



**International
Standard**

ISO 19887-1

**Gaseous Hydrogen — Fuel system
components for hydrogen-fuelled
vehicles —**

**Part 1:
Land vehicles**

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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 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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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*, in collaboration with Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 41, *Specific aspects for gaseous fuels*.

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 purpose of this document is to promote the implementation of hydrogen powered land vehicles through the creation of performance-based testing requirements for components on hydrogen-fuelled vehicles. The successful commercialization of hydrogen land vehicle technologies requires standards pertaining to vehicle fuel system components and the global homologation of standards requirements for technologies with the same end use. This will allow manufacturers to achieve economies of scale in production through the ability to manufacture one product for global use.

This document is based on the CSA Standard CSA/ANSI HGV 3.1:22.

Gaseous Hydrogen — Fuel system components for hydrogen-fuelled vehicles —

Part 1: Land vehicles

1 Scope

1.1 Inclusions

This document establishes requirements for newly produced compressed hydrogen gas fuel system components, as listed below, that are intended for use on hydrogen gas powered land vehicles:

- a) check valves (see [Clause 8](#));
- b) manual valves (see [Clause 9](#));
- c) manual container valves (see [Clause 10](#));
- d) automatic valves and automatic container valves (see [Clause 11](#));
- e) hydrogen injectors (see [Clause 12](#));
- f) pressure sensors, temperature sensors, and pressure gauges (see [Clause 13](#));
- g) pressure regulators (see [Clause 14](#));
- h) pressure relief valves (PRV) (see [Clause 15](#));
- i) pressure relief devices (PRD) (see [Clause 16](#), and refer to ISO 19882);
- j) excess flow valves (see [Clause 17](#));
- k) gastight housing and leakage capture passages (see [Clause 18](#));
- l) rigid fuel lines (see [Clause 19](#));
- m) flexible fuel lines, hoses, and hose assemblies (see [Clause 20](#));
- n) filter assemblies (see [Clause 21](#));
- o) fittings (see [Clause 22](#));
- p) non-metallic, low-pressure rigid fuel lines (see [Clause 23](#));
- q) discharge line closures (see [Clause 24](#)).

NOTE Other components not specifically identified here can be examined to meet the criteria of ISO 19887-1 and tested according to the appropriate functional needs.

1.2 Applicability

This document applies to components that have a nominal working pressure, as specified by the manufacturer, of 25 MPa, 35 MPa, 50 MPa, or 70 MPa at 15 °C, referred to in this document as the following pressure classes:

- a) “H25” – 25 MPa;
- b) “H35” – 35 MPa;
- c) “H50” – 50 MPa; and
- d) “H70” – 70 MPa.

Other nominal working pressures for hydrogen gas besides those defined can be used if the qualification test requirements of this document are met.

This document also applies to components downstream of the first stage of pressure reduction with a maximum operating pressure designated by the manufacturer in MPa or kPa.

1.3 Exclusions

This document does not apply to the following:

- a) hydrogen gas fuel system components incorporated during the manufacture of motor vehicles originally manufactured in compliance with the international regulations on hydrogen and fuel cell vehicles, such as UN GTR No. 13, UN Regulation No. 134, UN Regulation No. 146, or IEC 62282-4-101;
- b) fuel containers;
- c) stationary power generation applications;
- d) container mounting hardware;
- e) electronic fuel management;
- f) refuelling receptacles; or
- g) components intended for liquid hydrogen.

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, *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 6270-2, *Paints and varnishes — Determination of resistance to humidity — Part 2: Condensation (in-cabinet exposure with heated water reservoir)*

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

ISO/TR 11340, *Rubber and rubber products — Hydraulic hose assemblies — External leakage classification for hydraulic systems*

ISO 14687, *Hydrogen fuel quality — Product specification*

ISO 19882, *Gaseous hydrogen — Thermally activated pressure relief devices for compressed hydrogen vehicle fuel containers*

ASTM B117, *Standard Practice for Operating Salt Spray (Fog) Apparatus*

ASTM D572, *Standard Test Method for Rubber—Deterioration by Heat and Oxygen*

ASTM D1149, *Standard Test Methods for Rubber Deterioration—Cracking in an Ozone Controlled Environment*

ASTM D1193-06, *Standard Specification for Reagent Water*

ASTM G154, *Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Materials*

SAE J343, *Test and Test Procedures for SAE 100R Series Hydraulic Hose and Hose Assemblies*

SAE J2719, *Hydrogen Fuel Quality for Fuel Cell Vehicles*

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

bypass flow

intentional flow through or around an excess flow valve, or similar valve, in its activated position

3.2

compressed hydrogen gas

hydrogen gas that has been compressed

Note 1 to entry: For more information on compressed hydrogen gas composition, see [5.1.4.3](#).

3.3

discharge line

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

3.4

discharge line closure

device used to keep contamination out of a discharge line while still permitting escape of gas from the line to atmosphere

3.4.1

repeated-use discharge line closure

discharge line closure ([3.4](#)) intended to relieve multiple gas release events

3.4.2

single-use discharge line closure

discharge line closure ([3.4](#)) intended to relieve a single gas release event

3.5

duty cycle

one complete operation of the component such as pressurization and depressurization or on and off, as applicable

3.5.1

injector duty cycle

operating frequency of an injector as specified by the manufacturer

3.6

external leakage

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

3.7

filling cycle

pressure increase representing a vehicle fuelling for components subjected to container pressure

3.8

filter assembly

assembly that contains a filter media intended to remove contaminants from the gas stream

3.9

fitting

connector used to join sections of pipe, tube, hose, or components

3.10

flexible fuel line

non-rigid tubing or hose through which hydrogen gas flows

3.11

gastight housing

enclosure meant to capture leakage from pressure-retaining components

3.12

hydrogen injector

solenoid operating valve used to control hydrogen flow into an engine or associated intake

Note 1 to entry: Hydrogen injectors are primarily used for internal combustion engine applications but can also be used to control hydrogen flow into a fuel cell.

3.13

internal leakage

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

3.14

leakage capture line

line or hose meant to capture or deliver hydrogen leakage from gastight housings to outside the vehicle

3.15

leakage capture passages

portions of pressure-retaining components meant to capture and direct gas leakage from the pressure-retaining seals of that component

3.16

lock-up pressure

stabilized pressure at the outlet of a pressure regulator at zero flow

3.17

non-metallic, low-pressure rigid fuel line

tubing constructed from non-metallic materials that has been designed not to flex in normal operation and through which fuel flows on the downstream side of pressure regulation

3.18

normal cubic centimetre

Ncm³

quantity of the specified gas that occupies a volume of 1 cm³ at a temperature of 293,15 K (20 °C) and an absolute pressure of 101,325 kPa (1 atm)

3.19

pressure

gauge pressure against atmospheric pressure, unless otherwise stated

3.19.1

burst pressure

pressure that causes structural failure of the component and consequential fluid loss through the component envelope

Note 1 to entry: Burst pressure is the highest pressure recorded when the component bursts during a hydrostatic strength test.

3.19.2

container pressure

gas pressure within a container, up to 125 % of the nominal working pressure immediately after filling

3.19.3

hydrostatic pressure

hydraulic pressure to which a component is subjected during testing

3.19.4

maximum inlet pressure

maximum pressure to be applied to the inlet of a pressure regulator or regulator stage

3.19.5

maximum operating pressure

MOP

maximum pressure that a component is expected to experience in actual service

Note 1 to entry: Maximum operating pressure pertains only to components that are downstream of the first stage of pressure reduction.

Note 2 to entry: MOP is typically the pressure regulator PRV set pressure.

3.19.6

nominal working pressure

NWP

settled pressure at a uniform gas temperature of 15 °C

Note 1 to entry: Nominal working pressure pertains only to components that are upstream of the first stage of pressure reduction.

3.19.7

opening pressure

pressure at which a closure device or pressure relief valve initially opens to allow flow out of the device

3.19.8

set pressure

pressure at which a pressure relief valve is intended to be fully open

3.20

pressure gauge

mechanical device that converts pressure into a visual indication or measure of pressure

3.21

pressure regulator

device used to control the delivery pressure of gaseous fuel

3.22

pressure relief device

PRD

device that, when activated under specified performance conditions, is used to vent the container contents

3.23

pressure relief valve

PRV

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

3.24

pressure sensor

device that measures gas pressure for electronic transmission

3.25

rigid fuel line

tubing that has been designed not to flex in normal operation and through which fuel flows

Note 1 to entry: For example, fuel lines made of metallic materials or polymer tubing are considered rigid lines.

3.26

test gas

gas used for the component performance tests in this document, which may be either compressed hydrogen gas or non-reactive gas, unless otherwise specified in the specific test clauses

3.27

valve

component by which the flow of a fluid can be controlled

3.27.1

automatic container valve

automatic valve rigidly fixed to the container that controls the flow of gas to the fuel system

Note 1 to entry: An automatic container valve may also be considered a primary closure “shut-off valve”, which is defined in UN GTR No. 13 as a valve between the container and the vehicle fuel system that must default to the “closed” position when not connected to a power source.

3.27.2

automatic valve

on/off valve for controlling flow of gas that is not manually operated

3.27.3

check valve

mechanical valve that allows gas to flow in only one direction

3.27.4

excess flow valve

valve intended to automatically shut off or limit flow when a specified flow rate (or pressure differential) through the valve is exceeded

Note 1 to entry: The excess flow valve can either be internal or external excess flow valves and either a flow-limiter type or shut-off type.

3.27.4.1

external excess flow valve

excess flow valve installed outside the container or container valve

3.27.4.2

flow-limiter type excess flow valve

excess flow valve that limits flow when activated

3.27.4.3

internal excess flow valve

excess flow valve installed inside the container or container valve

3.27.4.4

shut-off type excess flow valve

excess flow valve that stops flow when activated

3.27.5

manual container valve

manual valve intended to be rigidly mounted to fuel containers

3.27.6

manual valve

hand-operated device for controlling the flow of gas

3.27.7

service valve

valve intended for use only during maintenance or repair and which requires a tool to operate

4 General requirements

4.1 General construction and assembly

4.1.1 Intended use

Components shall be made of materials suitable for use with compressed hydrogen gas.

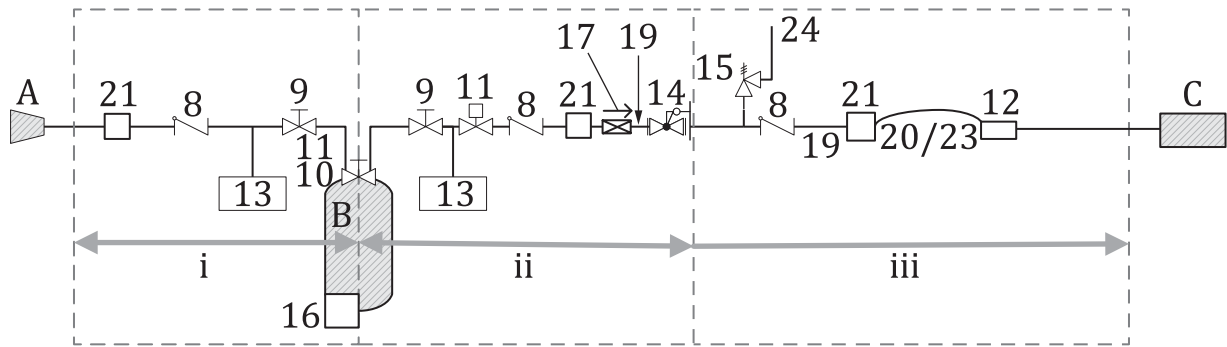
Components designed to comply with this document are intended to be used with hydrogen fuel complying with ISO 14687 or SAE J2719.

The tests and requirements in the following sections do not account for the presence of water in fuel cell components. Corrosive and other effects need to be accounted for if adapting this document for components which are designed for use with moist hydrogen.

Manufacturers of components for hydrogen gas powered vehicles shall consider the intended installation location and pressure class. Components that are upstream of the first stage of pressure reduction will be subjected to container pressure in service and shall be tested according to the nominal working pressure (NWP) requirements. Components that are downstream of the first stage of pressure reduction will be subjected to the maximum operating pressure (MOP), which is typically determined by the pressure relief valve (PRV) set pressure.

Additionally, components that are subjected to container pressure shall be categorized as filling cycle or duty cycle components to determine the appropriate testing requirements. Filling cycle components are those exposed to pressure and temperature cycles during vehicle fuelling. Duty cycle components are those exposed to pressure and temperature cycles by vehicle on/off cycles of the container valve or fluctuations during normal vehicle operation.

[Figure 1](#) shows an example of a hypothetical compressed hydrogen fuel system with a separated inlet and outlet on the container valve. Another variation of the system shown in [Figure 1](#) can be a single inlet and outlet on the container valve, which would expand the application of the filling cycles and duty cycles to the other components throughout the fuel system. [Figure 1](#) is for illustrative purposes only and is intended to provide an example of the categorization of various components. The figure is not intended to be an exhaustive list of all components in all configurations.



Key

Component by Clause number:

8	check valves	20	flexible fuel lines, hoses, and hose assemblies
9	manual valves	21	filter assemblies
10	manual container valves	22	fittings (not in figure)
11	automatic valves and automatic container valves	23	non-metallic, low-pressure rigid fuel lines
12	hydrogen injectors	24	discharge line closures
13	pressure sensors, temperature sensors, and pressure gauges	A	receptacle (not in scope)
14	pressure regulators	B	container (not in scope)
15	pressure relief valves	C	fuel cell/engine (not in scope)
16	pressure relief devices	i	NWP (Filling cycles)
17	excess flow valves	ii	NWP (Duty cycles)
18	gastight housing and leakage capture passages (not in figure)	iii	MOP (Duty cycles, downstream of first stage of pressure reduction)
19	rigid fuel lines		

Figure 1 — Hypothetical compressed hydrogen fuel system

4.1.2 Material requirements

4.1.2.1 General

Pressure-containing materials in contact with hydrogen shall be determined to be acceptable in hydrogen service, with particular attention to hydrogen embrittlement and hydrogen-accelerated fatigue. Materials and design shall be such that there will be no significant change in the functioning of the device, deformation or mechanical change in the device, and no harmful corrosion, deformation, or deterioration of the materials.

4.1.2.2 Metallic materials

Material acceptability for metallic materials shall be demonstrated by testing or by referencing published data for the same material, representative form (e.g., bar or plate, forging or casting, etc.), similar strength, and equivalent service conditions.

NOTE Information regarding material performance in hydrogen environments can be found in ISO/TR 15916, ANSI/CSA CHMC 1, ASME B31.12 and SAE J2579 Appendix B.

Hydrogen compatibility may be demonstrated by testing in hydrogen environments as anticipated in service, such as the continuous operation test specified in [5.6](#).

Resistance to chloride stress corrosion cracking shall be taken under consideration if selecting stainless steel materials. Resistance to corrosion cracking shall be taken under consideration if selecting carbon steel materials (e.g., by choosing appropriate coating, manufacturing processes).

Resistance to stress corrosion cracking and sustained load cracking shall be taken under consideration if selecting aluminium materials.

Resistance to galvanic corrosion shall be taken under consideration when joining components containing dissimilar materials.

4.1.2.3 Non-metallic materials

The suitability of non-metallic organic materials (e.g., rubbers, plastics) for hydrogen service shall be verified, taking into consideration the fact that hydrogen diffuses through these materials more easily than through metals.

Non-metallic materials shall retain their mechanical stability with respect to strength (e.g., fatigue properties, endurance limit, creep strength) when exposed to the full range of service conditions and lifetime as specified by the manufacturer.

Materials shall be sufficiently resistant to the chemical and physical action of the fluids that they contain and to environmental degradation. The chemical and physical properties necessary for operational safety should not be significantly affected within the scheduled lifetime of the component. Specifically, when selecting materials and manufacturing methods, due account should be taken of the material's wear resistance, impact strength, aging resistance, the effects of temperature variations, effects that arise when materials are put together, the effects of ultraviolet radiation, rapid gas decompression and the degradation effects of hydrogen on the mechanical performance of a material.

The manufacturer shall verify the material's suitability, including consideration for such characteristics as permeability, creep, long-term aging, stress cracking, and retention of mechanical properties, as appropriate. Safety margin shall be demonstrated by the hydrostatic strength test, allowable leakage, and the use of materials below their creep threshold for their qualification temperature.

Guidance to account for the degradation effects of hydrogen on the mechanical performance of a material can be found in ISO/TR 15916 and ANSI/AIAA G-095.

Hydrogen compatibility for non-metallic materials may be demonstrated by testing in hydrogen environments as anticipated in service or by one or more of the following:

- a) documented field experience with successful performance of the material in hydrogen environments with similar service conditions;
- b) performance of industry approved standards for hydrogen compatibility, such as CSA/ANSI CHMC 2;
- c) use of hydrogen as the test gas for the continuous operation test specified in [5.6](#) (and the other component specific clauses); and
- d) the hydrogen gas exposure test specified in [5.12.2](#).

4.1.3 Threaded openings

All threads shall comply with a recognized international or national standard.

Tapered threads, such as National Pipe Threads (NPT) should not be used in high-pressure applications as tapered threads have proven to be less robust than other thread designs. If used, tapered threads shall be sealed with appropriate sealant as specified by the manufacturer.

4.1.4 Service temperatures

All components shall be suitable for service within a temperature range of $-40\text{ }^{\circ}\text{C}$ to $85\text{ }^{\circ}\text{C}$. Components in an internal combustion engine compartment shall be suitable for service within a temperature range of $-40\text{ }^{\circ}\text{C}$ to $120\text{ }^{\circ}\text{C}$.

It is possible that operational gas temperatures are outside of this range. The manufacturer may choose to test beyond the service temperatures listed above.

4.1.5 Design service life

The design service life of the component shall be specified by the component manufacturer.

NOTE 1 The testing described in this document is based on an expected service life of 20 years. Service life values can be extended by adjusting the filling or duty cycles, as applicable, by the appropriate factor (ratio). For example, a service life of 25 years will require cycling to be multiplied by 1,25.

NOTE 2 Filling cycle testing is based on 15,000 cycles, which includes an embedded factor of safety and considers a maximum of 750 fuellings per year multiplied by the service life of the component. Duty cycles are component specific for the intended usage and safety factor of that particular component.

4.2 Failure modes and effects analysis (FMEA)

Design and Process FMEA, or equivalent, shall be performed for all components covered by this document.

NOTE FMEA is a methodology used in the automotive industry to identify potentially hazardous failure modes of safety devices and to recommend changes in design, manufacturing, inspection, or testing that eliminate such failure modes or minimize their effects. FMEA is applied to both device design and to the manufacturing and assembly process to identify corrective actions that improve device reliability and safety. See SAE J1739 for more information.

4.3 Electrical equipment and wiring

4.3.1 Openings

Any openings of the component through which electrical wiring components are routed shall be equipped with means to prevent chafing and abrasion of the conductor insulation.

4.3.2 Equipment

Electrically-operated valves and sensors used in areas where there is a potential for external hydrogen leakage into an oxidizing environment shall be inherently non-sparking (e.g., encapsulated solenoid coil and restrained connections such that the possibility for a spark is negligible).

Wiring in this region shall be protected against damage (e.g., by using insulated and sheathed cables or single insulated wires protected by outer coverings).

4.3.3 Materials

Materials used for electrical construction shall be suitable for their particular application. When determining the acceptability of an electrical insulating material, consideration shall be given to its mechanical strength, dielectric strength, heat-resistant properties, the degree to which it is enclosed or protected, and any other features influencing fire and accident hazards.

4.3.4 Connectors

The connectors shall be arranged such that the possibility of damage or loosening of wiring at the connection is negligible (e.g., connections with wires or cables that are encapsulated or moulded with the plug).

4.4 Component literature

4.4.1 General

Manufacturers of components for compressed hydrogen gas powered vehicles shall provide literature for their components. Literature may be provided in printed or electronic format. This literature shall provide information to guide the installer in making a proper installation. The literature shall also require that intermediate assemblers transmit the component warnings and literature to the installer. The manufacturer shall provide duplicate literature in response to requests, including service parts.

4.4.2 Instructions – General

Instructions shall include at least the following:

- a) nominal working pressure (MPa) and specification for hydrogen use as indicated by “H25”, “H35”, “H50”, or “H70”, or maximum operating pressure for components not exposed to container pressure;
- b) operating temperature limits;
- c) mounting limitations with regards to corrosion resistance, including whether the component is suitable for underbody, exterior, or interior locations;
- d) flow ratings (e.g., Kv) of connections if required for safety, such as flow requirements into and out of pressure relief valves;
- e) requirements for warning labels that can be required as part of the installation;
- f) components that require periodic replacement shall be identified;
- g) manufacturer’s or representative’s contact information;
- h) the design service life of the components as specified by the manufacturer; and
- i) other information as required by specific component clauses.

4.4.3 Instructions – Additional considerations

Instructions shall also include, as appropriate:

- a) installation instructions, including torques;
- b) installation orientation requirements;
- c) service procedures including recommended service intervals; and
- d) recommendations for service access.

4.4.4 Installation instructions

Installation instructions shall state that the installation shall be in accordance with the regulations of the local authority having jurisdiction.

4.5 Marking

4.5.1 General marking information

The components shall be marked with the following information as required by the relevant clause of this document:

- a) the direction of flow (when necessary for correct installation);

- b) the serial number, date code, or suitable traceability code;
- c) the specification for compressed hydrogen gas use and either
 - 1) nominal working pressure, if the component is upstream of the first stage of pressure reduction (may be indicated by “H25”, “H35”, “H50”, or “H70”); or
 - 2) maximum operating pressure if the component is downstream of the first stage of pressure reduction;
- d) the manufacturer’s or agent’s name, trademark, or symbol;
- e) the model designation (part number);
- f) the service temperature range; and
- g) the designation of this document “ISO 19887-1:2024”.

NOTE Additional specific component marking requirements can be found in subsequent clauses of this document.

4.5.2 Marking methods

Markings shall remain legible for the life of the component and shall not be removable without destroying or defacing the marking. Permanent adhesive labels may be used, or markings may be etched, stamped, or moulded into the component.

NOTE Marking information can be provided by a suitable identification code on at least one part of the component when it consists of more than one part.

4.5.3 Exclusion of markings

When the size and shape of components does not allow for the required markings, the required information:

- a) shall be provided in the manufacturer’s literature; and
- b) may be omitted from the component in the reverse order listed in the applicable marking clause (either the specific marking clause for the component or in [4.5.1](#)).

5 General test methods

5.1 General test requirements

5.1.1 Testing samples

Testing shall be conducted on finished components that are representative of normal production or material samples when specified. Unless otherwise specified, a new component may be used for each test specified herein.

5.1.2 References to other standards

This document references other standards that might not take into account temperature, pressure, and environmental conditions for compressed hydrogen fuel systems. Since these conditions can affect material or operating characteristics of components, these conditions shall be taken into account and utilized when evaluating the component to the referenced standard. The components shall comply under such conditions with the provisions of the referenced standard.

5.1.3 Pressure and temperature requirements

5.1.3.1 Ambient temperature

Unless stated otherwise, the tests specified herein shall be conducted at ambient temperature, defined as $20\text{ °C} \pm 15\text{ °C}$.

5.1.3.2 Temperature tolerances

Unless stated otherwise, the tests specified herein shall be conducted with the following tolerances on specified temperatures:

- a) $-40\text{ °C} + 0\text{ °C}$ or lower;
- b) $85\text{ °C} - 0\text{ °C}$ or higher; or
- c) $120\text{ °C} - 0\text{ °C}$ or higher.

The “or lower” and “or higher” tolerance limit shall be defined by the component manufacturer.

5.1.3.3 Pressure tolerances

Unless stated otherwise, the tests specified herein shall be conducted with the following tolerances on specified pressures:

- a) pressures 2 MPa or less: $+0/-1\text{ MPa}$;
- b) pressures 125 % NWP or greater: $+2\text{ MPa}/-0\text{ MPa}$.

5.1.4 Test gases

5.1.4.1 General

Unless otherwise specified, all tests shall be conducted using hydrogen or non-reactive gas (e.g., nitrogen, helium).

The dew point of the test gas at the test pressure shall be at a temperature at which there is no icing, hydrate formation, or liquid formation.

If testing with hydrogen, the component should be purged with a non-reactive gas.

Testing described in these requirements can result in the sudden release of test gas at high pressure with dangerous explosive force. Adequate protection from explosion, concussion, and flying debris should be utilized to protect test personnel and facilities.

5.1.4.2 Leak test gas

The leak test gas shall be hydrogen, helium, or a non-reactive gas mixture containing a detectable amount of hydrogen or helium gas.

5.1.4.3 Hydrogen gas

Hydrogen gas used for testing shall be compliant with ISO 14687 or SAE J2719, or meet the following specifications:

- a) hydrogen fuel index: $\geq 99,97\%$;
- b) total non-hydrogen gases: $\leq 300\text{ }\mu\text{mol/mol}$;
- c) water: $\leq 5\text{ }\mu\text{mol/mol}$; and

- d) particle concentrations: ≤ 1 mg/kg.

5.1.5 Material acceptance

Tests specified to establish the acceptance of a material (metallic or non-metallic) for use in a component may be waived when there is acceptable evidence in the form of a declaration, supplied by the manufacturer of the material, to substantiate its suitability for use in the expected environment.

5.1.6 Multi-functional components

It is recognized that multi-functional components can be made up of several components as defined in [1.1](#). Such components shall be examined for conformance to [Clauses 4](#) and [5](#) of this document and tested in accordance with the appropriate functional tests per the component specific clauses (e.g., [Clauses 8](#) through [24](#)).

5.1.7 Pre-cooling effects

The effects of pre-cooling shall be considered for hydrogen components that can be exposed to hydrogen flow during fuelling (upstream of the container).

NOTE Additional information on hydrogen pre-cooling is shown in [5.16](#).

5.1.8 Electrically operated components

Unless stated otherwise, electrical operation of a component shall be conducted at the nominal voltage as specified by the manufacturer.

5.2 Hydrostatic strength

5.2.1 General

Components intended for use at rated pressures equal to or in excess of 14 kPa shall not leak or rupture when subjected to the test outlined in [5.2.2 a\)](#).

This test shall be conducted at ambient temperature. The outlet opening in components shall be plugged and valve seats or internal blocks made to assume the open position. One virgin component shall undergo this test, as well as additional components as specified in the subsequent tests.

5.2.2 Test method

The test method is as follows:

- a) A hydrostatic pressure of 250 % of the specified nominal working pressure for components upstream of the first stage of pressure reduction, or 250 % of the maximum operating pressure for components downstream of the first stage of pressure reduction of the component, shall be applied to the inlet of the component for a period of at least 3 min. The component shall be examined to verify that leak or rupture has not occurred.
- b) The hydrostatic pressure shall then be increased at a rate of less than or equal to 5 % of the nominal working pressure or maximum operating pressure per second, whichever is appropriate, until the component bursts. The hydrostatic pressure at burst shall be recorded. The burst pressure of components subjected to the performance tests per other clauses in this document shall be not less than 80 % of the burst pressure of the virgin component, unless the hydrostatic pressure exceeds 400 % of the nominal working pressure, or maximum operating pressure, as applicable.

5.3 Leakage

5.3.1 General

Prior to conditioning, the component shall be sealed with leak test gas at a minimum of 2,5 % of nominal working pressure for components upstream of the first stage of pressure reduction, or a minimum of 2,5 % of maximum operating pressure for components downstream of the first stage of pressure reduction.

All tests shall be conducted while the component is continuously exposed to the specified test temperatures. The component shall be thermally conditioned at each of the required test temperatures and held for at least 1 h to ensure thermal stability before testing. The component shall either be bubble-free or have a leakage rate less than the values specified in [5.3.2](#) and [5.3.3](#).

5.3.2 External leakage

Each component outlet opening shall be plugged with the appropriate mating connection and the leak test gas shall be applied to the inlet.

At all test temperatures, the external leakage rate of the component shall be monitored by an appropriate method (e.g., immersion in a suitable liquid, global accumulation method, or other equivalent methods) for at least 1 min.

If no leakage is observed for the specified time period, the sample passes the test. If leakage is detected, the leak rate shall be measured by an appropriate method and shall not exceed 10 Ncm³/h of hydrogen gas.

5.3.3 Internal leakage

The internal leakage test shall be applicable only to components having a closed position. If the component is designed to be used with pressure differential in both directions, then the leakage test shall be conducted in each direction. Separate samples may be used for each direction.

The pressurized side of the component shall be connected with the appropriate mating connection, while leaving the opposite connection or connections open.

With the component in the closed position, leak test gas shall be applied to the connected opening and the leakage shall be measured at the other opening of the component for at least 1 min using an appropriate method.

The leak rate shall not exceed 10 Ncm³/h of hydrogen gas unless otherwise specified.

5.3.4 Test conditions

5.3.4.1 Components exposed to container pressure

The component shall be conditioned at ambient temperature and pressurized at both 5 % and 125 % of nominal working pressure.

The component shall be conditioned at -40 °C and pressurized at both 100 % and 5 % of nominal working pressure.

The component shall be conditioned at 85 °C or 120 °C, as applicable, and pressurized at both 5 % and 125 % of nominal working pressure.

5.3.4.2 Components downstream of the first stage of pressure reduction

The component shall be conditioned at ambient temperature and pressurized at both 5 % and 100 % of maximum operating pressure.

The component shall be conditioned at -40 °C and pressurized at both 100 % and 5 % of maximum operating pressure.

The component shall be conditioned at 85 °C or 120 °C, as applicable, and pressurized at both 5 % and 100 % of maximum operating pressure.

5.4 Excess torque resistance

A component designed to be connected directly to threaded fittings shall be capable of withstanding without deformation, breakage, or leakage a turning effort of 150 % (or the overtorque test value as defined in the specific threaded connection standard) of the maximum rated turning effort exerted to install the component.

The component shall be tested as follows:

- a) Test an unused component, applying the torque adjacent to the fitting, thereby installing it into a threaded fixture of suitable size.
- b) For a component having a threaded connection or threaded connections, apply the torque for 15 min to each threaded connection, release the torque, then remove the component and visually examine it for deformation or breakage.
- c) For a component that has been specified to be pulled up by turns (e.g., rotation angle), follow the manufacturer's instructions, apply 1,5 times the number of specified turns, or angle, as applicable, then remove the component and visually examine for deformation or breakage.

Subject the component to the external leakage test specified in [5.3.2](#) and the hydrostatic test specified in [5.2](#).

5.5 Bending moment

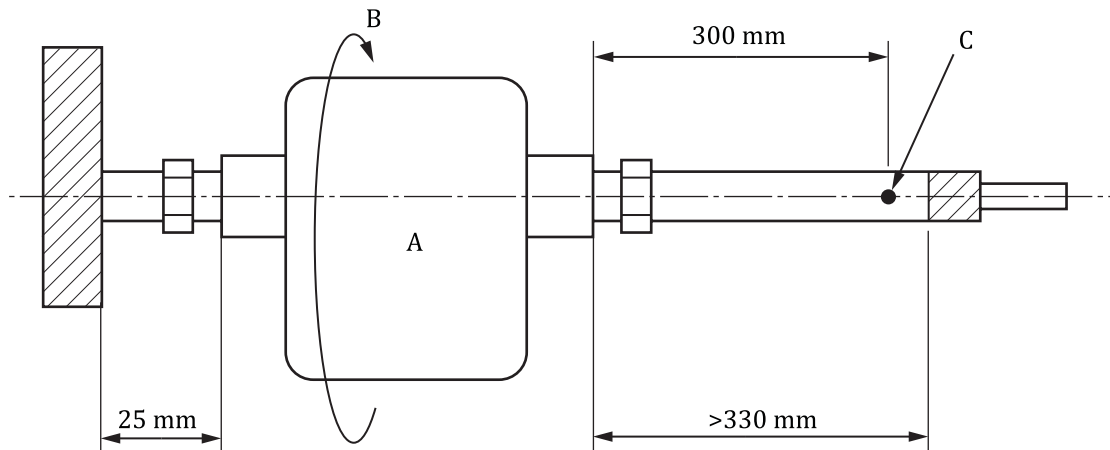
A component subject to bending moment tests shall be capable of operation without cracking, breaking, or leaking while being subjected to a bending moment, using the weight specified in [Table 1](#) in accordance with the following test procedure:

- a) The inlet and outlet connections of the component shall be assembled leak-tight to the appropriate fittings as described in Items 1) to 3). The length of the inlet fitting shall be such that, after assembly, the dimensions from the inlet fitting shall be 330 mm or greater:
 - 1) Pipe threaded connections shall be assembled to Schedule 80 pipe.
 - 2) Tubing connections shall be connected to tubing that can withstand the force as specified in [Table 1](#).
 - 3) Connections designed for other than threaded pipe or tubing shall be connected to a test fixture(s) representative of the intended connection means.
- b) The component outlet fitting shall be rigidly supported 25 mm from the component outlet, unless the following exceptions apply:
 - 1) When the component has an integral mounting means independent of the inlet and outlet connections, the component shall be mounted using the integral mounting means as specified by the manufacturer.
 - 2) When the component is intended to be mounted by either the integral mounting means or the component outlet, the mounting means that produces the most severe test condition shall be used.
 - 3) The component shall be mounted in the horizontal position. Refer to [Figure 2](#) for a typical test setup.
- c) With the component in the closed position, the appropriate force shall be applied at 300 mm from the inlet and maintained for at least 15 min. Without removing the force, the component shall be checked for leakage. Components shall not leak externally in excess of the leakage rates specified in [5.3.2](#).
- d) The test in Item c) shall be repeated three times with the component rotated 90° around the horizontal axis after each test.

- e) At the completion of the above tests, the component shall be removed and visually examined for deformation and breakage, and then subjected to the leakage test as specified in [5.3](#) and the hydrostatic test in [5.2](#).

Table 1 — Bending moment test force

Outside diameter of tubing	Force
< 8 mm	3,4 N
≥ 8 mm to < 12 mm	9,0 N
≥ 12 mm	17,0 N

**Key**

- A component
B rotate 90° between tests
C force point

Figure 2 — Bending moment illustration

5.6 Continuous operation**5.6.1 General**

Three samples of the component shall be subjected to the continuous operation test. For the details of test methods for specific components, see the appropriate clauses (e.g., [Clauses 8](#) through [24](#)) of this document. Other components (i.e., those for which specific requirements are not specified) shall be subjected to the continuous operation test requirements in [5.6.2](#).

5.6.2 Test method**5.6.2.1 Number of cycles**

Components shall be subjected to the following continuous operation test for a total number of cycles covering the expected service life of the component.

- The components shall be installed as indicated by the manufacturer and cycled using test gas under all appropriate loads. Cycling may be interrupted, if desired, for intermediate leakage testing.
- A cycle shall consist of one full operation and reset.
- At the completion of all cycling and leakage tests per [5.6.2.2](#) to [5.6.2.4](#), the components shall be subjected to the hydrostatic test as specified in [5.2](#).