the transfer of fluids, electric power, or control signals

[SOURCE: ISO 19880-1:2020, 3.12, modified — Notes to entry have been removed.]

3.7
dispenser
equipment in the *dispensing system* (3.9), including the *dispenser cabinet(s)* (3.8) and support structure, that is physically located in the fuelling area

Note 1 to entry: The hydrogen dispenser typically includes, as a minimum, the *fuelling assembly* (3.14), required temperature and pressure instrumentation, filters, and the user interface to conduct vehicle fuelling.

Note 2 to entry: The manufacturer of the hydrogen dispenser can elect to include additional equipment in the dispenser, including the possibility of all equipment in the dispensing system.

[SOURCE: ISO 19880-1:2020, 3.13]

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3.8
dispenser cabinet
protective *housing* (3.23) that encloses process piping and can also enclose measurement, control and ancillary *dispenser* (3.7) equipment

[SOURCE: ISO 19880-1:2020, 3.14]

3.9
dispensing system
system downstream of the hydrogen supply system comprising all equipment necessary to carry out the vehicle fuelling operation, through which the liquid hydrogen is supplied to the vehicle and which transferred quantity may be measured

Note 1 to entry: The supply system includes the *fuelling station storage tank* (3.39) and other associated equipment to bring the hydrogen to the appropriate pressure and temperature.

3.10
enclosure
structure, protective *housing* (3.22), container, machine cabinet, etc. which encloses or partially encloses equipment of a station that may have access for maintenance but is not intended to be occupied

[SOURCE: ISO 19880-1:2020, 3.18, modified — Notes to entry have been removed.]

3.11
factory acceptance testing
FAT
tests performed in the factory on *fuelling station* (3.19) equipment or systems to verify functionality and/or integrity prior to shipment to the site, (or an appropriate alternative type acceptance methodology)

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[SOURCE: ISO 19880-1:2020, 3.21]

3.12
mass flowrate
flowrate measured in g/s unless otherwise stated

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3.13
fuelling
transfer of hydrogen fuel from the *fuelling station* (3.19) to the *LHSS* (3.23)

3.14
fuelling assembly
part of the *dispenser* (3.7) providing the interface between the *fuelling station* (3.19) and the vehicle, comprising an assembly consisting of a hose *breakaway device* (3.3), a *hose(s)* (3.15), a *nozzle* (3.26) and connections between these components

[SOURCE: ISO 19880-1:2020, 3.26, modified — Notes to entry have been removed and definition revised for clarity.]

3.15
fuelling hose
flexible tube designed for dispensing liquid hydrogen to vehicles through a fuelling *nozzle* (3.26)

Note 1 to entry: ISO 7369, ISO 10380 and ISO 21012 provide example of hoses.

3.16
fuelling pad
area with special construction requirements adjacent to the hydrogen *dispensers* (3.7), where customers park their vehicles during fuelling

[SOURCE: ISO 19880-1:2020, 3.28]

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3.17
fuelling process
procedure to implement vehicle fuelling according to parameters defined in the *fuelling protocol* (3.18), including design, hardware, as well as control and operation rules of hardware of the *hydrogen fuelling station* (3.19)

3.18
fuelling protocol
specification of minimum safety and performance requirements of the *fuelling process* (3.17), allowing interoperability between *hydrogen fuelling station* (3.19) and vehicle

3.19
hydrogen fuelling station
fuelling station
facility for the dispensing of liquid hydrogen vehicle fuel, often referred to as a hydrogen refuelling station (HRS) or hydrogen filling station, including the supply of hydrogen, and hydrogen pump, storage, and *dispensing systems* (3.9)

3.20
fuelling station operator
person or organisation responsible for the safe operation, maintenance and housekeeping of the *fuelling station* (3.19)

[SOURCE: ISO 19880-1:2020, 3.32]

3.21
guard
part of a machine specially used to provide protection by means of a physical barrier

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Note 1 to entry: Depending on its construction, a guard can be called casing, cover, screen, door, enclosed guard, etc.

[SOURCE: ISO 19880-1:2020, 3.33]

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3.22
housing
guard (3.21) or *enclosure* (3.10) for operating parts, control mechanisms, or other components, that need not be accessible during normal operation

[SOURCE: ISO 19880-1:2020, 3.40]

3.23
liquefied 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

Note 1 to entry: The LHSS is composed of the liquefied hydrogen storage container(s), pressure relief devices, shut-off devices, check-valves, boil-off valve and interconnection pipings and fittings between the above components, on-board vehicle, as defined in ISO 13985.

3.24
liquid hydrogen
LH_2
hydrogen that has been liquefied, i.e. brought to a liquid state

3.25
subcooled liquid hydrogen
liquid hydrogen (3.24) at a pressure-temperature condition above the saturation pressure for this temperature

Note 1 to entry: Variation of either pressure, temperature or both can bring a saturated liquid to a subcooled liquid state.

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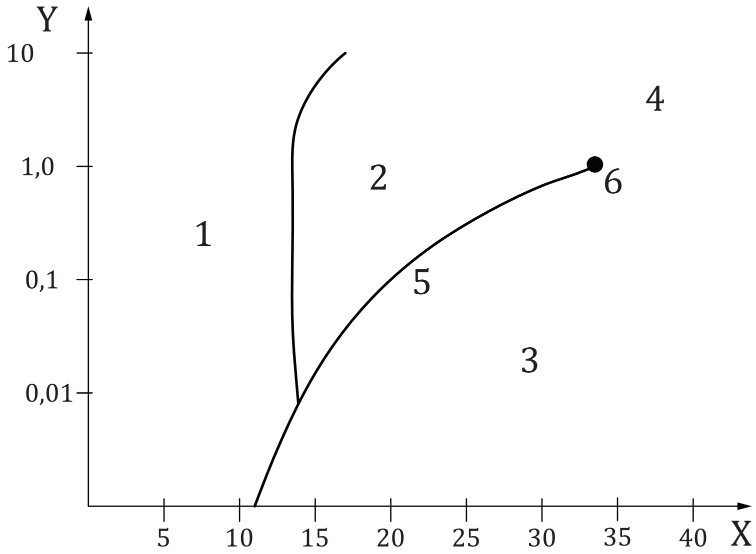
Note 2 to entry: Figure 1 shows the saturation curve for hydrogen.



Key

X	temperature (K)
Y	pressure (MPa(g))
1	solid
2	liquid
3	gaseous
4	supercritical
5	saturation curve
6	critical point

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Figure 1 — Phase diagram of hydrogen

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3.26
nozzle
device connected to a fuel *dispensing system* (3.9), which permits the quick connect and disconnect of fuel supply to the vehicle fuel system

[SOURCE: ISO 19880-1:2020, 3.53, modified — "vehicle storage system" changed to "vehicle fuel system".]

3.27
pressure
gauge pressure measured in MPa against atmospheric pressure unless otherwise stated

3.28
design pressure
pressure used for the calculation of the minimum characteristics for each component or sub-system in the system

Note 1 to entry: The design pressure cannot be less than the pressure at the most severe condition of coincident internal or external pressure and temperature (minimum or maximum) expected during service.

3.29
maximum allowable working pressure
MAWP
highest pressure to which a component, a pressure container or a storage system is permitted to operate permanently under normal operating conditions

Note 1 to entry: Further guidance on pressure terminology is included in Annex D.

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3.30
maximum fuelling pressure
MFP
maximum *dispensing system* (3.9) pressure expected during normal (fault-free) vehicle fuelling

Note 1 to entry: Further guidance on pressure terminology is included in Annex D

[SOURCE: ISO 19880-1:2020, 3.46, modified — Note 1 to entry replaced.]

3.31
maximum operating pressure
MOP
highest pressure expected for a component or system during normal operation including anticipated transients

Note 1 to entry: Further guidance on pressure terminology is included in Annex D

[SOURCE: ISO 19880-1:2020, 3.47, modified — Note 1 to entry replaced.]

3.32
operating pressure
pressure at which the piping system operates

Note 1 to entry: Operating pressure cannot exceed the maximum operating pressure.

3.33
target pressure
P_{target}
dispenser (3.7) fuel pressure that the *fuelling protocol* (3.18) targets for the end of fuelling

Note 1 to entry: The pressure measurement is as close as possible to the *fuelling assembly* (3.14).

Note 2 to entry: Further guidance on pressure terminology is included in Annex D.

3.34
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

3.35
qualified personnel
personnel with knowledge or abilities, gained through training and/or experience as measured against established requirements, standards or tests, that enable the individual to perform a required function

[SOURCE: ISO 10417:2004, 3.13, modified — The word "characteristics" has been replaced with "knowledge".]

3.36
receptacle
device from the *vehicle fuel system* (3.41) which receives the *nozzle* (3.26)

[SOURCE: ISO 19880-1:2020, 3.64, modified — "vehicle storage system" changed to "vehicle fuel system".]

3.37
site acceptance testing
SAT
tests performed after installation of the *fuelling station* (3.19) at the site to verify functionality and/or integrity

[SOURCE: ISO 19880-1:2020, 3.75]

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3.38
standards development organisation
SDO
industry- or sector-based standards organisations that develop and publish industry specific standards

Note 1 to entry: In some cases, international industry-based SDOs can have direct liaisons with international standards organisations. SDOs are differentiated from standards setting organisations (SSOs) in that SDOs can be accredited to develop standards using open and transparent processes.

Note 2 to entry: In the European Union, only standards created by CEN, CENELEC, and ETSI are recognised as European standards, and member states are required to notify the European Commission and each other about all the draft technical regulations. These rules were laid down in Directive 2015/1535/EU with the goal of providing transparency and control with regard to technical regulations.

[SOURCE: ISO 19880-1:2020, 3.77]

3.39
fuelling station storage tank
liquid hydrogen reservoir, located at the *fuelling station* (3.19), to contain liquid hydrogen, which is then transferred to the *vehicle fuel system* (3.41)

3.40
temperature
temperature measured in K unless otherwise stated

3.41
vehicle fuel system
VFS
LHSS fuel system
assembly of components used to store or supply hydrogen fuel to a fuel cell (FC) or internal combustion engine (ICE), according to UN GTR No.13

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Note 1 to entry: The fuel system typically includes one or more *LHSS* (3.23), receptacles, interconnecting lines, boil-off gas management system.

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4 Requirements

4.1 Hydrogen and cryogenic temperatures compatibility

All components of the fuelling system which come in contact with liquid hydrogen and cryogenic gaseous hydrogen shall be compatible with and suitable for liquid hydrogen service and cryogenic gas flows, such as those associated with the handling of cryogenic gaseous hydrogen returning from the LHSS fuel system. They shall also be designed and qualified for the intended service life of the fuelling station.

Piping systems exposed to temperature fluctuations over the service temperature range shall be designed to withstand thermal expansion and contraction.

Consideration shall also be given to the possible condensation of air. Where prevention is not possible, countermeasures such as dripping pans shall be used.

NOTE Guidance for material under cryogenic service is given in ISO/TR 15916, ISO 21010 or ISO 21028-1.

4.2 Material specifications

Material used in the manufacture of components for liquid hydrogen service shall have proven performance with hydrogen and cryogenic temperatures.

NOTE Guidance for material compatibility choices is given in ISO 21010 and ISO 11114-1.

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4.3 Piping

Piping, valves, filters, fittings, gaskets and sealants shall be suitable for hydrogen service at the temperatures and pressures involved.

Guidance on design, thickness definition, cyclic effects accommodation for piping are provided in A.1.

4.4 Pressure relief devices

Liquid hydrogen systems and equipment shall be protected from over-pressure, e.g. by use of one or more PRD(s), or by other appropriate means.

Re-closing PRDs shall meet the requirements of ISO 21013-1 (equivalent national/regional standards can exist).

Non re-closing safety devices shall meet the requirements of ISO 21013-2 (equivalent national/regional standards can exist).

Sizing and capacity determination of liquid hydrogen system PRDs shall meet the requirements of ISO 21013-3 (equivalent national/regional standards can exist). The different behaviour of gaseous and liquid phases shall be taken in consideration. These pressure-relief devices shall be set to discharge at or below the design pressure of the section of the pressure equipment they protect.

When fittings and piping are used on the upstream and/or downstream sides of pressure-relief systems, the passages shall be designed so that the flow capacity of the pressure relief systems will not be reduced below the capacity required for the pressure equipment on which the pressure-relief systems are installed. The opening through all piping and fittings shall have at least the same flow area as the inlet of the pressure-relief device to which it is connected. The nominal size of the discharge piping shall be at least as large as that of the pressure-relief device outlet. Oversized pressure-relief devices may be used without requiring all openings in their lines to have the same flow area, provided the required flow capacity is assured through the system.

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Pressure relief devices shall be provided to prevent over-pressure, including overpressure by thermal expansion where liquid can be trapped.

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Pressure relief devices and vent piping shall be designed or located so that moisture cannot collect and freeze in a manner which would interfere with proper operation of the pressure relief device.

Consideration should also be given in the design of the installation to facilitate the periodic inspection and testing of the pressure relief devices. Pressure relief valves shall be inspected and set point tested according to the manufacturer risk assessment and maintenance manual.

Further guidance on PRDs is provided in A.2 as well as on pressure terminology in Annex D.

4.5 Dispensing system

4.5.1 General requirements

An exemplary diagram of a fuelling station dispensing system is provided in Figure 2.

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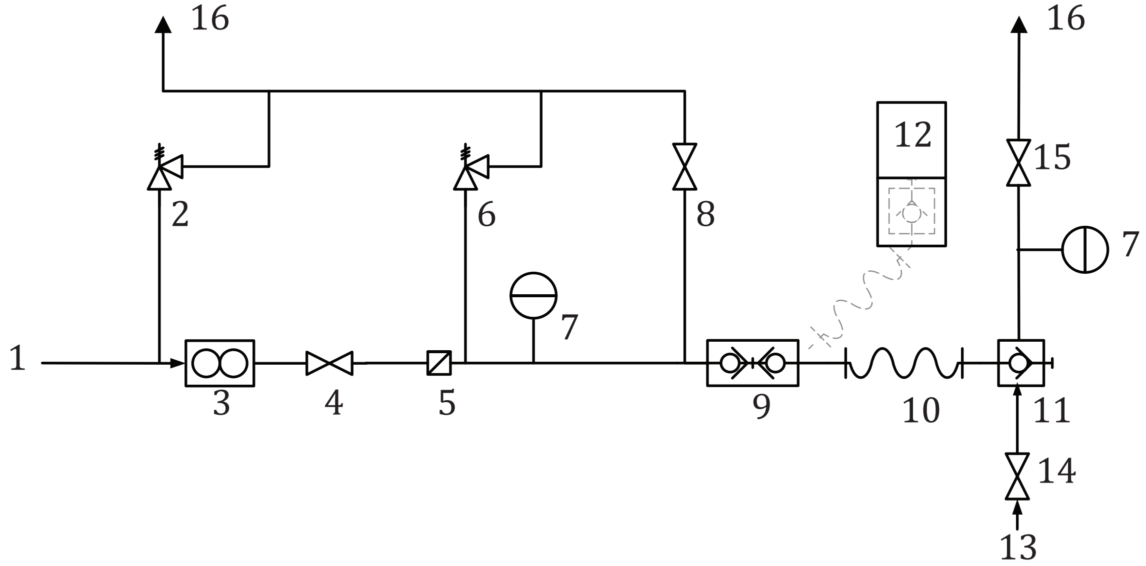

Key

1	liquid hydrogen supply
2	pressure relief device supply
3	flowmeter
4	main fuelling valve
5	filter
6	pressure relief device dispenser
7	pressure sensor
8	vent valve
9	hose breakaway device
10	fuelling hose
11	nozzle
12	nozzle parking position
13	purge gas supply
14	purge gas inlet valve
15	purge gas outlet valve
16	vent

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Figure 2 — Exemplary illustration of a fuelling station dispensing system

The dispensing system shall be equipped with a main fuelling valve capable of starting and stopping the flow of hydrogen transferred to the vehicle, according to the inputs of the control system. The main fuelling valve may additionally control the flowrate.

The dispensing system shall be equipped with a vent valve to handle hydrogen during the cool-down or purge process of the dispenser. It shall be capable of receiving the backgas from the vehicle in case of initial depressurisation of the vehicle fuel system. This valve should be of the normally open type, unless otherwise defined by risk assessment. Venting shall be directed to vent pipe termination point assessed and determined to be a safe location, i.e. accounting for ignition sources, as well as impact on persons, systems and structures.

Safety shut off valves in liquid hydrogen service shall be installed such that their actuators do not risk being blocked by accumulation of ice.

The dispensing system shall be capable of depressurising an LHSS, if required by the fuelling protocol specific starting pressure, while not exceeding its maximum operating pressure to initiate the fuelling process. The corresponding procedure is described in Annex E.

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