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Hydrogen technologies

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DRAFT INTERNATIONAL STANDARD

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Gaseous hydrogen — Fueling stations —

Part 3: **Valves**

Carburant d'hydrogène gazeux — Stations-service —

Partie 3: Vannes

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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 our 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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75% of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

The committee responsible for this document is ISO/TC 197.

This Standard was developed using the CSA Standards mentioned in the Bibliography under a Copyright License Agreement between CSA and ISO.

ISO 19880 Standard series consists of the following parts, under the general title of Gaseous hydrogen

Fueling stations:

— Part 1: General requirements

— Part 2: Dispensers

— Part 3: Valves

— Part 4: Compressors

— Part 5: Hoses

— Part 6: Fittings

— Part 7: (reserved for future use)

— Part 8: Hydrogen quality control

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 presents unique properties and therefore unique safety concerns.

Among many hydrogen energy applications, the automobile sector commercialization has begun. For the success of the industry, however, hydrogen infrastructure for fueling vehicles is as essential as hydrogen vehicles themselves if not more. The development of safety standards for fuel stations and components therein is therefore of paramount importance.

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

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

This standard will facilitate the development of hydrogen infrastructure that is needed to pave a way for the wide deployment of hydrogen-fueled vehicles. Benefits to be gained by the implementation of this International Standard include: the establishment of a certain level of safety performance in valves, a safety-critical component; streamlined design and construction processes for fuel stations by providing standardized components; and wider public acceptance of hydrogen stations through the transparency of the international standardization processes.

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

Gaseous hydrogen — Fueling stations —

Part 3:
Valves

1 Scope

This Standard 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 standard 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 normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

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

ISO 14687-2:2012, *Hydrogen fuel — Product specification — Part 2: Proton exchange membrane (PEM) fuel cell applications for road vehicles*

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

3 Terms and definitions

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

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
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/m^2.

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

3.3
dispenser
parts of the pressurized-gas fueling station via which the pressurized gas is dispensed to vehicles

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

3.4
maximum allowable working pressure
MAWP
maximum pressure permissible in a vessel or system during normal (fault free) operation at the temperature specified for the pressure

3.5
valve
device by which the flow of a fluid may be started, stopped, or regulated, using a movable part which opens or obstruct passage

3.5.1
shut-off valve
on/off valve for controlling flow of gas, which is pneumatically or electrically actuated

3.5.2
check valve
valve which allows gas to flow in only one direction

3.5.3
excess flow valve
valve which automatically shuts off, or limits, the gas flow when the flow exceeds a set design value

3.5.4
flow control valve
gas flow restricting device, installed downstream of a pressure regulator, which controls gas flow

3.5.5
hose breakaway device
device which is installed on a dispensing hose and designed to separate when a given pull force is applied in order to cut off the flow of hydrogen to prevent gas leakage and protect the dispenser from damage from vehicles driving away

Note 1 to entry: This device is treated as a type of valve according to the definition of clause 3.5.

3.5.6
manual valve
hand-operated device for controlling the flow of gas

3.5.7
pressure safety valve
PSV
pressure activated valve that opens at a specified set point to protect the system from burst and re-closes when the pressure falls below the set point

4 General requirement

4.1 General

This standard does not require existing valves designed under existing codes and regulations and field-proven to be retested. The requirements contained within this standard 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. Components shall comply with all construction specifications set forth herein, or their construction shall demonstrate at least equivalent performance.

4.2 Intended use

Components shall be made of materials suitable for use with compressed hydrogen gas. Components designed to comply with this standard are intended to be used with hydrogen fuel that is in compliance with ISO 14687-2.

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 chemical and physical properties necessary for operational safety shall not be significantly affected within the scheduled lifetime of the equipment unless replacement is foreseen; specifically, when selecting materials and manufacturing methods, due account shall be taken of the material's corrosion and wear resistance, electrical conductivity, impact strength, aging resistance, the effects of temperature variations, the effects arising when materials are put together (for example, galvanic corrosion), the effects of ultraviolet radiation, and to the 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 Component literature

Manufacturers of valves for gaseous hydrogen fueling station shall provide literature for their components. 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. The literature shall be published in the predominant language(s) of the destination country. Critical parts of the component literature shall be worded in the imperative.

Instructions shall include at least the following:

— MAWP and/or Pressure Class (H-rating) in accordance with TS 19880-1;

— material name or code used for the valve body;

— operating temperature limits;

— Cv value;

— requirements for warning labels that might be required as part of the installation;

— names of parts that require periodic replacement and their frequency of replacement. Instructions shall also include, as appropriate;

— installation instructions, including torques;

— installation orientation requirements;

— service procedures; and

— recommendations for service access.

In addition, for externally actuated valves, “fail-safe” (unpowered) position of valve shall be included, and for electrically actuated valves, the area classification of actuator shall be included.

4.5 Marking

4.5.1 Marking information

The valves shall include the following information as required:

— manufacture’s or agent’s name, trademark or symbol;

— model designation (part number);

NOTE 1 Specific information required for each valve can be found in this Standard.

NOTE 2 This information can be provided by a suitable identification code on at least one part of the valve when it consists of more than one part.

4.5.2 Marking method

Marking 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 molded into the component.

5 General test methods

5.1 Test conditions

5.1.1 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.

5.1.2 Pressure

Unless otherwise stated, all pressures noted within this standard are gauge pressure.

5.1.3 Normal test temperature

Unless otherwise stated, any test at room temperature shall be conducted between 15 °C minimum and 35 °C maximum.

5.1.4 Specified test temperature

The tests in these requirements shall be conducted at - 40 °C (± 5°C) and at 85 °C (± 5°C). If the manufacturer specifies the temperature range for use, the test temperatures are the minimum and the maximum of the range.

5.1.5 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.

5.1.6 Test sequence

For any valve type, the tests described in 5.2, 5.3, and 5.4 shall be performed in this sequence using the same test sample.

5.2 Hydrogen gas pressure cycle test

5.2.1 General

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

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 5.3 at room temperature only.

5.2.2 Test method

The outlet of the valve shall be plugged and the inlet shall be attached to hydrogen pressure supply. Cycling shall be between less than 5 % of the MAWP and the MAWP ± 5 % within a period of not less than 6 s (10 cycles/min). 100 000 cycles shall be completed at room temperature, with additional 1 000 cycles at an ambient temperature of - 40 °C (± 5°C) and 1 000 cycles at an ambient temperature of 85 °C (± 5°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.

5.3 Leakage

5.3.1 General

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

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 cm^3 (normal)/h of hydrogen gas using the following test method. This criteria is applicable to all general and specific leakage tests.

This test shall be conducted for 1 min each at two temperature conditions: - 40 °C (± 5°C) and 85 °C (± 5°C). If the manufacture specifies the temperature range for use, the test temperatures are the minimum and the maximum of the range.

5.3.2 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 100 % of the MAWP. A flow measuring device or other method capable of indicating the allowable leak rate shall be used.

5.3.3 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 100% of MAWP, and the pressure for the low pressure test shall be 2,5 % of the MAWP. A flow measuring device capable of indicating the allowable leak rate shall be used.

5.4 Hydrostatic strength test

5.4.1 Test pressure

Valves shall be capable of withstanding without rupture the test pressure of 4 times the MAWP. When the country has its own regulation, the test pressure should follow the regulation.

5.4.2 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 it is not considered a failure as long as the pressure has exceeded 1.5 times the MAWP at the time leakage occurs.

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 the applicable hydrostatic test pressure. This pressure shall be sustained for 1 min without rupturing the valve. A means may be used to reduce the leakage rate if any when performing this test.

5.5 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 5.3.

NOTE The value of 150 % is based on Clause 7 of ISO 12619-2.

5.6 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 300 mm or more (see Fig.1).

b) The outlet connections shall be rigidly supported, 25 mm or more 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; or,

— 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 pressurized to 5 percent of the specified maximum allowable working pressure 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 minutes. Without removing the weight, the valve shall then be tested for leakage as specified in 5.3.

NOTE Depending on how this test is performed, raising the load to compensate buoyancy may be necessary.

e) Conduct procedure d) 4 times, rotating the valve 90º 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 5.3.

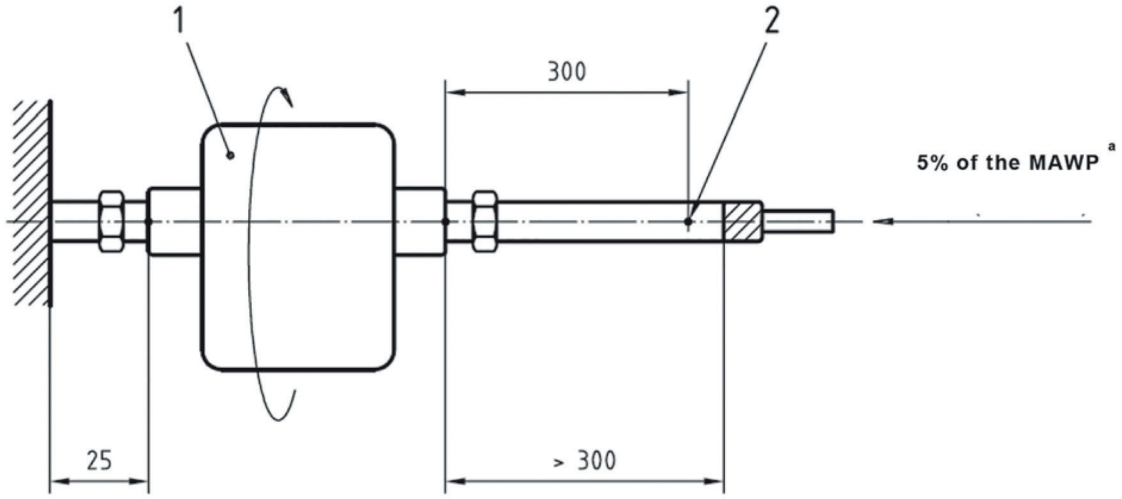
Table 1 shows the pipe diameters and their corresponding bending moments.

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

Table 1 *(continued)*

Outside diameter of pipe mm	Weight kg
12,7	4,5
19,1	8,2
25,4	14,5



Key

1 Component

2 Force point

a 4 x 90º rotation

Figure 1 — Test method of bending moment

5.7 Non-metallic materials test

5.7.1 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.

5.7.2 Non-metallic material test

a) The outlet of the valve shall be plugged and the inlet shall be attached to hydrogen pressure supply

b) Apply hydrogen at the MAWP 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 5.3 Leakage.

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 Test (Clause 6.2)		×
External Leakage (Clause 5.3.2)	×[a]	
Internal Leakage (Clause 6.4)		×
Hydrostatic Strength (Clause 5.4)	×	
Excess Torque Resistance (Clause 5.5)	×	
Bending Moment (Clause 5.6)	×	
Non-metallic Synthetic Material (Clause 5.7)	×	

[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. Prior to conducting this test, the valve shall comply with 6.3 and 6.4.

The inlet of the valve shall be attached to hydrogen pressure supply. Apply MAWP 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 MAWP and the MAWP ± 5 % 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 (± 5°C) and 1 000 cycles at an ambient temperature of 85 °C (± 5°C). If the manufacture 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, 6.4 and 6.5 upon completion of the 102 000 cycles.

6.3 External leakage test

Test specified in 5.3.2 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 100 % of MAWP, and the pressure for the low pressure test shall be 10 % of the MAWP. A leakage measuring device capable of indicating the allowable leak rate shall be used. Leakage shall be no more than 10 cm^3 (normal)/ h.

6.5 Hydrostatic strength test

Test specified in 5.4 shall be conducted as stated.

6.6 Excess torque resistance test

Test specified in 5.5 shall be conducted as stated.

6.7 Bending moment test

Test specified in 5.6 shall be conducted as stated.

6.8 Non-metallic synthetic material test

Tests specified in 5.7 shall be conducted as stated.

7 Excess flow valves

7.1 General

Excess flow valves include:

— Internal excess flow valve

Excess flow valve installed inside the cylinder or cylinder valve

— External excess flow valve

Excess flow valve installed outside the cylinder or cylinder valve

— Shut-off type excess flow valve

Excess flow valve that stops flow when in the closed position

— Flow-limiter type excess flow valve

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 standard provides requirements for two different designs: internal and external excess flow valves. A valve of either design could 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, 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 Requirement
Hydrogen Gas Pressure Cycle Test (Clause 5.2)	×[a]	
External Leakage (Clause 5.3.2)	×	
Internal Leakage (Clause 7.2.5)		×
Hydrostatic Strength (Clause 5.4)	×	
Excess Torque Resistance (Clause 5.5)	×	
Bending Moment (Clause 5.6)	×	
Non-metallic Synthetic Material (Clause 5.7)	×	
Operation Cycle Test (Clause 7.2.10)		×
Operation Test (Clause 7.2.11)		×
Pressure Impulse Test (Clause 7.2.12)		×
[a] Upon completion of this test, the valve needs to pass 7.2.4, 7.2.5, and 7.2.6.		

7.2.3 Hydrogen gas pressure cycle test

Test specified in 5.2 shall be conducted as stated.

The valve shall comply with 7.2.4, 7.2.5 and 7.2.6 upon completion of the 102 000 cycles.

7.2.4 External leakage test

Test specified in 5.3.2 shall be conducted as stated.

7.2.5 Internal leakage test

Test specified in 5.3.3 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 Hydrostatic strength test

Test specified in 5.4 shall be conducted as stated in open position.

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

7.2.7 Excess torque resistance test

Test specified in 5.5 shall be conducted as stated.

7.2.8 Bending moment test

Test specified in 5.6 shall be conducted as stated.

7.2.9 Non-metallic synthetic material test

Tests specified in 5.7 shall be conducted as stated.

7.2.10 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 7.2.11.

7.2.11 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.

7.2.12 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 pressurized 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) MAWP 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 7.2.10.

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 Test (Clause 5.2)	×[a]	
External Leakage (Clause 5.3.2)	×	
Hydrostatic Strength (Clause 5.4)	×	
Excess Torque Resistance (Clause 5.5)	×	
Bending Moment (Clause 5.6)	×	
Non-metallic Synthetic Material (Clause 5.7)	×	
[a] Upon completion of this test, the valve is to pass 8.2.3 and 8.2.4.		

8.2.2 Hydrogen gas pressure cycle test

Test specified in 5.2 shall be conducted as stated.

The valve shall comply with 8.2.3 and 8.2.4 upon completion of the 102 000 cycles.

8.2.3 External leakage

Test specified in 5.3.2 shall be conducted as stated.

8.2.4 Hydrostatic strength

Test specified in 5.4 shall be conducted as stated.

8.2.5 Excess torque resistance

Test specified in 5.5 shall be conducted as stated.

8.2.6 Bending moment

Test specified in 5.6 shall be conducted as stated.

8.2.7 Non-metallic synthetic material

Test specified in 5.7 shall be conducted as stated.

9 Hose breakaway devices

9.1 Electrical conductivity

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

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 Test (Clause 5.2)	×[a]	
External Leakage Test (Clause 9.2.3)		×
Hydrostatic Strength (Clause 9.2.4)		×
Excess Torque Resistance (Clause 5.5)	×	
Bending Moment (Clause 5.6)	×[b]	
Non-metallic Synthetic Material (Clause 5.7)	×	
Separation Test (Clause 9.2.8)		×
Impact Test (Clause 9.2.9)		×
Drop Test (Clause 9.2.10)		×
Twisting Test (Clause 9.2.11)		×
Cold gas in warm valve test (Clause 9.2.12)		×

[a] Upon completion of the test, the device needs to pass 9.2.3 and 9.2.4; [b] Not applicable for devices with an unfixed end.

9.2.2 Hydrogen gas pressure cycle test

Test specified in 5.2 shall be conducted as stated.

The valve shall comply with 9.2.3 and 9.2.4 upon completion of the 102 000 cycles.

9.2.3 External leakage test

A hose breakaway device shall not leak more than 10 cm^3 (normal)/h 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.

This test shall be conducted at - 40 °C (± 5°C) and at 85 °C (± 5°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 MAWP 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 MAWP. When equilibrium conditions are attained, the leakage shall be measured.

The leakage rate under any test condition shall not exceed 10 cm^3 (normal)/h using hydrogen as the test medium.

9.2.4 Hydrostatic strength test

Hose breakaway devices shall be capable of withstanding a test pressure equal to 3 times the MAWP without rupture. Because the hydrostatic strength test is a terminal test, do not use these test samples for any further testing.

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 3 times the MAWP. 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 1,5 times the MAWP 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 1,5 times the MAWP at the time when leakage occurs.

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 4 times the MAWP or observe the relevant national standard 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.

9.2.5 Excess torque resistance test

Test specified in 5.5 shall be conducted as stated.

9.2.6 Bending moment test

Test specified in 5.6 shall be conducted as stated. If the breakaway device is not fixed at either end, this test is not applicable.

9.2.7 Non-metallic synthetic material test

Test specified in 5.7 shall be conducted as stated.

9.2.8 Separation test

When tested in accordance with the following method, the hose breakaway device shall separate upon application of a maximum pull force of 1000 N but not less than 220 N when the device is installed as specified by the manufacturer. Upon separation under the pressurized 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 through a maximum 1,5 mm orifice.

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 pressurized, 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	Number of "one time use" samples to test
1	- 40 °C	Atmospheric	5	2
2	85 °C	Atmospheric	5	2
3	- 40 °C	MAWP	5	2
4	85 °C	MAWP	5	2
			Note: one sample, tested 20 times.	Note: total samples, each test once.

9.2.9 Impact test (applicable to rigid-mount devices)

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.

Test method

This test shall be conducted with a hose breakaway device conditioned at - 40 °C (± 5°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 center 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 center line of the outlet gas pathway, with the device being turned 90º 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 9.2.8.

9.2.10 Drop test

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

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 fueling hose of 4,6 m in length in the connected configuration and

conditioned at - 40°C (± 5°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 pressurized to the MAWP. Drop the pressurized device five more times. Upon completing the drops, disconnect the device and repeated the above procedures on the disconnected halves; except that the pressurized halve 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 pressurized.

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 fueling hose of 4,6 m in length, conditioned at - 40°C (± 5°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 pressurized to the MAWP and subjected to five additional drops; except that the pressurized 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 pressurized.

Upon completion of the above procedure:

The disconnected halves of "one time use" devices shall comply with 5.3, while "reusable" devices shall comply with 9.2.3 in the separated configuration and with 9.2.3 and 9.2.4 in the reassembled configuration.

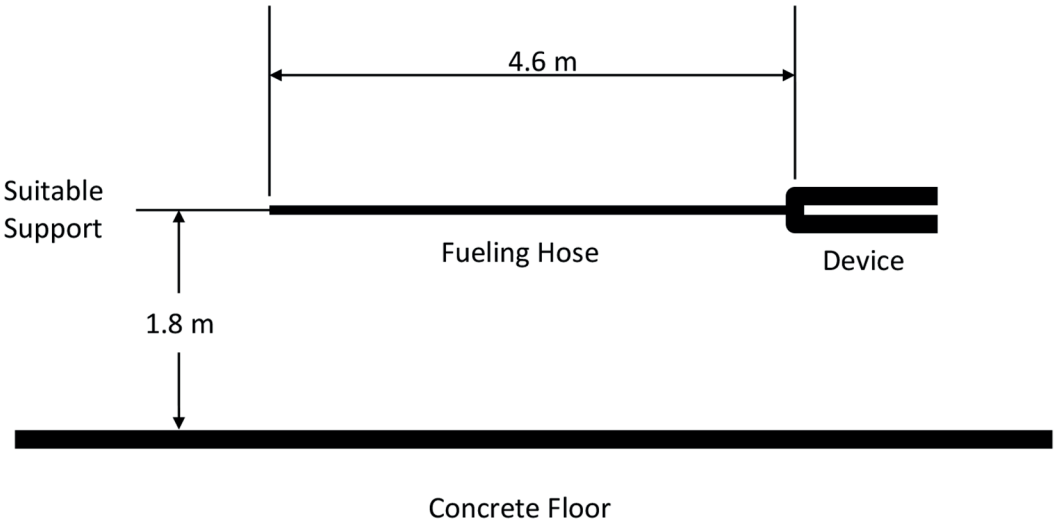


Figure 2 — Drop Test

9.2.11 Twisting test

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.

Test method

Rotation shall be checked at 0 MPa and at the manufacturer's specified MAWP. 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 MAWP (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 180º at a maximum of 10

cycles/min. A cycle shall consist of rotating the movable portions of the device 180º and then back to their original position.

The device shall be rotated for 25 000 cycles at - 40 °C (± 5°C) and 25 000 cycles at 85 °C (± 5°C). Following cycling, the device shall comply with 9.2.3 and 9.2.8.

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.

9.2.12 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 (± 5°C) at a flow rate of 30 g/s for a minimum of 3 min. For those valves which have ports open to atmosphere or external moving parts, this test shall be conducted at 90 % relative humidity (ambient conditions). The valve shall be depressurized and re- pressurized after a 2 min hold period.

This test shall be repeated 10 times. Then the test procedure shall be repeated for additional ten cycles, except that the hold period shall be increased to 15 min.

9.2.13 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 Test (Clause 5.2)	×[a]	
External Leakage (Clause 5.3.2)	×	
Internal Leakage (Clause 5.3.3)	×	
Hydrostatic Strength (Clause 5.4)	×	
Excess Torque Resistance (Clause 5.5)	×	
Bending Moment (Clause 5.6)	×	
Non-metallic Synthetic Material (Clause 5.7)	×	
Maximum Flow Shut-off (Clause 10.2.9)		×
Operation Test (Clause 10.2.10)		×
Excess Torque Operation (Clause 10.2.11)		×
[a] Upon completion of the test, the valve needs to pass 10.2.3, 10.2.4, and 10.2.5.		

10.2.2 Hydrogen gas pressure cycle test

Test specified in 5.2 shall be conducted as stated.

The valve shall comply with 10.2.3, 10.2.4 and 10.2.5 upon completion of the 102 000 cycles.

10.2.3 External leakage test

Test specified in 5.3.2 shall be conducted as stated.

10.2.4 Internal leakage test

Test specified in 5.3.3 shall be conducted as stated.

10.2.5 Hydrostatic strength test

Test specified in 5.4 shall be conducted as stated.

10.2.6 Excess torque resistance test

Test specified in 5.5 shall be conducted as stated.

10.2.7 Bending moment test

Test specified in 5.6 shall be conducted as stated.

10.2.8 Non-metallic synthetic material test

Tests specified in 5.7 shall be conducted as stated.

10.2.9 Maximum flow shut-off test

A valve shall function properly when gas is passing through it at the MAWP and the maximum flow rate.
Test method

This test shall be performed with the valve at a temperature of - 40°C (± 5°C). If the manufacture specifies the minimum temperature for use, the test temperatures is the minimum temperature.

The inlet of the valve shall be connected to a system capable of supplying clean test gas at the MAWP 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 MAWP. 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 5.3.

10.2.10 Operation test

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

10.2.11 Test method

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 MAWP. Stop pressurization but maintain the inlet pressure at the MAWP. Open the manual valve to release pressure. Repeat this close/open procedure 150 times at -40°C (±5°C) and another 150 times at 85°C (± 5°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.

10.2.12 Excess torque operation

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

Test method

With no pressurization, close the valve by applying to its handle 150% or more 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 Test (Clause 11.2)		×
External Leakage (Clause 11.3)		×
Hydrostatic Strength (Clause 5.4)		×
Excess Torque Resistance (Clause 5.5)	×	
Bending Moment (Clause 5.6)	×	
Non-metallic Synthetic Material (Clause 5.7)	×	
Operation Test (Clause 11.8)		×

11.2 Hydrogen gas pressure cycle test

The setpoint of the PSV shall be set at a value higher than the MAWP, which is sufficient to prevent it from activation. Prior to conducting this test the valve shall comply with 5.3. The PSV shall withstand 102 000 cycles of hydrogen gas pressure cycle between less than 5 % of the MAWP and the MAWP ± 5 % within a period of not less than 6 s (10 cycles/min). 100 000 cycles shall be completed at room temperature, with additional 1 000 cycles at an ambient temperature of - 40 °C (± 5°C) and 1 000 cycles at an ambient temperature of 85 °C (± 5°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 and 11.4 upon completion of the 102 000 cycles.

11.3 External leakage test

Test specified in 5.3.2 shall be conducted as stated. Test the PSV at - 40 °C (± 5°C), 20 °C (± 5°C) and 85 °C (± 5°C) at MAWP.

11.4 Hydrostatic strength test

Test specified in 5.4 shall be conducted as stated.

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

11.5 Excess torque resistance test

Test specified in 5.5 shall be conducted as stated.

11.6 Bending moment test

Test specified in 5.6 shall be conducted as stated.

11.7 Non-metallic synthetic material test

Tests specified in 5.7 shall be conducted as stated.

11.8 Operation test

Verify the opening and re-seating pressures of the PSV. The opening pressure shall be equal to the set pressure ± 5 % at 20 °C (± 5°C), and ± 5 % at – 40 °C (± 5°C) and 85 °C (± 5°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 °C (± 5°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.

b) Lower the inlet pressure until the PSV re-seats; note that value. The valves are considered to have passed if all the following requirements are met:

   — opening pressures at ± 5 % of the manufacturer's set pressure;

   — re-seating pressures at no less than 90 % of the set pressure; and,

   — re-seating pressures within ± 5 % of the average re-seating pressure.

c) Repeat a) and b) at – 40 °C (± 5°C) and 85 °C (± 5°C). At each test temperature, the following criteria shall be met:

   — opening pressures at ± 10 % of the manufacturer's set pressure;

   — re-seating pressures at no less than 80 % of the set pressure; and,

   — re-seating pressures within ± 10 % of the average re-seating pressure.

12 Shut-off valves

12.1 Classification

Shut-off valves are classified as follows:

Class A – A valve which is cycled as a normal part of the appliance or system operation.

Class B – A valve which is cycled to shut off gas flow to a component or components for the purpose of service, replacement or system shutdown applications.

12.2 Construction and assembly

Diaphragm type valves in which a flexible diaphragm constitutes the gas seal and which utilize control gas on the atmospheric side of the diaphragm shall have the atmospheric side of the main diaphragm enclosed in a gas-tight casing with a means to bleed the control gas.

Diaphragm type valves which do not utilize control gas on the atmospheric side of the diaphragm shall have the atmospheric side of the main diaphragm enclosed in a gas-tight casing with a means to vent hydrogen to a safe location in the event of diaphragm rupture.

In addition to the requirements of this standard, electrically actuated valves shall also meet the requirements of "intrinsically safe" as defined in IEC 60079-0.

12.3 Tests

12.3.1 Applicability

The tests required to be carried out are indicated in Table 9.

Table 9 — Tests applicable

Test	General Test Requirement	Specific Test Requirement
Hydrogen Gas Pressure Cycle Test (Clause 12.3.2)		×
External Leakage (Clause 5.3.2)	×	
Internal Leakage (Clause 5.3.3)	×	
Hydrostatic Strength (Clause 5.4)	×	
Excess Torque Resistance (Clause 5.5)	×	
Bending Moment (Clause 5.6)	×	
Non-metallic Synthetic Material (Clause 5.7)	×	
Maximum Flow Shut-off (Clause 12.3.9)		×
Cold Gas in Warm Valve Test (Clause 12.3.10)		×

12.3.2 Hydrogen gas pressure cycle test

A Class 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.

A Class B valve shall withstand 100 cycles of opening and closing at room temperature. Prior to conducting this test, the valve shall comply with 12.3.3 and 12.3.4.

The inlet of the valve shall be attached to hydrogen pressure supply with the outlet open. With the valve closed, the MAWP is applied to the inlet. Stop the test gas supply. Then open the valve and depressurize. Close the valve when the pressure is completely released from it. This constitutes one cycle.

Cycling shall be between less than 5 % of the MAWP and the MAWP ± 5 % 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 (± 5°C) and 1 000 cycles at an ambient temperature of 85 °C (± 5°C). If the manufacture specifies the temperature range for use, the test temperatures are the minimum and the maximum of the range.

The Class A valve shall comply with 12.3.3, 12.3.4 and 12.3.5 completion of the 102 000 cycles.

12.3.3 External leakage test

Test specified in 5.3.2 shall be conducted as stated.

12.3.4 Internal leakage test

Test specified in 5.3.3 shall be conducted as stated.

12.3.5 Hydrostatic strength test

Test specified in 5.4 shall be conducted as stated.

12.3.6 Excess torque resistance test

Test specified in 5.5 shall be conducted as stated.

12.3.7 Bending moment test

Test specified in 5.6 shall be conducted as stated.

12.3.8 Non-metallic synthetic material test

Tests specified in 5.7 shall be conducted as stated.

12.3.9 Maximum flow shut-off test

A valve shall function properly when gas is passing through it at the MAWP and the maximum flow rate. Every size in a family of valves shall be tested.

Test method

The inlet of the valve under test shall be connected to a system capable of supplying clean test gas at the MAWP at – 40 °C (± 5°C) and 85 °C (± 5°C) at the manufacturer's specified maximum flow rate. If the manufacturer specifies the temperature range for use, the test temperatures are the minimum and the maximum of the range. The valve shall be maintained at the required test temperature for 1 h prior to and during the test.

With the outlet of the valve open to the atmosphere, test gas shall be allowed to flow through the valve. After 1 min, and with the gas still flowing, the valve shall be capable of completely closing.

After 1 min, with the valve still closed and pressure maintained at the inlet of the valve, measure the leakage at the outlet using an appropriate method.

The leak rate shall be less than 10 cm^3 (normal)/h for hydrogen.

12.3.10 Cold gas in warm valve test

This test is applicable to the Class A valves and hose breakaway devices that are used where pre-cooled gas is carried.

The valve shall be subjected to pre-cooled hydrogen gas at - 40 °C (± 5°C) at a flow rate of 30 g/s for a minimum of 3 min. For those valves which have ports open to atmosphere or external moving parts, this test shall be conducted at 90 % ± 10 % relative humidity (ambient conditions). The valve shall be depressurized and re- pressurized after a 2 min hold period.

This test shall be repeated 10 times. Then the test procedure shall be repeated for additional ten cycles, except that the hold period shall be increased to 15 min.

The valve shall comply with the leakage tests specified in 12.3.3 and 12.3.4.

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