
**Gaseous hydrogen — Fuelling
stations —**

**Part 3:
Valves**

*Carburant d'hydrogène gazeux — Stations-service —
Partie 3: Vannes*

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Published in Switzerland

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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 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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

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

A list of all parts in the ISO 19880 series can be found on the ISO website.

Introduction

Over the course of several years, international efforts have been initiated for the development of regulations, codes and standards that are required for the introduction of hydrogen energy systems. Hydrogen has unique properties and therefore presents unique safety concerns.

One of the many hydrogen energy applications is the automobile sector for which commercialization begun recently. For the success of this application, however, hydrogen infrastructure for fuelling vehicles is as essential as the hydrogen vehicles themselves. Thus, the development of safety standards for fuelling stations and components is of paramount importance.

This document provides safety performance requirements and test methods for valves to be used in gaseous hydrogen environment. Valves are critical to the safety of hydrogen fuelling stations, because they control the flow of gaseous hydrogen, shut it down in an emergency and, at the same time, may become a potential source of hydrogen release or leakage.

This document will facilitate the development of hydrogen infrastructure that is needed to pave a way for the widespread deployment of hydrogen-fuelled vehicles. Benefits to be gained by the implementation of this document include: the establishment of a certain level of safety performance for valves, a safety-critical component; the streamlining of the design and construction processes for fuelling stations by providing standardized components; and the promotion of public acceptance of hydrogen stations through the transparency of the international standardization processes.

This document is based on the Canadian Standards Association references CSA HGV3.1-2013, ANSI/CSA HGV 4.4-2013, ANSI/CSA HGV 4.6-2013 and ANSI/CSA HGV 4.7-2013.

This document is not intended to exclude any specific technologies that meet the performance requirements herein.

This document is to be applied in conjunction with other International Standards relevant to hydrogen fuelling stations and components.

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Gaseous hydrogen — Fuelling stations —

Part 3: Valves

1 Scope

This document provides the requirements and test methods for the safety performance of high pressure gas valves that are used in gaseous hydrogen stations of up to the H70 designation.

This document covers the following gas valves:

- check valve;
- excess flow valve;
- flow control valve;
- hose breakaway device;
- manual valve;
- pressure safety valve;
- shut-off valve.

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.

IEC 60079-0, *Explosive atmospheres — Part 0: Equipment — General requirements*

3 Terms and definitions

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

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

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

3.1

allowable temperature range

minimum and maximum temperatures for which the manufacturer has designed the equipment (or any part to which the term is referred) when handling the specified fluid at the specified pressure

3.2

component pressure rating

maximum allowable pressure at which it is permissible to operate a component as specified by the manufacturer at a specified temperature

Note 1 to entry: Further guidance on dispenser pressure terminology is found in ISO 19880-1.

3.3

Cv value

<flow coefficient> coefficient to represent the flow rate of fluid that a valve is capable of handling

Note 1 to entry: Cv is the flow coefficient of a valve with the fluid at 15,56 °C under a pressure difference of 6 894 N/m².

Note 2 to entry: There are different types of flow coefficients including Cv, Kv and Av.

3.4

dispenser

system downstream of the hydrogen supply system comprising all equipment necessary to carry out the vehicle fuelling operation, through which the compressed hydrogen is supplied to the vehicle

Note 1 to entry: As an example, the dispenser can include a dispenser cabinet, gas flow meter, a fuelling hose and fuelling nozzle attachments.

3.5

hydrogen service level

HSL

pressure level in MPa used to characterize the hydrogen service of the dispenser based on the NWP rating of the vehicle
Note 1 to entry: The numerical value of HSL also matches the number after the "H" in Pressure Class.

Note 1 to entry: Hydrogen service level is expressed in MPa.

3.6

maximum allowable working pressure

MAWP

maximum pressure permissible in a system at the temperature specified for the pressure

Note 1 to entry: The maximum allowable working pressure may also be defined as the design pressure, the maximum allowable operating pressure, the maximum permissible working pressure, or the maximum allowable pressure for the rating of pressure vessels and equipment manufactured in accordance with national pressure vessel codes.

3.7

maximum operating pressure

MOP

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

3.8

valve

device by which the flow of a fluid may be started, stopped or regulated, using a movable part which opens or obstructs passage

3.8.1

check valve

valve which allows gas to flow in only one direction

3.8.2

excess flow valve

valve which automatically shuts off or limits the gas flow when the flow exceeds a set design value

3.8.3

flow control valve

gas flow restricting device, installed downstream of a pressure regulator, which controls gas flow

3.8.4**breakaway device**

device on the fuelling hose that disconnects the hose from the dispenser when a tension 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

Note 1 to entry: This device is treated as a type of valve according to [3.8](#).

3.8.5**manual valve**

hand-operated device for controlling the flow of gas

3.8.6**pressure safety valve****PSV**

pressure activated valve that opens at a specified set point to protect the system from burst and recloses when the pressure falls below the set point

3.8.7**shut-off valve**

on/off valve for controlling the flow of gas, which is pneumatically or electrically actuated

4 General requirements**4.1 General**

This document defines proof of design (type) tests for valves, designed and manufactured under existing standards that are intended for use in hydrogen fuelling stations.

The requirements contained within this document are intended to provide performance-based tests to verify capability of valves for high pressure hydrogen service but not to prevent alternative methods to demonstrate acceptable capability. Valves that have extensive, successful service at comparable design conditions with similarly proportioned components made of the same or like material are not required to perform verification tests defined in [Clauses 5](#) through [12](#) of this document if allowed by applicable codes and regulations.

Components shall comply with all construction specifications set forth herein, or their construction shall demonstrate at least equivalent performance.

4.2 Intended use

The quality of hydrogen fuel dispensed to vehicles is defined in ISO 14687. The design, manufacture and operation of valves constructed in accordance with this document shall not introduce contamination to the hydrogen passing through or in contact with them.

4.3 Material requirements

Resistance to chloride stress corrosion cracking shall be taken under consideration if selecting stainless steel materials. Resistance to sustained load cracking shall be taken under consideration if selecting aluminum materials.

Materials normally 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.

Non-metallic materials normally in contact with hydrogen shall be determined to be acceptable in hydrogen service. Consideration shall be given to the fact that hydrogen diffuses through these materials much more easily than through metals; therefore, the suitability of materials shall be verified.

Non-metallic materials shall retain their mechanical stability with respect to strength (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 material chemical and physical properties necessary for operational safety shall not be significantly affected within the scheduled lifetime of the equipment unless replacement is foreseen.

When selecting materials and manufacturing methods, due account shall be taken of:

- material's corrosion and wear resistance;
- electrical conductivity;
- impact strength;
- aging resistance;
- effects of temperature variations;
- effects arising when materials are combined (for example, galvanic corrosion);
- effects of ultraviolet radiation;
- degradation effects of hydrogen on the mechanical performance of a material.

Guidance to account for the degradation effects of hydrogen on the mechanical performance of a material can be found in ISO/TR 15916.

4.4 Product quality

The manufacturer shall establish production processes with quality control measures to ensure that production valve(s) meet requirements established in this document. As part of this requirement, a hydraulic proof pressure test at 150 % and a gas leak test at 100 % of the component pressure rating shall be conducted. Alternatively a gas leak test at 125 % of the component pressure rating may be conducted.

5 General test methods

5.1 General

General test requirements for all valves are outlined in [5.2](#) to [5.11](#). Where additional test requirements exist for specific types of valves, these are included in [Clauses 6](#) to [12](#).

Any component to be installed downstream of the precool system shall be subject to a cold gas in warm valve test.

5.2 Test conditions

5.2.1 Test sample

A new valve may be used for each test specified. When a series of valves that differ in size only is to be evaluated, three representative samples shall be chosen. At a minimum the smallest, largest and one intermediate size valves shall be evaluated.

5.2.2 Pressure

Unless otherwise stated, all pressures noted within this document are gauge pressure. For general applications, the component pressure rating of the valve to be tested shall be used as is. Since the component pressure rating is to be greater or equal to the system MAWP, the following is permitted:

- a) For dispenser applications, the component pressure rating of the valve may be replaced with the MAWP of the dispenser system in which the valve is to be used.
- b) For applications in other pressure systems, the component pressure rating of the valve may be the MAWP of such a pressure system.

5.2.3 Normal test temperature

Unless otherwise stated, any test at room temperature shall be conducted at 20 °C (± 5) °C.

5.2.4 Specified test temperature

The tests in these requirements shall be conducted at -40 °C ($+0$ °C, -3 °C) and at 85 °C ($+3$ °C, -0 °C) where the valve is used in a dispenser. If the manufacturer specifies the temperature range for use, the test temperatures are the minimum and the maximum of the range.

5.2.5 Test media

Test media as specified in these requirements shall be:

- a) hydrogen for leak tests;
- b) hydrogen for permeation;
- c) hydrogen for gas pressure cycle test;
- d) liquids (e.g., water or oil) for hydrostatic strength tests;
- e) hydrogen, helium, nitrogen or dry air for all other tests.

5.2.6 Test sequence

For any valve type, the tests described in [5.3](#), [5.4](#), [5.5](#), [5.6](#) and [5.7](#) shall be performed in this sequence using the same test sample.

5.3 Hydrogen gas pressure cycle test

5.3.1 General

For the details of test methods for particular valves, see the applicable part of this document.

The method specified in this clause is general in nature and applicable even to miscellaneous valves.

A valve shall withstand 102 000 hydrogen gas pressure cycles without damage or leakage. The replacement of valve seals shall be acceptable at intervals of 16 000 cycles. Prior to conducting this test the valve shall comply with [5.4](#) at room temperature only.

5.3.2 Test method

The outlet of the valve shall be plugged and the inlet shall be attached to hydrogen pressure supply. The valve shall be in the open position unless otherwise provided in the clause applicable to a specific valve to be tested. Cycling shall be between less than 5 % of the component pressure rating and the component pressure rating ($+3$ %, -0 %) within a period of not less than 6 s (10 cycles per minute). 100 000 cycles shall be completed at room temperature, with additional 1 000 cycles at an ambient

temperature of $-40\text{ }^{\circ}\text{C}$ ($+0\text{ }^{\circ}\text{C}$, $-3\text{ }^{\circ}\text{C}$) and 1 000 cycles at an ambient temperature of $85\text{ }^{\circ}\text{C}$ ($+3\text{ }^{\circ}\text{C}$, $-0\text{ }^{\circ}\text{C}$). If the manufacturer specifies the temperature range for operation, apply the minimum temperature instead of $-40\text{ }^{\circ}\text{C}$ and the maximum temperature instead of $85\text{ }^{\circ}\text{C}$.

5.4 Leakage

5.4.1 General

Prior to conditioning, purge the valve with nitrogen and then seal it at approximately 30 % of component pressure rating.

Conduct all tests while the valve is continuously exposed to the specified test temperatures. The device shall either be bubble-free or have a leakage rate of less than $10\text{ cm}^3/\text{h}$ (normal) of hydrogen gas using the following test method. This criterion is applicable to all general and specific leakage tests.

This test shall be conducted for 1 min each at two temperature conditions: $-40\text{ }^{\circ}\text{C}$ ($+0\text{ }^{\circ}\text{C}$, $-3\text{ }^{\circ}\text{C}$) and $85\text{ }^{\circ}\text{C}$ ($+3\text{ }^{\circ}\text{C}$, $-0\text{ }^{\circ}\text{C}$). If the manufacturer specifies the temperature range for use, the test temperatures are the minimum and the maximum of the range.

5.4.2 External leakage test

The valve under test and the test gas (hydrogen) shall be maintained at the required test temperature for 1 h prior to and during the test.

The test pressure shall be at least 100 % of the component pressure rating. A flow measuring device or other method capable of indicating the allowable leak rate shall be used.

5.4.3 Internal leakage test

The internal leakage test is applicable only to valves having a closed position. The aim of this test is to check the pressure tightness of the closed system.

Connect the inlet or outlet (as applicable) of a valve, with the appropriate mating connection, while leaving the opposite connection or connections open.

The valve under test and the test gas (hydrogen) shall be maintained at the required test temperature for 1 h prior to and during the test.

The pressure for the high pressure test shall be at least 100 % of component pressure rating, and the pressure for the low pressure test shall be 2,5 % or less of the component pressure rating. A flow measuring device capable of indicating the allowable leak rate shall be used.

5.5 Worst case fault pressure cycle test

Valves shall be capable of withstanding the pressure expected to occur in a fault condition of the system.

This test shall be conducted at room temperature only. The test media should be hydrogen.

The inlet of the valve shall be connected to a source capable of supplying the necessary test pressure with the outlet closed. Follow the test method of the hydrogen gas cycle test for the valve. Cycling shall be between 5 % or less of 110 % of the component pressure rating and at least 110 % of the component pressure rating ($+3\text{ }^{\circ}\text{C}$, $-0\text{ }^{\circ}\text{C}$) within a period of not less than 6 s (10 cycles per minute). After ten cycles, the valve shall be tested in accordance with [5.4.2](#) and [5.4.3](#) with no leakage.

5.6 Proof pressure test

The inlet of the valve shall be connected to a source capable of supplying the necessary test pressure.

Test media shall be liquid. With the valve open and its outlet sealed, and the valve seats or internal blocks made to assume the open position, the pressure shall be slowly increased to 150 % of the component pressure rating and maintain that pressure for 10 min and the device under test shall be checked for leakage. The valve shall not have any leakage.

5.7 Hydrostatic strength test

5.7.1 Test pressure

This is a test to be conducted following the proof pressure test of [5.6](#).

Valves shall be capable of withstanding without rupture the test pressure of 2,4 times the component pressure rating. When the country or region in which the valve is being put on the market/is intended for use has its own regulation, the test pressure should follow the regulation. The pressure for hydrostatic strength test shall be included in the marking on the valve. If it is impossible to do so in the marking, it shall be included in its literature.

NOTE The ultimate strength criteria are based on the fatigue limit of metals. No fatigue is expected to occur as long as the maximum stress is less than 50 % of the ultimate strength. Since the dispenser MOP is 1,25 times the HSL and component pressure rating is at least 1,375 x HSL, the maximum stress during normal cycling is less than 38 % of ultimate strength and is acceptable for dispenser service.

5.7.2 Test method

This test shall be conducted at room temperature only. This is a destructive test and the valves used in the test shall not be used for any subsequent tests or applications.

If the valve leaks during pressurization to the hydrostatic test pressure of 2,4 times the component pressure rating, it is not considered a failure as long as the pressure has exceeded 150 % the component pressure rating at the time leakage occurs and the hydrostatic test pressure is subsequently achieved.

Upon completing the proof pressure test of [5.6](#), don't reduce the pressure from 150 % of the component pressure rating. The pressure is then increased to the applicable hydrostatic test pressure. This pressure shall be sustained for 1 min without rupturing the valve. Leakage is permitted above 150 % of the component pressure rating, and a means may be used to reduce the leakage rate, if any, when performing this test.

5.8 Excess torque resistance test

A valve designed to be connected directly to threaded fittings or pipes shall be capable of withstanding without deformation, breakage or leakage, a torque of 150 % of the rated installation value, according to the following test procedure.

- a) Test an unused valve, applying the torque adjacent to the fitting.
- b) For a valve having a threaded connection or threaded connections, apply the torque for 15 min, release it, then remove the valve and examine it for deformation and breakage.
- c) Subject the valve to the leakage test specified in [5.4](#).

NOTE The value of 150 % is based on ISO 12619-2.

5.9 Bending moment test

A valve shall be capable of operation without cracking, breaking or leaking when tested according to the following procedure.

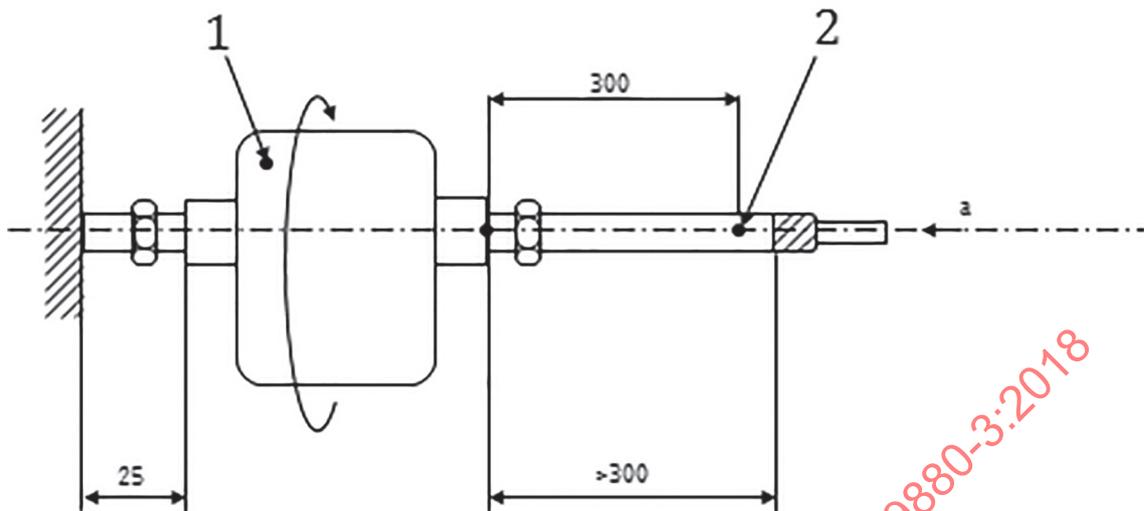
- a) Assemble the connections of the valve, leak-tight, to an appropriate mating connection or connections, representative of design intent. After assembly, the length of the inlet piping shall be at least 300 mm (see [Figure 1](#)).

- b) The outlet connections shall be rigidly supported, at least 25 mm from the valve outlet, except in the following cases:
 - if the valve has an integral mounting means independent of the inlet and outlet connections, the valve shall be mounted using the integral mounting means specified by the manufacturer;
 - if the valve 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.
 - c) Check this assembly for leaks prior to subjecting it to procedure d).
 - d) With the valve in the closed position, the system shall be pressurised to 5 % of the specified component pressure rating and the appropriate minimum weight as specified in [Table 1](#) shall then be suspended on the inlet fitting, without shock, 300 mm from the inlet of the valve for 15 min. Without removing the weight, the valve shall then be tested for leakage as specified in [5.4](#).
- NOTE Depending on how this test is performed, raising the load to compensate buoyancy can be necessary.
- e) Conduct procedure d) 4 times, rotating the valve 90° around the horizontal axis between each test. Between procedures, open and close (if applicable) the valve 3 times with the bending moment removed.
 - f) At the completion of the above tests, remove the valve and examine it for deformation; then subject it to the leakage test according to [5.4](#).

[Table 1](#) shows the pipe diameters and their corresponding bending moments.

Table 1 — Load for bending moment test

Outside diameter of pipe mm	Weight kg
3,18	0,9
6,95	1,6
9,53	2,3
12,7	4,5
19,1	8,2
25,4	14,5

**Key**

- 1 component
- 2 force point
- a 5 % of the MAWP ($4 \times 90^\circ$ rotation).

Figure 1 — Test method of bending moment

5.10 Non-metallic materials test

5.10.1 General

A non-metallic material such as resin or rubber in contact with high pressure hydrogen gas expands when the pressure of hydrogen decreases in a short time from a high level. When the pressure is reduced rapidly, blisters can occur in the material. To evaluate the effects of expansion and blisters, non-metallic materials shall be tested according to the following procedure.

5.10.2 Test method

- a) The outlet of the valve shall be plugged and the inlet shall be attached to hydrogen pressure supply.
- b) Apply hydrogen at the component pressure rating for minimum of 70 h at room temperature.
- c) Following this period, rapidly reduce the test pressure to atmospheric pressure.
- d) The valve shall comply with 5.4.

5.11 Cold gas in warm valve test

This test is applicable to the valves that are used where pre-cooled gas is carried.

The valve shall be subjected to pre-cooled hydrogen gas at -40 °C ($+0\text{ °C}$, -3 °C) at a flow rate of 30 g/s for a minimum of 3 min. For those valves which have ports open to the atmosphere or external moving parts, this test shall be conducted at 90 % relative humidity (ambient conditions). The valve shall be depressurised and re-pressurised after a 2 min hold period at room temperature.

This test shall be repeated 10 times. Then the test procedure shall be repeated for additional 10 cycles, except that the hold period shall be increased to 15 min. Upon completion of the test, the valve shall comply with 5.4.

6 Check valves

6.1 Applicability

The tests required to be carried out are indicated in [Table 2](#).

Table 2 — Tests applicable

Test	General test requirement	Specific test requirement
Hydrogen gas pressure cycle (Clause 6.2)		x
External leakage (Clause 5.4.2)	x ^a	
Internal leakage (Clause 6.4)		x
Worst case fault pressure cycle (Clause 5.5)	x	
Proof pressure (Clause 5.6)	x	
Hydrostatic strength (Clause 5.7)	x	
Excess torque resistance (Clause 5.8)	x	
Bending moment (Clause 5.9)	x	
Non-metallic material (Clause 5.10)	x	

^a Not applicable for check valves built into other components.

6.2 Hydrogen gas pressure cycle test

A valve shall withstand 102 000 hydrogen gas pressure cycles without damage or leakage. The replacement of valve seals shall be acceptable at intervals of 16 000 cycles.

The inlet of the valve shall be connected to hydrogen pressure supply. Apply the component pressure rating with the outlet closed. The pressure shall then be vented from the check valve inlet. Then open the outlet to relieve the pressure. Cycling shall be between less than 5 % of the component pressure rating and the component pressure rating (+3 %, -0 %) within a period of not less than 6 s.

100 000 cycles shall be completed at room temperature with additional 1 000 cycles at an ambient temperature of -40 °C (+0 °C, -3 °C) and 1 000 cycles at an ambient temperature of 85 °C (+3 °C, -0 °C). If the manufacturer specifies the temperature range for use, the test temperature of -40 °C is the minimum temperature and the test temperature of 85 °C is the maximum temperature.

The valve shall comply with [6.3](#) to [6.7](#) upon completion of the 102 000 cycles.

6.3 External leakage test

The test specified in [5.4.2](#) shall be conducted as stated.

6.4 Internal leakage test

Connect the outlet of the check valve with the appropriate mating connection, while leaving the opposite connection or connections open.

The valve under test and the test gas shall be maintained at the required test temperature for 1 h prior to and during the test.

The pressure for the high pressure test shall be at least 100 % of component pressure rating, and the pressure for the low pressure test shall be 10 % or less of the component pressure rating. A leakage measuring device capable of indicating the allowable leak rate shall be used. Leakage shall be no more than 10 cm³/h (normal).

6.5 Worst case fault pressure cycle test

The test specified in [5.5](#) shall be conducted as stated.

6.6 Proof pressure test

The test specified in [5.6](#) shall be conducted as stated.

6.7 Hydrostatic strength test

The test specified in [5.7](#) shall be conducted as stated.

6.8 Excess torque resistance test

The test specified in [5.8](#) shall be conducted as stated.

6.9 Bending moment test

The test specified in [5.9](#) shall be conducted as stated.

6.10 Non-metallic material test

The tests specified in [5.10](#) shall be conducted as stated.

7 Excess flow valves

7.1 General

Excess flow valves include:

- Internal excess flow valve, installed inside the cylinder or cylinder valve;
- External excess flow valve, installed outside the cylinder or cylinder valve;
- Shut-off type excess flow valve, that stops flow when in the closed position;
- Flow-limiter type excess flow valve, that limits flow when activated.

NOTE Devices reset manually or automatically when the excess flow condition is no longer present.

7.2 Tests

7.2.1 Classification

There are many types of excess flow valves available. This document provides requirements for two different designs: internal and external excess flow valves. A valve of either design can be one of two different types: shut-off or flow-limiter. A shut-off valve should have a means of resetting after activation. As excess flow valve designs vary, and so will the tests required.

The function of an excess flow valve can also be achieved in other ways. For example, instead of using a mechanical device, an electronic system can be adopted to ensure the closing or limiting of the gas flow from the cylinder in an accident.

7.2.2 Applicability

The tests required to be carried out are indicated in [Table 3](#).

Table 3 — Tests applicable

Test	General test requirement	Specific test requirement
Hydrogen gas pressure cycle (Clause 5.3)	×	
External leakage (Clause 5.4.2)	×	
Internal leakage (Clause 7.2.5)		×
Worst case fault pressure cycle (Clause 5.5)	×	
Proof pressure (Clause 5.6)	×	
Hydrostatic strength (Clause 5.7)	×	
Excess torque resistance (Clause 5.8)	×	
Bending moment (Clause 5.9)	×	
Non-metallic material (Clause 5.10)	×	
Operation cycle test (Clause 7.2.11)		×
Operation test (Clause 7.2.12)		×
Pressure impulse test (Clause 7.2.14)		×

7.2.3 Hydrogen gas pressure cycle test

The test specified in 5.3 shall be conducted as stated.

The valve shall comply with 7.2.4 to 7.2.8 upon completion of the 102 000 cycles.

7.2.4 External leakage test

The test specified in 5.4.2 shall be conducted as stated.

7.2.5 Internal leakage test

The test specified in 5.4.3 shall be conducted as stated.

The internal leakage test shall only be conducted on shut-off type excess flow valves with manual reset in closed position.

7.2.6 Worst case fault pressure test

The tests specified in 5.5 shall be conducted as stated.

7.2.7 Proof pressure test

The test specified in 5.6 shall be conducted as stated.

7.2.8 Hydrostatic strength test

The test specified in 5.7 shall be conducted as stated in open position.

The purpose of the hydrostatic strength test is to establish the strength of the housing.

7.2.9 Excess torque resistance test

The test specified in 5.8 shall be conducted as stated.

7.2.10 Bending moment test

The test specified in 5.9 shall be conducted as stated.

7.2.11 Non-metallic material test

The tests specified in [5.10](#) shall be conducted as stated.

7.2.12 Operation cycle test

The excess flow valve shall be subjected to 20 cycles at a differential pressure equal to the excess flow trip or choking point. One cycle shall consist of one trip or flow-limiting event and one reset or opening. Upon completion of the test, the valve shall comply with [7.2.4](#), [7.2.5](#) and [7.2.13](#).

7.2.13 Operation test

Measure the activation flow or ΔP and the flow of the excess flow valve when it activates. Perform the test using the activation conditions stated by the manufacturer; the measured flows and pressures shall meet the manufacturer's specified flow and pressure.

7.2.14 Pressure impulse test

The excess flow valve shall withstand 100 pressure pulses, as follows:

- a) If the excess flow valve is external, connect both inlet and outlet to a pipe or tube of the type specified by the manufacturer and of at least 1 m in length each.
- b) If the excess flow valve is internal, the valve containing the excess flow valve to be tested shall be connected securely by a suitable fitting to a pressurised source of nitrogen or hydrogen. Connect the outlet to a pipe or tube of the type specified by the manufacturer and of at least 1 m in length.
- c) Both the outlet and inlet of the excess flow valve shall be conditioned at atmospheric pressure.
- d) The component pressure rating shall be instantaneously applied to the valve inlet.
- e) c) and d) shall be repeated 100 times.
- f) Test the component in the same way with a reverse flow direction. Following the pressure impulse test, conduct a test according to [7.2.12](#).

8 Flow control valves

8.1 General

This clause applies to the following:

- a) pneumatically actuated valves;
- b) electrically actuated valves;
- c) pressure regulators (fixed set-point or pneumatically actuated).

Electrically actuated valves shall also meet the requirements of "intrinsically safe" as defined in IEC 60079-0.

8.2 Tests

8.2.1 Applicability

The tests required to be carried out are indicated in [Table 4](#).

Table 4 — Tests applicable

Test	General test requirement	Specific test requirement
Hydrogen gas pressure cycle (Clause 5.3)	×	
External leakage (Clause 5.4.2)	×	
Worst case fault pressure cycle (Clause 5.5)	×	
Proof pressure (Clause 5.6)	×	
Hydrostatic strength (Clause 5.7)	×	
Excess torque resistance (Clause 5.8)	×	
Bending moment (Clause 5.9)	×	
Non-metallic material (Clause 5.10)	×	
Operation test under full pressure load (Clause 8.2.10)		

8.2.2 Hydrogen gas pressure cycle test

The test specified in 5.3 shall be conducted as stated.

The valve shall comply with 8.2.3 to 8.2.6 upon completion of the 102 000 cycles.

8.2.3 External leakage test

The test specified in 5.4.2 shall be conducted as stated.

8.2.4 Worst case fault pressure test

The test specified in 5.5 shall be conducted as stated.

8.2.5 Proof pressure test

The test specified in 5.6 shall be conducted as stated.

8.2.6 Hydrostatic strength test

The test specified in 5.7 shall be conducted as stated.

8.2.7 Excess torque resistance test

The test specified in 5.8 shall be conducted as stated.

8.2.8 Bending moment test

The test specified in 5.9 shall be conducted as stated.

8.2.9 Non-metallic material test

The test specified in 5.10 shall be conducted as stated.

8.2.10 Operation test under full pressure load

The inlet of the valve shall be connected to hydrogen pressure supply with the outlet closed. With the valve opened, apply the pressure of its component pressure rating to the inlet. Maintain the pressure and then close and open the valve under the same pressure load within a period of not less than 6 s (10 cycles per minute). This constitutes one cycle.

100 000 cycles shall be completed at room temperature with additional 1 000 cycles at an ambient temperature of -40 °C ($+0\text{ °C}$, -3 °C) and 1 000 cycles at an ambient temperature of 85 °C ($+3\text{ °C}$, -0 °C). If the manufacturer specifies the temperature range for use, the test temperature of -40 °C is the minimum temperature and the test temperature of 85 °C is the maximum temperature.

The valve shall comply with [8.2.3](#) upon completion of the 102 000 cycles.

9 Hose breakaway devices

9.1 Specific design requirements

9.1.1 General

In addition to the general design requirements of [Clause 4](#), the following requirements listed in [9.1.2](#) to [9.1.4](#) apply.

9.1.2 Electrical conductivity

The electrical resistance between the extreme ends of a hose breakaway device shall not exceed $10\ \Omega$. The resistance shall be measured at atmospheric pressure and while being exposed to an internal pressure equal to the manufacturer's specified component pressure rating.

9.1.3 Containment of/controlled relieving of hydrogen when uncoupled

The breakaway shall be designed according to one of the following:

- 1) The hose breakaway on the fuelling line shall incorporate double shut-off features that isolate both sides of the connection when uncoupled. When uncoupled (for example, in a drive-away event), both the part that remains on the dispenser (inlet component) and the part that decouples with the vehicle (outlet component) seal.
- 2) The hose breakaway on the fuelling line shall incorporate shut-off features that isolate the dispenser side of the connection when uncoupled, but relieve the hydrogen from the part that decouples with the vehicle in a safely controlled manner, for example, through a maximum 1,5 mm orifice.

9.1.4 Separation

The hose breakaway device shall separate upon application of a maximum pull force of 1 000 N but not less than 220 N when the device is installed as specified by the manufacturer.

9.2 Tests

9.2.1 Applicability

The tests required to be carried out are indicated in [Table 5](#).

Table 5 — Tests applicable

Test	General test requirement	Specific test requirement
Hydrogen gas pressure cycle (Clause 5.3)	×	
External leakage (Clause 9.2.3)		×
Worst case fault pressure cycle (Clause 5.5)	×	
Proof pressure (Clause 5.6)	×	
^a Not applicable for devices with an unfixed end.		

Table 5 (continued)

Test	General test requirement	Specific test requirement
Hydrostatic strength (Clause 9.2.4)		x
Excess torque resistance (Clause 5.8)	x	
Bending moment (Clause 5.9)	x ^a	
Non-metallic material (Clause 5.10)	x	
Separation test (Clause 9.2.8)		x
Impact test (Clause 9.2.9)		x
Drop test (Clause 9.2.10)		x
Twisting test (Clause 9.2.11)		x
Cold gas in warm valve test (Clause 5.11)		x
^a Not applicable for devices with an unfixed end.		

9.2.2 Hydrogen gas pressure cycle test

The test specified in 5.3 shall be conducted as stated.

The valve shall comply with 9.2.3 to 9.2.6 upon completion of the 102 000 cycles.

9.2.3 External leakage test

9.2.3.1 General

A hose breakaway device shall not leak more than 10 cm³/h (normal) when tested using hydrogen or hydrogen in accordance with the following test method.

This test will be performed both on the coupled device as well as the uncoupled inlet half attached to the test gas supply system. The uncoupled outlet half shall also be tested if it is of a non-relieving design.

9.2.3.2 Test method

This test shall be conducted at -40 °C (+0 °C, -3 °C) and at 85 °C (+3 °C, -0 °C). The hose breakaway devices shall be conditioned and maintained at the required test temperature for not less than 2 h per 25,4 mm of maximum diameter of the device prior to test and during the test.

The inlet of the hose breakaway device under test shall be connected to a system capable of supplying clean test gas at 100 % of the manufacturer's specified component pressure rating and to a flow measuring device or means capable of indicating the allowable leak rate.

With the hose breakaway device in the normal assembled configuration and with its outlet plugged, test gas shall be slowly admitted and maintained at 100 % of the specified component pressure rating. When equilibrium conditions are attained, the leakage shall be measured.

The leakage rate under any test condition shall not exceed 10 cm³/h (normal) using hydrogen as the test medium.

9.2.4 Worst case fault pressure test

The test specified in 5.5 shall be conducted as stated.

9.2.5 Proof pressure test

The test specified in 5.6 shall be conducted as stated.

9.2.6 Hydrostatic strength test

9.2.6.1 General

Hose breakaway devices shall be capable of withstanding a test pressure equal to 2,4 times the component pressure rating without rupture. Because the hydrostatic strength test is a terminal test, do not use these test samples for any further testing.

9.2.6.2 Test method (coupled):

This test shall be conducted at room temperature only.

The inlet of the coupled hose breakaway device shall be connected to a suitable hydrostatic system. Care shall be taken to remove all air or other test gas from the device and the test system. With the device open and its outlet sealed, the pressure shall be slowly increased to 2,4 times the component pressure rating. The test pressure shall be held for 3 min without rupture.

If the coupled device uncouples during pressurization it is not considered a failure as long as the pressure has exceeded 150 % of the component pressure rating at the time of uncoupling. If the coupled device does uncouple, a fixture is to be added to hold it together and the test shall be repeated.

If the coupled device leaks during pressurization it is not considered a failure as long as the pressure has exceeded 150 % of the component pressure rating at the time when leakage occurs.

9.2.6.3 Test method (uncoupled):

Each of the port end connections of the uncoupled hose breakaway devices (inlet and outlet halves) shall be connected to a suitable hydrostatic system. Care shall be taken to remove all air or other test gas from the device and the test system. The test pressure shall be slowly increased to 2,4 times the component pressure rating or observe the relevant national requirements, if available. The test pressure shall be held for 5 min without rupture.

In the event of testing an outlet half with the “relieving” option included, the device shall have the bleed-down orifice plugged and be subjected to a full hydrostatic strength test uncoupled.

9.2.7 Excess torque resistance test

The test specified in [5.8](#) shall be conducted as stated.

9.2.8 Bending moment test

The test specified in [5.9](#) shall be conducted as stated. If the breakaway device is not fixed at either end, this test is not applicable.

9.2.9 Non-metallic material test

The test specified in [5.10](#) shall be conducted as stated.

9.2.10 Separation test

9.2.10.1 General

When tested in accordance with the following method, the hose breakaway device shall separate upon application of a pull force within the range specified in [9.1.4](#). Upon separation under the pressurised condition, the flow of gas from the inlet component shall cease, and the flow of gas from the outlet component shall either

- 1) cease within 1 s, or

2) bleed down the attached hose in accordance with 9.1.3 2).

The hose breakaway device will be tested against the requirements of 9.2.12.

9.2.10.2 Test method

The hose breakaway device being tested shall be installed as specified by the manufacturer in a simulated dispenser/hose assembly.

The test shall be conducted at four different temperature and pressure combinations as shown in Table 6. For reusable devices, one sample shall be provided. The sample shall be tested for a total of 20 times, 5 times at each of the listed temperature/pressure combinations. For “one time use” devices, 8 samples shall be provided. Two “one time use” samples shall be tested at each of the listed temperature/pressure combinations.

The hose breakaway device being tested shall be maintained at the required test temperature for at least 2 h per 25,4 mm of maximum diameter of the device prior to the test and shall remain conditioned throughout the test.

A direct tensile force shall be applied beginning at a force less than 220 N and increasing until the device separates. The device shall separate and, if pressurised, the flow of gas from the inlet half shall cease and shall not continue to leak in accordance with 9.2.3. The flow of gas from the outlet half shall either

- 1) cease and not continue to leak in accordance with 9.2.3, or
- 2) control the depressurization of the hose.

A reusable device sample shall then be reassembled for subsequent testing.

Upon completion of the test specified above, each “one time use” sample shall comply with 9.2.3 in the separated configuration. The reusable sample shall comply with 9.2.3 both in the separated configuration and when reassembled.

If the device is intended for connection directly to a rigid assembly such as the dispenser, the above tests shall be repeated on new samples with the pull force directed at angles specified by the manufacturer as the most critical.

The test method is summarized in Table 6.

Table 6 — Separation test

	Temperature	Internal pressure	Number of times to test the reusable sample ^a	Number of “one time use” samples to test ^b
1	-40 °C	Atmospheric	5	2
2	85 °C	Atmospheric	5	2
3	-40 °C	Component pressure rating	5	2
4	85 °C	Component pressure rating	5	2

^a One sample, tested 20 times.

^b Total samples, each tested once.

9.2.11 Impact test (Applicable to rigid-mount devices)

9.2.11.1 General

A hose breakaway device shall be capable of withstanding the impact of 20 Nm per 25,4 mm of tubing nominal diameter (based on connector size) without separating, leaking, cracking or breaking. If the breakaway device is mounted to the dispenser with a guide, this test is not applicable.

9.2.11.2 Test method

This test shall be conducted with a hose breakaway device conditioned at -40 °C ($+0\text{ °C}$, -3 °C) for 2 h per 25,4 mm of maximum diameter of the device.

The device shall be supported by securing it to an appropriate nipple or coupling mounted on a rigid surface so that the free length of the nipple or coupling is not greater than 25,4 mm. The outlet end of the device shall have an appropriate fitting. The test device shall be arranged so that the centre of impact shall be 6,5 mm from the extreme outlet end.

The device shall then be successively struck four times at right angles to the longitudinal centre line of the outlet gas pathway, with the device being turned 90° after each impact. The device shall not separate during this test. After each impact, the device shall be examined visually for cracks and breakage. Upon completion of the above procedure, the device shall comply with [9.2.3](#) and [9.2.10](#).

9.2.12 Drop test

9.2.12.1 General

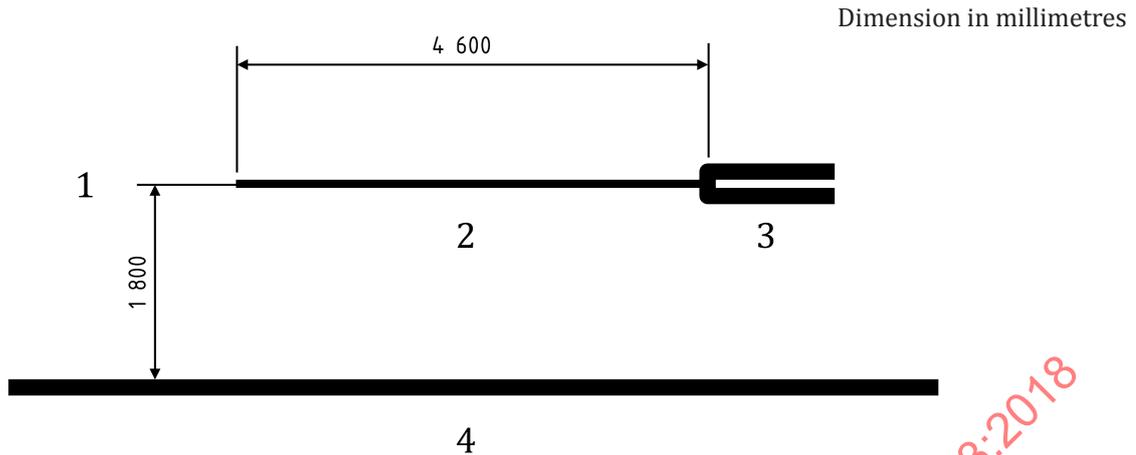
A hose breakaway device shall be capable of withstanding a drop from a height of 1,8 m without separating, leaking, cracking or breaking.

9.2.12.2 Test method

If the inline hose breakaway device may come into contact with the ground when attached to a dispenser, it shall be attached to a fuelling hose of 4,6 m in length in the connected configuration and conditioned at -40 °C ($+0\text{ °C}$, -3 °C) for 2 h per 25,4 mm of the maximum diameter of the device. Then drop it from a height of 1,8 m onto a concrete floor as shown in [Figure 2](#). The device shall be dropped 5 times and then pressurised to the component pressure rating. Drop the pressurised device 5 more times. Upon completing the drops, disconnect the device and repeated the above procedures on the disconnected halves; except that the pressurised half of a "one time use" device shall be dropped only once. However, the device shall be dropped 10 times without any pressure applied if the outlet of the device is not capable of being pressurised.

In the case of a rigid-mount hose breakaway device or the inline hose breakaway device that does not come into contact with the ground, the disconnected half on the vehicle side shall be attached to a fuelling hose of 4,6 m in length, conditioned at -40 °C ($+0\text{ °C}$, -3 °C) for 2 h per 25,4 mm of the maximum diameter of the device and then dropped from a height of 1,8 m onto a concrete floor as shown in [Figure 2](#). The test device shall be dropped 5 times, then pressurised to the component pressure rating and subjected to 5 additional drops; except that the pressurised half of a "one time use" device shall be dropped only once. The test device shall be dropped 10 times without any pressure applied if the outlet of the device is not capable of being pressurised.

Upon completion of the above procedure, the disconnected halves of "one time use" devices shall comply with [9.2.3](#), while "reusable" devices shall comply with [9.2.3](#) in the separated configuration and with [9.2.3](#) and [9.2.6](#) in the reassembled configuration.



Key

- 1 suitable support
- 2 fuelling hose
- 3 device
- 4 concrete floor

Figure 2 — Drop test

9.2.13 Twisting test

9.2.13.1 General

Using a torque up to 20,5 Nm a hose breakaway device shall withstand 50 000 cycles of twisting due to torque rotation. This test does not apply to devices not capable of rotation at 20,5 Nm.

9.2.13.2 Test method

Rotation shall be checked at 0 MPa and at the manufacturer’s specified component pressure rating. Hose breakaway devices that can be rotated under both pressure conditions shall have half of the required cycles conducted at 0 MPa and half of the required cycles at the manufacturer’s specified component pressure rating (applied by suitable means with clean dry tests gas). Devices that can be rotated only at 0 MPa or only at maximum pressure shall have the 50 000 cycles conducted only at that pressure.

The device inlet shall be securely connected to a suitable, rigidly mounted fitting. The outlet shall be plugged and attached to an apparatus capable of rotating the device through 180° at a maximum of 10 cycles per minute. A cycle shall consist of rotating the movable portions of the device 180° and then back to their original position.

The device shall be rotated for 25 000 cycles at -40 °C (+0 °C, -3 °C) and 25 000 cycles at 85 °C (+3 °C, -0 °C). Following cycling, the device shall comply with [9.2.3](#) and [9.2.10](#).

If the device is intended for connecting directly to a rigid assembly such as the dispenser, a pull force of 89 N at the manufacturer’s specified angles shall be applied during rotation. This pull force need not be applied to inline devices.

9.2.14 Cold gas in warm valve test

The test specified in [5.11](#) shall be conducted as specified. The valve shall comply with the leakage tests specified in [9.2.3](#).

10 Manual valves

10.1 Construction and assembly

A manual valve with 90° rotation from “on” to “off” position shall be provided with rigidly secured stops to limit rotation. The valve handle shall be perpendicular to the direction of flow in the “off” position.

10.2 Tests

10.2.1 Applicability

The tests required to be carried out are indicated in [Table 7](#).

Table 7 — Tests applicable

Test	General test requirement	Specific test requirement
Hydrogen gas pressure cycle (Clause 5.3)	×	
External leakage (Clause 5.4.2)	×	
Internal leakage (Clause 5.4.3)	×	
Worst case fault pressure cycle (Clause 5.5)	×	
Proof pressure (Clause 5.6)	×	
Hydrostatic strength (Clause 5.7)	×	
Excess torque resistance (Clause 5.8)	×	
Bending moment (Clause 5.9)	×	
Non-metallic material (Clause 5.10)	×	
Maximum flow shut-off (Clause 10.2.9)		×
Operation test (Clause 10.2.10)		×
Excess torque operation (Clause 10.2.11)		×

10.2.2 Hydrogen gas pressure cycle test

The test specified in [5.3](#) shall be conducted as stated.

The valve shall comply with [10.2.3](#) to [10.2.7](#) upon completion of the 102 000 cycles.

10.2.3 External leakage test

The test specified in [5.4.2](#) shall be conducted as stated.

10.2.4 Internal leakage test

The test specified in [5.4.3](#) shall be conducted as stated.

10.2.5 Worst case fault pressure test

The test specified in [5.5](#) shall be conducted as stated.

10.2.6 Proof pressure test

The test specified in [5.6](#) shall be conducted as stated.

10.2.7 Hydrostatic strength test

The test specified in [5.7](#) shall be conducted as stated.

10.2.8 Excess torque resistance test

The test specified in [5.8](#) shall be conducted as stated.

10.2.9 Bending moment test

The test specified in [5.9](#) shall be conducted as stated.

10.2.10 Non-metallic material test

The tests specified in [5.10](#) shall be conducted as stated.

10.2.11 Maximum flow shut-off test

10.2.11.1 General

A valve shall function properly when gas is passing through it at the component pressure rating and the maximum flow rate.

10.2.11.2 Test method

This test shall be performed with the valve at a temperature of -40 °C ($+0\text{ °C}$, -3 °C). If the manufacturer specifies the minimum temperature for use, the test temperature is the minimum temperature.

The inlet of the valve shall be connected to a system capable of supplying clean test gas at the component pressure rating through a tube or pipe the size of which is equal to or greater than the valve inlet connection. During the test, the supply pressure shall not fall below 80 % of the component pressure rating. With the outlet of the valve open to the atmosphere, the valve shall be subjected to a flow of the test gas and shall be capable of completely closing.

At the completion of this test, each valve shall be subjected to the test of and comply with [5.4.2](#) and [5.4.3](#).

10.2.12 Operation test

A manual valve should withstand 300 open/close cycles without damage or leakage.

The outlet of the valve shall be open to a vent and the inlet shall be attached to hydrogen pressure supply. For safety, it is recommended to conduct this test with equipment that allows remote operation of the valve. With the manual valve in the closed position, apply pressure to its inlet to reach the component pressure rating. Stop pressurization but maintain the inlet pressure at the component pressure rating. Open the manual valve to release pressure. Repeat this close/open procedure 150 times at -40 °C ($+0\text{ °C}$, -3 °C) and another 150 times at 85 °C ($+3\text{ °C}$, -0 °C). At the completion of this operation test, the valve shall be subjected to the leak testing described in [10.2.3](#) and [10.2.4](#).

10.2.13 Excess torque operation test

This test is not applicable to manual valves with 90° rotation from "on" to "off" position.

With no pressurization, close the valve by applying to its handle at least 150 % of the torque specified for its operation, and then open it to its fully open position. Repeat this procedure 20 times. At the completion of this test, the valve shall be subjected to the leak testing described in [10.2.3](#) and [10.2.4](#).

11 Pressure safety valves (PSV)

11.1 Applicability

The tests required to be carried out are indicated in [Table 8](#).

Table 8 — Tests applicable

Test	General test requirement	Specific test requirement
Hydrogen gas pressure cycle (Clause 11.2)		x
External leakage (Clause 11.3.1)		x
Seat leakage (Clause 11.3.2)		x
Worst case fault pressure cycle (Clause 11.4)	x	
Proof pressure (Clause 11.5)	x	
Hydrostatic strength (Clause 11.6)		x
Excess torque resistance (Clause 5.8)	x	
Bending moment (Clause 11.8)		x
Non-metallic material (Clause 5.10)	x	
Operation test (Clause 11.10)		x

11.2 Hydrogen gas pressure cycle test

The test shall be conducted in such a way that the PSV would not activate to open under a test pressure of its component rating. Examples include: a high set point or the use of a mechanical lift restrictor. The PSV shall withstand 102 000 cycles of hydrogen gas pressure cycle between less than 5 % of the component pressure rating and the component pressure rating (+3 %, -0 %) within a period of not less than 6 s (10 cycles per minute). 100 000 cycles shall be completed at room temperature, with additional 1 000 cycles at an ambient temperature of -40 °C (+0 °C, -3 °C) and 1 000 cycles at an ambient temperature of 85 °C (+3 °C, -0 °C).

If the manufacturer specifies the temperature range for operation, apply the minimum temperature instead of -40 °C and the maximum temperature instead of 85 °C.

The replacement of valve seals shall be acceptable at intervals of 16 000 cycles. The valve shall comply with [11.3](#) to [11.6](#) upon completion of the 102 000 cycles.

11.3 PSV leakage tests

11.3.1 External leakage test

External leakage tests shall comply with [5.4.2](#). The test pressure for the shell on the discharge side of the seat shall be 100 % of the manufacturer's stated maximum back pressure for which the PSV is designed. The test pressure for the inlet to the seat shall be 100 % component pressure rating. In order to prevent activation during testing of the portion of the valve from the inlet to the seat, a mechanical lift restrictor as recommended by the valve manufacturer shall be fitted. The mechanical lift restrictor should only be fitted after completion of tests on the discharge side of the valve seat. Test the PSV at -40 °C (+0 °C, -3 °C), 20 °C ± 5 °C and 85 °C (+3 °C, -0 °C).

11.3.2 Seat leakage test

The seat leakage test is intended to test the pressure tightness of the valve seat and shall be carried out after adjustment of the valve set pressure. Tests shall comply with [5.4.3](#) using a test pressure of 90 % of set pressure.

11.4 Worst case fault pressure test

The test specified in 5.5 shall be conducted with a means to prevent the activation of the PSV. The outlet of the PSV shall not be plugged for this test.

11.5 Proof pressure test

The test specified in 5.6 shall be conducted with a means to prevent the activation of the PSV. The outlet of the PSV shall not be plugged for this test.

11.6 Hydrostatic strength test

The test specified in 5.7 shall be conducted as stated.

If the PSV discharge pressure rating is lower than the valve inlet, the portion between the valve inlet and the seat shall be tested independently from the shell on the discharge side of the seat.

The test pressure for the shell on the discharge side of the seat shall be 2,4 times the manufacturer's stated maximum back pressure for which the PSV is designed.

In order to test the portion of the valve from the inlet to the seat, a mechanical lift restrictor or suitable blanking device as recommended by the valve manufacturer shall be fitted. The test pressure for the inlet to the seat shall be 2,4 times the component pressure rating.

For the purposes of this test, the PSV's mechanism shall be removed and its orifice blocked.

11.7 Excess torque resistance test

The test specified in 5.8 shall be conducted as stated.

11.8 Bending moment test

The test specified in 5.9 shall be conducted as stated with the following provisions for pressure safety valves.

Valves shall be tested in the orientation as specified by the manufacturer and shall be mounted in line with recognised standards giving sufficient support to inlet and outlet piping as to prevent excessive external loading to the valve body.

11.9 Non-metallic material test

The tests specified in 5.10 shall be conducted as stated.

11.10 Operation test

Verify the opening and re-seating pressures of the PSV. The opening pressure shall be equal to the set pressure $\pm 5\%$ at $20\text{ °C} \pm 5\text{ °C}$, and $\pm 5\%$ at -40 °C ($+0\text{ °C}$, -3 °C) and 85 °C ($+3\text{ °C}$, -0 °C).

Three randomly selected samples shall be subjected to the following test procedure. This test has three steps, which shall be conducted in the order given. Appropriate test media shall be chosen (i.e. air, nitrogen, or hydrogen). If the test medium is not hydrogen, then the calculated flow values shall be corrected for hydrogen.

- a) Establish the opening and re-seating values for the samples at $20\text{ °C} \pm 5\text{ °C}$. Do this by first slowly pressurizing the inlet of the sample to 110 % of the set pressure, noting the value at which it first opens.