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Gas cylinders — Residual pressure valves — Specification and type testing of cylinder valves incorporating residual pressure devices

Bouteilles à gaz — Robinets à pression résiduelle — Spécifications et essais de type de robinets de bouteille intégrant des dispositifs de pression résiduelle

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO 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).

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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 Technical Committee ISO/TC 58, *Gas cylinders*, Subcommittee SC 2, *Cylinder fittings*.

This second edition cancels and replaces the first edition (ISO 15996:2005), which has been technically revised. It also incorporates the Amendment ISO 15996:2005/Amd 1:2007.

The main changes compared to the previous edition are as follows:

a) Title and scope: extension to cover the complete RPV (valve including the residual pressure device) and not the RPD (residual pressure device) only; informative reference to ISO 10297 was modified;

b) Scope: inclusion of main valves, valves with integrated pressure regulator (VIPRs) and RPVs for pressure drums and tubes; exclusion of dissolved gases, possible application for RPD stand-alone devices;

c) Terms, definitions and symbols: introduction of new definitions and adaptation of existing definitions; introduction of different types of RPDs to replace the old descriptions and change of order (type A became type 2 and type B became type 1);

d) Valve design considerations: inclusion of design considerations with addition of informative Annex A;

e) Performance requirements and considerations:

   1) Closing-off pressure and opening pressure: introduction of requirements for opening pressure and closing-off pressure, especially of a minimum value for the closing-off pressure;

   2) Endurance: reduction of number of endurance cycles for type 2 RPDs;

   3) Visual examination: introduction of visual examination at the end of the complete test procedure;

4) Resistance of the non-return function against pressure in the reverse direction for type 1 RPDs: exclusion of RPDs in VIPRs and adaptation of pass-fail requirements;

5) Leak tightness in the reverse direction for type 1 RPDs: exclusion of RPDs in VIPRs;

6) Integrity under high flow: exclusion of RPDs when installed outside the filling path in a VIPR;

f) RPV type testing:

1) General: introduction of information on how to deal with changes within the RPV design;

2) Test samples: addition of requirement to submit the test samples for oxygen pressure surge testing with the relevant filling connector(s);

3) Test gases: introduction of requirements on the use and quality of the test gases;

4) Test schedule: adaptation to meet the new requirements, addition of test pressure and test temperature; deletion of information on variants;

5) Strength test of the non-return function in the reverse direction for type 1 RPD tests: decrease of number of test samples to one;

6) Verification of opening pressure and closing-off pressure: addition of verification at low and high temperature; addition of detailed test procedure;

7) Leak tightness test in the reverse direction for type 1 RPDs: modification and clarification of tightness test in the flow direction; addition of test at 0,5 bar in the reverse direction;

8) Visual examination: addition of visual examination to the test sequence;

9) Oxygen pressure surge test: information transferred to normative Annex B; addition of test for main valves; addition of detailed information on test procedure;

g) Marking: introduction of marking requirements;

h) Annex A (informative): deletion of examples of RPV designs; introduction of design considerations;

i) Annex B (normative): information on test equipment transferred to informative Annex D; new Annex B giving mandatory requirements on oxygen pressure surge test;

j) Annex C (informative): update of MIL standard reference for vibration test;

k) Annex D (informative): complete modification of integrity under high flow test (reduction of number of test samples, adaptation of gases for which an additional test with carbon dioxide should be carried out, change from liquid carbon dioxide to gaseous carbon dioxide as test gas, modification of test procedure);

l) Annex E: new informative Annex E giving information on test equipment (former Annex B).

Introduction

Increased requirements to avoid contamination of gases and cylinders have led to the development of valves incorporating residual pressure devices (RPDs) hereinafter referred to as residual pressure valves (RPVs).

These devices are designed to maintain a positive pressure relative to atmosphere within the cylinder by closing off its internal gas passages in the discharging direction. This prevents the cylinder from being completely emptied in customer use and stops ingress of atmospheric contamination if the valve operating mechanism (main shut-off) is left open. Many of these devices include a non-return function that protects the cylinder from backflow from downstream processes.

This document has been written so that it is suitable for the application of the UN Model Regulations.

Considering the changes described in the Foreword, when an RPV has been approved according to the previous version of this document, the body responsible for approving the same RPV to this new edition should consider which tests need to be performed.

In this document the unit bar is used, due to its universal use in the field of technical gases. It should, however, be noted that bar is not an SI unit, and that the corresponding SI unit for pressure is Pa (1 bar = 10^5 Pa = 10^5 N/m^2).

Pressure values given in this document are given as gauge pressure (pressure exceeding atmospheric pressure) unless noted otherwise.

Gas cylinders — Residual pressure valves — Specification and type testing of cylinder valves incorporating residual pressure devices

1 Scope

This document specifies design, type testing and marking requirements for cylinder valves incorporating residual pressure devices, hereinafter referred to as residual pressure valves (RPVs). This document applies to the following types of RPVs:

a) cylinder valves intended to be fitted to refillable transportable gas cylinders;

b) main valves (excluding ball valves) for cylinder bundles;

c) cylinder valves or main valves with integrated pressure regulator (VIPR);

d) valves for pressure drums and tubes;

which convey compressed or liquefied gases.

NOTE Where there is no risk of ambiguity, cylinders, pressure drums, tubes and cylinder bundles are addressed with the collective term "cylinder" within this document.

These requirements are in addition to those in ISO 10297.

For RPD stand-alone devices this document can also be applied.

This document does not apply to RPVs for portable fire extinguishers, cryogenic equipment, low pressure refrigerant gases (cylinder test pressure less than 50 bar), dissolved gases or liquefied petroleum gas (LPG).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies

ISO 10286, *Gas cylinders — Terminology*

ISO 10297:2014, *Gas cylinders — Cylinder valves — Specification and type testing*

ISO 10524-3, *Pressure regulators for use with medical gases — Part 3: Pressure regulators integrated with cylinder valves*

ISO 22435, *Gas cylinders — Cylinder valves with integrated pressure regulators — Specification and type testing*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 10286, ISO 10297 and the following apply.

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

— ISO Online browsing platform: available at http://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
residual pressure valve
RPV
valve which incorporates a *residual pressure device* (3.2)

Note 1 to entry: The term "valve" covers the valves listed in Clause 1, a) to d).

3.2
residual pressure device
RPD
device that is designed to prevent ingress of contaminants by maintaining a positive pressure within the cylinder relative to atmosphere by closing off its internal gas passages in the discharging direction

Note 1 to entry: This definition might be different to definitions given in applicable transport regulations.

3.3
type 1 RPD
RPD (3.2) that retains a positive pressure in the cylinder above the pressure downstream of the valve outlet and also incorporates a non-return feature to prevent backflow into the cylinder from a higher pressure on the valve outlet

Note 1 to entry: Cylinders with RPVs with a type 1 RPD located between the filling port and cylinder cannot be filled or vacuumed unless the RPD is neutralized or a special fill connector is used to overcome the non-return feature.

3.4
type 2 RPD
RPD (3.2) that retains a positive pressure in the cylinder above atmospheric pressure but will not prevent backflow into the cylinder if the pressure on the valve outlet is high enough to overcome the RPD mechanism and the residual pressure in the cylinder

Note 1 to entry: Cylinders with RPVs with a type 2 RPD can be filled with a conventional fill connector, but, if located between the filling port and cylinder, cannot be vacuumed or vented below the closing-off pressure unless the RPD is neutralized or a special fill connector is used.

3.5
discharging direction
path taken by gas through the *RPD* (3.2) when flowing out of the cylinder through the outlet connection

3.6
reverse direction
path taken by gas towards the *RPD* (3.2) in the opposite direction to the *discharging direction* (3.5)

3.7
filling direction
path taken by gas through the *RPV* (3.1) when filling the cylinder

Note 1 to entry: Depending on the design of the *RPV* (3.1), filling direction and *reverse direction* (3.6) might be the same.

3.8
opening pressure
differential pressure between upstream pressure and downstream pressure of the *RPD* (3.2) at which the RPD starts to open to allow gas to flow in the *discharging direction* (3.5)

Note 1 to entry: Due to the effects of manufacturing tolerances this is normally expressed as a pressure range.

3.9
closing-off pressure
cylinder pressure at which leak tight closure of the *RPD* (3.2) is achieved during gas withdrawal through the outlet connection

Note 1 to entry: Due to the effects of manufacturing tolerances and different discharge rates this is expressed as a pressure range.

3.10
RPV working pressure
p_w
settled pressure of a compressed gas at a uniform reference temperature of 15 °C in a full cylinder for which the *RPV* (3.1) is intended

Note 1 to entry: This definition does not apply to liquefied gases (e.g. carbon dioxide), or dissolved gases (e.g. acetylene).

Note 2 to entry: The RPV working pressure is expressed in bar.

3.11
RPV test pressure
p_{vt}
pressure applied to a *RPV* (3.1) during testing

Note 1 to entry: The RPV test pressure is a minimum value and is expressed in bar.

3.12
NTP
normal temperature and pressure i.e. 20,0 °C (293,15 K), 1,013 bar absolute (0,101 3 MPa absolute)

3.13
RPV filling connector
device fitted to the filling connection of *RPVs* (3.1) fitted with *type 1 RPDs* (3.3) during filling to overcome the non-return feature and for both *type 1* and *type 2 RPDs* (3.4) during venting and vacuuming

Note 1 to entry: These connectors are design-specific and usually not standardized.

3.14
standard connector
device that is manufactured to an international, regional or national standard which is fitted to the valve filling connection of a valve with or without *RPD* (3.2) to allow users to withdraw gas from the cylinder and which can also be used to fill cylinders having *RPVs* (3.1) fitted with type 2 *RPDs* (3.4)

Note 1 to entry: These connectors are usually standardized.

3.15
RPD neutralization device
device fitted to *RPVs* (3.1) with type 2 *RPDs* (3.4) to neutralize the *RPD* (3.2) if so designed and intended to be neutralized during filling and vacuuming

4 RPV design considerations and requirements

4.1 Design considerations

Design considerations are given in 4.1.1 to 4.1.2 and Annex A.

4.1.1 Resistance against vibration

RPDs should resist leakage of gas due to vibration experienced in transport.

An example of a vibration test is given in Annex C.

4.1.2 Integrity under high flow

RPDs, except when installed outside the filling path in a VIPR, should be able to withstand the dynamic and thermal loads created by the gas flow during cylinder filling and venting.

An example of an integrity under high flow test is given in Annex D.

NOTE This test covers the practice of venting cylinders prior to filling followed by the cylinder filling process. It ensures that the seals within the RPD are not displaced or damaged by the high mass flows, high velocities and low temperatures involved.

4.2 Design requirements

4.2.1 General

RPDs shall operate within specification and be leak tight over a range of service temperatures, from at least –20 °C to +65 °C in indoor and outdoor environments.

Where higher or lower service temperatures are required, any additional requirements and tests shall be agreed between the manufacturer and purchaser.

4.2.2 Valve outlet connection

To accommodate the RPD, the internal dimensions of the RPV outlet connection are permitted to differ from those quoted in the relevant outlet connection standard, provided safety and performance are not compromised and the modified design does not conflict with corresponding standard connectors.

4.3 Performance requirements for RPDs

4.3.1 Requirements for type 1 and type 2 RPDs

4.3.1.1 Opening pressure and closing-off pressure

The opening pressure and closing-off pressure at room temperature shall meet manufacturer's specifications. In addition, the opening pressure and closing-off pressure at low and high temperatures (see Table 2) shall be measured and recorded to ensure that the RPD functions over the specified temperature range (see 4.2.1).

To ensure confident and reliable pre-fill checking of cylinders fitted with RPVs, the closing-off pressure at room temperature shall be no less than 1,5 bar. For specific applications, the closing-off pressure at room temperature may be reduced if agreed between the manufacturer and the purchaser.

NOTE Applicable regulations and/or standards (e.g. ISO 10524-3) or purchasers can require a higher minimum closing-off pressure.

The verification of opening pressure and closing-off pressure is given in 5.9.2.

4.3.1.2 Leakage

Leakage shall not exceed 6 cm^3/h corrected to NTP over the range of temperatures specified in Table 2.

NOTE Leakage of 6 cm^3/h is approximately 4 bubbles of 3,5 mm diameter per minute.

4.3.1.3 Endurance

RPDs shall meet the requirements for the opening pressure given in 4.3.1.1 after endurance testing.

NOTE This requirement is in addition to the endurance test specified in ISO 10297, where the RPV is to be tested with the RPD neutralized using the manufacturer's recommended method or by using a RPV not fitted with the RPD.

The endurance test is given in 5.9.3.

After the endurance test and the subsequent tests/verifications have been performed a visual examination shall be carried out to ensure that no component is displaced (according to the manufacturer's drawing), non-functional (e.g. broken or damaged) or missing.

The visual examination is given in 5.9.5.

4.3.1.4 Resistance to ignition

If required by ISO 10297:2014, 5.9, an oxygen pressure surge test shall be carried out.

The oxygen pressure surge test is given in Annex B, except for VIPRs where the test shall be carried out according to ISO 22435 for industrial applications or ISO 10524-3 for medical applications.

4.3.2 Additional requirements for type 1 RPDs

4.3.2.1 Resistance of the non-return function against pressure in the reverse direction for type 1 RPDs

Except when installed in a VIPR, type 1 RPDs shall be able to resist a hydraulic pressure of 1,5 × p_{vt} in the reverse direction without permanent visible deformation of the metallic components, damage of non-metallic materials or bursting of the RPD.

NOTE Generally, the strength of all RPVs via the RPV inlet connection is covered by ISO 10297.

The strength test of the non-return-function in the reverse direction for type 1 RPDs is given in 5.9.1.

4.3.2.2 Leak tightness in the reverse direction for type 1 RPDs

Except when installed in a VIPR, type 1 RPDs shall meet the leakage requirements given in 4.3.1.2 at 0,5 bar and p_{vt} applied in the reverse direction. The leak tightness test in the reverse direction for type 1 RPDs is given in 5.9.4.

NOTE This test is in addition to the tightness tests given in ISO 10297.

5 RPV type testing

5.1 General

5.1.1 Evaluation of conformity shall be carried out in accordance with the applicable regulations of the countries of use.

To comply with this document, RPVs shall be type tested.

A type test is valid for a given RPV design.

5.1.2 Some changes within the RPV design which could adversely affect RPD performance require tests to be repeated using the number of test samples quoted in Table 2 including:

a) increase of RPV test pressure [repetition of all tests except verification of opening pressure and closing-off pressure, endurance test for type 2 RPDs and (optional) vibration test];

b) change in gas service [addition of relevant parts of (optional) integrity under high flow test, if intended for certain gases as given in Annex D];

c) changes of the RPV filling connector gas passage geometry, e.g. diameter and flow impingement angles, or non-metallic material (repetition of oxygen pressure surge test, if intended for oxygen service, to be decided case by case depending on the change). See Note.

d) changes of metallic RPD components material (repetition of any tests to be decided case by case depending on changes of chemical composition and mechanical properties);

e) changes of non-metallic RPD components material [repetition of all tests except for changes in lubricant material where the strength test in the reverse direction for type 1 RPDs, the leak tightness test in the reverse direction for type 1 RPDs and the (optional) vibration test have not to be repeated];

f) changes to the design of the RPD components, e.g. piston/retainer diameter, dimension of o-ring(s), spring (repetition of tests to be decided case by case depending on the change). See Note.

NOTE Any changes to the RPD piston length or filling connector pin length, which do not affect the total stroke of the RPD piston or the gas passage geometry, usually do not require the oxygen pressure surge test to be repeated.

5.2 Documentation

The manufacturer shall make available, to the test laboratory:

a) a set of drawings consisting of the assembly drawing, parts list, material specifications including material standard for metallic materials and certificates (for the materials used for the test samples), and drawings with sufficient detail to permit satisfactory test sample verification (any change and/or material variant within the given valve design shall be clearly identified) including information about lubricants and adhesives, their approximate amounts and where they are applied;

b) drawings or other documentation with sufficient detail to specify the RPV filling connector for type 1 RPDs used for oxidizing gases. This information may also be submitted by a third party;

c) marking information;

d) a description of the RPV and method of operation including details of opening pressure and closing-off pressure of the RPD;

e) information on the intended use of the RPV [gases and gas mixtures, RPV working or test pressure, service temperatures if outside of the normal temperature range (see 4.2.1), etc.];

f) certificates of material compatibility if not covered by ISO 11114-1 or ISO 11114-2.

5.3 Test samples

Complete RPVs shall be submitted as test samples. The test samples shall be in the condition that the manufacturer intends to supply to the customers.

The number of test samples for testing a RPV design is given in Table 2. Additional test samples can be required for changes within the RPV design in accordance with the requirements of 5.1.2.

If oxygen pressure surge testing is required (see ISO 10297:2014, 5.9) the test samples shall be supplied with a standard connector, if not already available, and with the corresponding RPV filling connector or RPD neutralization device, if needed.

After testing, the test samples shall be rendered unserviceable or shall be clearly marked as test samples to avoid accidental entry into service.

5.4 Test report

A written report shall be issued summarizing the tests carried out and the results obtained, and shall include or reference the documentation listed in 5.2 and, if applicable

a) number of endurance cycles and service conditions, if greater than required, and

b) pressure rise time determined during the oxygen pressure surge test and information on the cycles needed for its calibration.

This report shall be signed by the responsible person(s) of the test laboratory.

5.5 Test temperatures

The test temperatures are given in Table 2.

5.6 Test pressures

5.6.1 RPV test pressure

For compressed gases, p_{vt} is given by Formula (1):

$$p_{vt} = 1{,}2 \times p_w \quad (1)$$

For liquefied gases, e.g. carbon dioxide p_{vt} shall be at least equal to the cylinder test pressure quoted in the relevant transport regulation for that gas or gas group and its intended filling ratio. Where the transport regulation does not specify a cylinder test pressure, the test pressure marked on the cylinder for which the valve is intended shall be used.

NOTE There are regulations that require the valve test pressure to correspond with the standardised valve outlet connection pressure rating.

5.6.2 Other test pressures

The test pressures are given in Table 2.

5.7 Test gases

5.7.1 Gas quality

Gas quality shall correspond to Table 1.

Table 1 — Gas quality

Parameter	Oxygen	All other gases (including air)
Dew point ≤−40 °C at atmospheric pressure[a]	Yes	Yes
Oil content ≤0,1 mg/m^3 [a]	Yes	Yes
Minimum purity ≥99,5 % by volume	Yes	No
Hydrocarbon content ≤0,01 % by volume	Yes	No
Maximum particle size ≤40 µm	Yes	Yes
NOTE Standard industrial gases normally meet the above requirements. [a] These values are identical to Class 2 requirements in ISO 8573-1:2010.		

5.7.2 Verification of opening pressure and closing-off pressure

In general, the verification should be carried out with air or nitrogen. Alternatively, helium, hydrogen or non-flammable mixtures of these gases may be used, if agreed between the manufacturer and the test laboratory.

WARNING — Caution should be taken during handling and testing with hydrogen due to flammability risks. Proper training, procedures and precautions shall be in place prior to testing.

5.7.3 Leak tightness test in the reverse direction for type 1 RPDs

In general, the leak tightness test should be carried out with air or nitrogen. Alternatively, helium, hydrogen or non-flammable mixtures of these gases may be used, if agreed between the manufacturer and the test laboratory.

For valves for helium, hydrogen or their mixtures, the test gas shall be helium, hydrogen or an inert mixture of these gases.

WARNING — Caution should be taken during handling and testing with hydrogen due to flammability risks. Proper training, procedures and precautions shall be in place prior to testing.

5.7.4 Endurance test

In general, the endurance test should be carried out with air or nitrogen. Alternatively, other gases may be used, if agreed between the manufacturer and the test laboratory.

5.7.5 Oxygen pressure surge test

The oxygen pressure surge test shall be carried out with oxygen.

5.7.6 Vibration test

In general, the vibration test should be carried out with air or nitrogen.

5.7.7 Integrity under high flow test

See Annex D.

5.8 Test schedule

The tests shall be carried out in accordance with the schedule given in Table 2.

Table 2 — Test schedule for type testing for a given RPV design

Test	Test and relevant subclause	Condition of test sample	Test temperature °C	Test pressure bar	Test sample number	Number of tests per sample	Total number of tests
1	Strength test of the non-return function in the reverse direction for type 1 RPDs, 5.9.1	As received	Room temperature[a]	$1{,}5 \times p_{vt}$	1	1	1
2	Verification of opening pressure and closing-off pressure, 5.9.2	As received	Room temperature[a]		2 to 4	3	9
3	Endurance test, 5.9.3	From test 2	Room temperature[a]	See 5.9.3	2 to 4[c]	1	3[c]
4	Verification of opening pressure and closing off pressure, 5.9.2	From test 3	-20^{0}_{-5} Room temperature[a] $65^{+2,5}_{-2,5}$	—	2 to 4	9	27
5	Leak tightness test in the reverse direction for type 1 RPDs, 5.9.4	From test 4	-20^{0}_{-5} Room temperature[a] $65^{+2,5}_{-2,5}$	0,5 and p_{vt}	2 to 4	6	18
6	Strength test of the non-return function in the reverse direction for type 1 RPDs, 5.9.1	From test 5	Room temperature[a]	$1{,}5 \times p_{vt}$	2	1	1
7	Visual examination, 5.9.5	From test 5	Room temperature[a]	—	3 to 4	1	2

[a] Typically between 15 °C and 30 °C.

[b] If the RPV is intended to be used for compressed and liquefied gases two test samples are required.

[c] For valves that are required to be pre-conditioned before oxygen pressure surge testing (see ISO 10297:2014, 5.9); three test samples (same test samples as used for preconditioning according to ISO 10297:2014, 6.13) in addition shall be tested.

Table 2 *(continued)*

Test	Test and relevant subclause	Condition of test sample	Test temperature °C	Test pressure bar	Test sample number	Number of tests per sample	Total number of tests
8 (if required, see 4.3.1.4)	Oxygen pressure surge test, Annex B	As received (for valves with lubricants rated for valve test pressure, see ISO 10297:2014, 5.9) or pre-conditioned via endurance cycling procedure according to ISO 10297 (for valves with lubricants not rated for valve test pressure, see ISO 10297:2014, 5.9)	See Annex B	p_{vt}	5a to 7a	1	3
9 (optional)	Vibration test, Annex C	As received	Room temperature[a]	0,5	5b to 7b	1	3
10 (optional)	Integrity under high flow test, Annex D	As received	Room temperature[a]	See Annex D	5c[b]	1	1[b]

[a] Typically between 15 °C and 30 °C.

[b] If the RPV is intended to be used for compressed and liquefied gases two test samples are required.

[c] For valves that are required to be pre-conditioned before oxygen pressure surge testing (see ISO 10297:2014, 5.9); three test samples (same test samples as used for preconditioning according to ISO 10297:2014, 6.13) in addition shall be tested.

5.9 RPD performance tests

5.9.1 Strength test of the non-return function in the reverse direction for type 1 RPDs

The test has to be carried out with the valve operating mechanism (main shut-off) of the RPV open and with the RPV inlet connection open. The hydraulic pressure shall be applied via the RPV outlet connection and be raised continuously and gradually until at least 1,5 × p_{vt} is reached. The pressure shall be maintained for at least 2 min.

After the test, the RPD and its components shall be subjected to a visual examination. An example of test equipment for the strength test is shown in Figure E.1.

5.9.2 Verification of opening pressure and closing-off pressure

The opening pressure and closing-off pressure of all test samples shall be measured. The opening pressure and closing-off pressure at room temperature shall be verified against the manufacturer's specification.

Test equipment shall not introduce any significant flow restrictions.

Before determining the opening pressure and closing-off pressure, the RPD shall be activated three times by pressurising the RPV in the open condition via the valve inlet connection with twice the maximum opening pressure specified by the manufacturer.

Afterwards, the following procedure shall be applied at all required temperatures (according to Table 2) in the following sequence:

a) with the valve operating mechanism open, gradually pressurize the RPV from the valve inlet connection, using a pressurization rate of maximum 10 bar/min. The pressure shall be increased from 0 bar until gas is detected (e.g. visible bubbles) flowing from the RPV outlet connection. The opening pressure shall be recorded;

b) close the valve operating mechanism;

c) further increase the pressure to fill the volume of (0,5 ± 10 %) l water capacity upstream of the RPV (see Figure E.2) to a value of twice the maximum opening pressure specified by the manufacturer;

d) stop the pressure supply by closing the shut-off valve (see Figure E.2) to isolate the volume;

e) open the valve operating mechanism fully and let the pressure decrease through the RPV outlet until the RPD closes. The RPD is considered activated when the flow rate decreases suddenly. Measure the leakage rate. If the leakage rate meets 4.3.1.2, the closing-off pressure has been reached and shall be recorded;

f) if the leakage rate exceeds the value given in 4.3.1.2, vent the gas upstream of the RPV to decrease the pressure in steps of 0,2 bar including a step at the pressure given in 4.3.1.1 and measure the leakage rate at each step. If the leakage rate meets 4.3.1.2, the closing-off pressure has been reached and shall be recorded.

Perform this procedure 3 times.

The opening pressure and closing-off pressure ranges are given by the lowest and highest pressures determined from the recorded data of all verifications (before and after endurance testing) of all test samples at room temperature.

An example of test equipment for the verification is shown in Figure E.2.

5.9.3 Endurance test

The RPD shall be cycled via the RPV inlet connection from the closed position to 2 times the maximum determined opening pressure of all test samples resulting from Test 2 of Table 2 or 10 bar, whichever is the greater.

Type 1 RPDs shall be tested for 100 000 cycles.

Type 2 RPDs shall be tested for 2 000 cycles.

NOTE The number of cycles for type 2 RPDs is the same as the number of endurance cycles for the valve operating mechanism as specified in ISO 10297 because the type 2 RPD does not open and close more frequently than the valve operating mechanism.

The cycle time should usually be set between 3 s and 10 s. Under exceptional circumstances, e.g. for high pressure RPDs, this time may be extended by agreement between the manufacturer and test laboratory. A device may be used for visual indication that the RPD opens and closes.

An example of test equipment for the endurance test is shown in Figure E.3.

5.9.4 Leak tightness test in the reverse direction for type 1 RPDs

The test has to be carried out with the valve operating mechanism (main shut-off) of the RPV open and with the RPV inlet connection open (which will allow to check for internal leakage). The pneumatic pressure shall be applied via the RPV outlet connection.

The pneumatic pressure shall be raised continuously and gradually from 0,1 bar until 0,5 bar is reached. This pressure shall be maintained for at least 1 min before measuring the leakage rate. The pressure

shall then further be raised continuously and gradually until p_{vt} is reached. This pressure shall be maintained for at least 1 min before measuring the leakage rate.

An example of test equipment for the leak tightness test in the reverse direction for type 1 PRD is shown in Figure E.1.

5.9.5 Visual examination

When the endurance test and the subsequent tests/verifications have been completed, components such as o-rings, gaskets, springs and diaphragms shall be subjected to a visual examination.

Note shall be made of any components appearing to be excessively worn even though the RPD met the requirements.

During the visual examination verification that the RPD and its components correspond to the submitted set of drawings shall be carried out and recorded.

6 Marking

RPVs complying with this document shall be marked with the following in addition to the requirements of ISO 10297.

a) All RPVs incorporating a type 1 RPD shall be marked with “T1”. RPVs for specific applications not having a closing-off pressure of minimum 1,5 bar (see 4.3.1.1) shall be marked with “T1A”;

b) All RPVs incorporating a type 2 RPD shall be marked with “T2”. RPVs for specific applications not having a closing-off pressure of minimum 1,5 bar (see 4.3.1.1) shall be marked with “T2A”.

NOTE Attention is drawn to the requirements for marking in relevant regulations that might override the requirements given in this document. The relevant transport regulation might require additional marking.

Annex A
(informative)

Design considerations

When designing RPVs the following aspects should be considered:

a) mechanical stresses;

b) chemical attack;

c) noise caused by the RPD;

d) electrochemical potential relationship of adjacent materials with regard to possible accelerated corrosion inside the RPV;

e) spring material;

f) non-metallic material with regard to possible damage due to explosive decompression with e.g. carbon dioxide;

g) valving into cylinders;

h) for RPDs placed in a RPV outlet: avoiding mechanical interference caused by a gas withdrawal connector made in accordance with a relevant regional, national or International Standard or proprietary design;

i) filling process;

j) transport; and

k) end use of the cylinder.

NOTE EIGA SI 21/13, EIGA IGC Doc 64 and CGA V-9 provide guidance on design considerations.

Annex B
(normative)

Oxygen pressure surge test

All valves shall be tested via the valve filling connection.

If a valve is used in an application where it can be subjected to an oxygen pressure surge via additional connections, the oxygen pressure surge test shall be carried out via all those connections.

In addition, all main valves shall be tested via the valve inlet connection.

If the RPD is not designed or not intended to be neutralized during filling, the tests with the RPD neutralized (test 1 and 2 of Table B.1) are not required.

The oxygen pressure surge test facility shall conform to ISO 10297:2014, C.2.

The test procedure shall conform to ISO 10297:2014, C.3, except that Tables B.1 and B.2 shall be used instead of ISO 10297:2014, Table C.1. The tests shall be carried out as described in those tables but the sequence of tests is not mandated to be in the order listed.

The test sequence for RPVs where the RPD is installed in the filling/outlet connection (no separate outlet connection) is given in Table B.1 and B.2.

In all other designs the oxygen pressure surge testing shall be performed with the RPD in the conditions that an oxygen pressure surge can occur. The testing configuration shall be decided on a case by case basis depending on the specific RPV design.

Table B.1 — Sequence of oxygen pressure surge test from the filling connection for all RPVs with RPD located in the filling/outlet connection (no separate outlet connection)

Test	Valve operating mechanism	RPD	Valve inlet connection	Connector/Device
1	Closed	Neutralized	Open	Corresponding RPV filling connector or RPD neutralization device
2	Open	Neutralized	Sealed with a screwed metallic plug	Corresponding RPV filling connector or RPD neutralization device
3	Open	Not neutralized	Sealed with a screwed metallic plug	Standard connector
4	Closed	Not neutralized	Open	Standard connector

Table B.2 — Sequence of additional oxygen pressure surge test from the inlet connection for a main valve

Tests	Valve operating mechanism	RPD	Valve filling/outlet connection
1	Open	Not neutralized	Sealed with a screwed metallic plug
2	Closed	Not neutralized	Open

Annex C
(informative)

Vibration test

The following test is given as an example of how to reproduce vibration during transport.

The test is carried out with a minimum of 3 samples (at least 1 sample per design change, see 5.1.2).

The residual pressure valve is connected to a 5 l gas cylinder mounted on a vibration apparatus. The test is carried out with an initial pressure of at least 0,5 bar in the gas cylinder and with the main valve orifice open. After being subjected to vibration for 2,5 h (equivalent to 4 000 km, see MIL-STD-810G) along the axis of the RPD, the cylinder pressure should not be less than 50 % of the initial pressure.

For carrying out the test in the laboratory, see for example MIL-STD-810G, Method 514.6, Procedure I, reference spectrum of Figure 514.6C-1.

Annex D
(informative)

Integrity under high flow test

The following test is given as an example of integrity under high flow test.

The test is carried out with the test sample and its corresponding filling/vacuuming connector.

The flow test is carried out on the RPV in the discharging and filling direction with the valve operating mechanism fully open.

SAFETY PRECAUTIONS — The following tests can create an oxygen deficient atmosphere. Suitable precautions should be taken to avoid risk of asphyxiation to personnel.

a) RPVs used for compressed gases should be tested with air or nitrogen at p_w. For this test a cylinder of nominal 20 l water capacity should be used. The internal cylinder cleanliness should not compromise the quality of the gas as given in Table 1.

b) RPVs used for liquefied gases should be tested with gaseous carbon dioxide. For the test with gaseous carbon dioxide, a cylinder of nominal 10 l water capacity filled using a minimum filling ratio of 0,6 should be used having a minimum cylinder pressure of 40 bar at the beginning of the test. The carbon dioxide should meet food grade quality to ensure a low level of moisture content.

c) RPVs used for both, compressed and liquefied gases, and for gas mixtures containing a vaporised high pressure liquefied gas should be tested according to both a) and b).

The test should be carried out as follows:

a) Discharging direction (see Figure D.1): a filled cylinder should have its contents discharged safely 10 times to the atmosphere through the RPV in the discharging direction with the valve operating mechanism fully open and with the outlet unobstructed. If the test sample is not directly fitted to the cylinder the gas passage diameter upstream of the test sample should be such that its flow capacity is greater than the flow capacity of the RPV. The closing-off pressure should be determined after each blow down before cylinder warm up and should be at least 50 % of the minimum closing-off pressure specified by the manufacturer;

b) Filling direction (see Figure D.2), if the RPD is located such that gas passes through it during filling: a filled cylinder should have its contents discharged safely 10 times to the atmosphere through the RPV in the filling direction with the valve operating mechanism fully open and with the inlet unobstructed. Any RPD should be neutralized.

After the test the opening pressure and closing-off pressure should be checked according to the procedure given in 5.9.2 but only one time at room temperature.

After the test, a visual examination should be carried out to ensure that no component has been displaced (according to the manufacturer's drawing), non-functional (e.g. broken or damaged) or missing.