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Gas cylinders — Cylinder valves with integrated pressure regulators — Specification and type testing

Bouteilles à gaz — Robinets de bouteilles avec détendeur intégré — Spécifications et essais de type

Reference number
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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 58, *Gas cylinders*, Subcommittee SC 2, *Cylinder fittings*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 23, *Transportable gas cylinders*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 22435:2007), which has been technically revised. It also incorporates the Amendment ISO 22435:2007/Amd. 1:2012.

The main changes are as follows:

— Introduction: clarification that this document gives additional requirements to those specified in ISO 10297, ISO 17871, ISO 17879 and ISO 23826, unless specifically mentioned.

— Scope:

  — requirements in this document are in addition to those specified in ISO 10297, ISO 17871, ISO 17879 and ISO 23826, unless specifically mentioned;

  — clarification of different VIPR types with different positions of primary operating mechanism within the valve;

  — exclusion of VIPRs for liquefied petroleum gas (LPG) and cryogenic applications.

— Terms and definitions: definition of a primary valve operating mechanism.

— Introduction of VIPR types A, B and C for easy referencing of different design types.

— Symbols and descriptions:

  — clarification of inlet pressure to the regulating function p_1 and valve test pressure for different gas types;

  — additional characteristic column in table with link to test method, if relevant.

— Design requirements and considerations:

  — general: VIPRs to comply with the relevant closure standards;

  — materials: lubricant requirements given in relevant closure standard;

  — pressure and flow indicating devices: relevant pressure indicator requirements in this document;

  — cylinder connection: subclause removed;

  — main shut-off valve: subclause removed because requirements already given in relevant closure standard;

  — pressure adjusting device: addition of a new subclause;

  — leakage: total external and internal leakage shall not exceed 12 cm^3/h;

  — mechanical strength: mechanical strength of inlet side moved to relevant closure standard;

  — resistance to ignition: moved to ISO 10297;

  — resilience to ignition: addition of a new subclause;

  — resistance to vibration and resistance to shock: addition of two new subclauses.

— Type testing:

  — general: clarification of changes to the VIPR design that require repetition of type tests;

  — test schedule: table reformatted for relevant tests;

  — test method for accuracy of VIPR with flowmeter: reference standard changed to ISO 2503;

  — test methods for leakage: test for regulating device only;

  — test method for the endurance test of the VIPR with the pressure regulator valve acting as primary valve operating mechanism: moved to ISO 10297;

  — test method for endurance of the filling connection closing device: moved to ISO 10297;

  — test method for VIPR pressure regulator endurance test: addition of new test.

— Removal of previous Annex A "Valve impact test" and Annex B "Endurance test", because both are already given in relevant closure standards.

— Addition of new Annexes A, B, C and D.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Valves with integrated pressure regulators (VIPRs) are used to reduce the pressure receptacle pressure to a lower pressure suitable for end use processes.

VIPRs incorporate the basic functionality of a primary valve operating mechanism, with the additional ability to regulate the pressure and/or flow at the valve outlet. They remove the need for end users to make and break a high-pressure gas connection.

These valves operate over a wide range of inlet and outlet pressures and flows which require specific design characteristics. It is important that the operating characteristics of these valves be specified and tested in a defined manner.

Such valves are more complicated than conventional cylinder valves yet subject to the same environmental and transport conditions. These conditions should be kept in mind at the design and development stage.

This document gives additional requirements for VIPRs to those given for cylinder valves in general in ISO 10297, for quick-release cylinder valves in ISO 17871, for self-closing cylinder valves in ISO 17879 or for ball valves in ISO 23826.

This document focusses on:

a) suitability of materials;

b) safety (mechanical strength, safe relief of excess pressure, etc.);

c) gas-specificity;

d) cleanliness;

e) testing;

f) identification;

g) information supplied.

When a VIPR has been tested according to the previous version of this document, the organisation responsible for testing the same VIPR to this document 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. Bar is not an SI unit and 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.

Tests and examinations performed to demonstrate compliance with this document are conducted using instruments calibrated before being put into service and thereafter according to an established programme.

Any tolerances given in this document include measurement uncertainties.

Gas cylinders — Cylinder valves with integrated pressure regulators — Specification and type testing

1 Scope

This document specifies design, type test methods, marking and instruction requirements for cylinder valves with integrated pressure regulators (VIPRs) intended to be fitted to gas cylinders, pressure drums or tubes or used as a main valve for bundles of cylinders that convey compressed, liquefied or dissolved gases.

These are requirements for VIPRs that are in addition to those given in the relevant closure standard, for example, in ISO 10297 for cylinder valves, in ISO 17871 for quick-release cylinder valves, in ISO 17879 for self-closing cylinder valves or in ISO 23826 for ball valves. For ISO 17871, these requirements are only applicable to quick-release cylinder valves types B, C, D and E.

NOTE 1 If the pressure regulating system of a VIPR is acting as the primary valve operating mechanism, it is covered by the relevant closure standard, e.g. ISO 10297, ISO 17871, ISO 17879 and ISO 23826. This also includes designs where closure of the primary valve operating mechanism of a VIPR is obtained by closing the seat of the pressure regulating system.

NOTE 2 If the primary valve operating mechanism of a VIPR is located at the low-pressure side of the pressure regulating system, it is covered by the relevant closure standard, e.g. ISO 10297, ISO 17871, ISO 17879 and ISO 23826.

NOTE 3 The term “pressure receptacle” is used within this document to cover instances where no differentiation is necessary between gas cylinders, bundles of cylinders, pressure drums and tubes.

This document does not apply to VIPRs for

a) medical applications (see ISO 10524-3);

b) liquefied petroleum gas (LPG);

c) cryogenic applications.

NOTE 4 Additional requirements for a VIPR with a residual pressure device (RPD) are specified in ISO 15996.

NOTE 5 Additional requirements for pressure relief valves can exist in international/regional regulations/standards.

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 5171:2019, *Gas welding equipment — Pressure gauges used in welding, cutting and allied processes*

ISO 2503:2009, *Gas welding equipment — Pressure regulators and pressure regulators with flow-metering devices for gas cylinders used in welding, cutting and allied processes up to 300 bar (30 MPa)*

ISO 7289, *Gas welding equipment — Quick-action couplings with shut-off valves for welding, cutting and allied processes*

ISO 9090, *Gas tightness of equipment for gas welding and allied processes*

ISO 10156, *Gas cylinders — Gases and gas mixtures — Determination of fire potential and oxidizing ability for the selection of cylinder valve outlets*

ISO 10225, *Gas welding equipment — Marking for equipment used for gas welding, cutting and allied processes*

ISO 10286, *Gas cylinders — Vocabulary*

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

ISO 17871, *Gas cylinders — Quick-release cylinder valves — Specification and type testing*

ISO 17879, *Gas cylinders — Self-closing cylinder valves — Specification and type testing*

ISO 23826, *Gas cylinders — Ball valves — Specification and testing*

ISO/TR 28821, *Gas welding equipment — Hose connections for equipment for welding, cutting and allied processes — Listing of connections which are either standardised or in common use*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 10286, ISO 10297, ISO 2503 and the following apply.

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

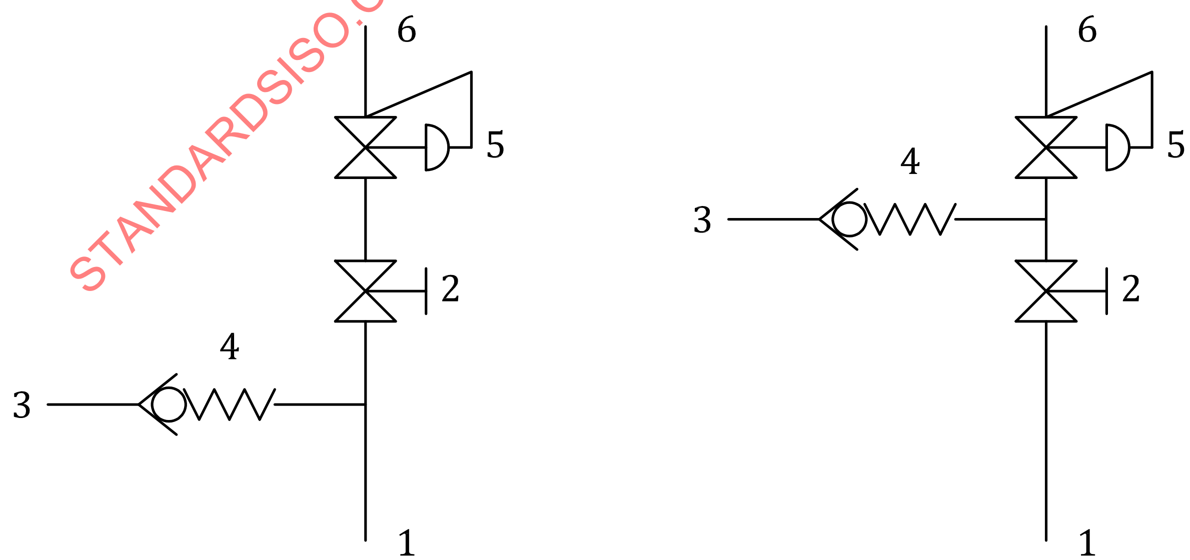
— ISO Online browsing platform: available at https://www.iso.org/obp

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

3.1
valve with integrated pressure regulator
VIPR
device intended to be permanently fitted to a pressure receptacle which comprises of at least a shut-off function and pressure regulating system

3.2
VIPR type A
VIPR (3.1) design where the *primary valve operating mechanism* (3.5) is located upstream of the *pressure regulating system* (3.7)

Note 1 to entry: For typical designs, see Figure 1. The filling connection can also be located between the primary valve operating mechanism and the pressure regulating system.



a) Filling connection upstream of the primary valve operating mechanism

b) Filling connection between the primary valve operating mechanism and the pressure regulating system

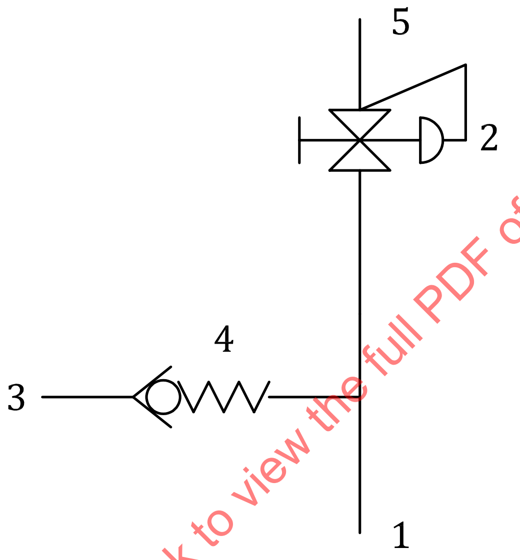
Key

1 valve inlet connection
2 primary valve operating mechanism
3 valve filling connection
4 filling connection closing device
5 pressure regulating system
6 valve outlet connection

Figure 1 — General structure of a VIPR type A design

3.3
VIPR type B
VIPR design where the *pressure regulating system* (3.7) is also acting as the *primary valve operating mechanism* (3.5)

Note 1 to entry: See Figure 2.



Key

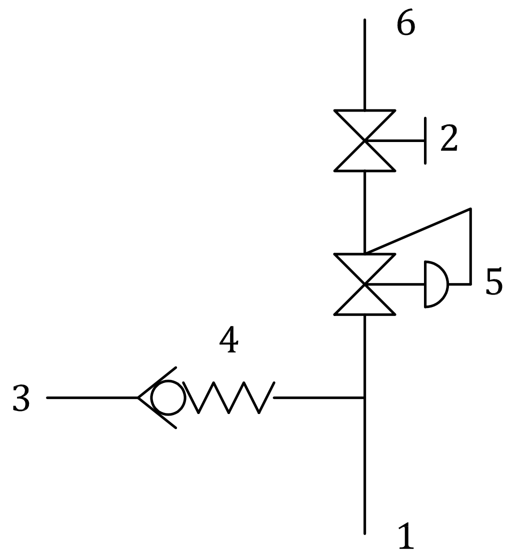
1 valve inlet connection
2 pressure regulating system including primary valve operating mechanism
3 valve filling connection
4 filling connection closing device
5 valve outlet connection

Figure 2 — General structure of a VIPR type B design

3.4
VIPR type C
VIPR design where the *primary valve operating mechanism* (3.5) is located downstream of the *pressure regulating system* (3.7)

Note 1 to entry: The primary valve operating mechanism can be a flow selector.

Note 2 to entry: See Figure 3.



Key

1 valve inlet connection
2 primary valve operating mechanism
3 valve filling connection
4 filling connection closing device
5 pressure regulating system
6 valve outlet connection

Figure 3 — General structure of a VIPR type C design

3.5
primary valve operating mechanism
mechanism which isolates the pressure receptacle contents by closing and opening the shut-off valve orifice and which includes the internal and external sealing systems

3.6
secondary shut-off mechanism
mechanism which is located downstream of the *primary valve operating mechanism* (3.5) and which closes and opens a shut-off valve orifice

3.7
pressure regulating system
device that reduces the inlet pressure to a controlled outlet pressure

Note 1 to entry: A pressure regulating system can comprise of one or more stages of pressure regulation.

3.8
maximum closing pressure
p_{4max}
maximum value of p_4 that can be achieved by combination of pressure receptacle pressure and various settings of set pressure and flow rate

3.9
flow characteristic
variation of the outlet pressure in relation to the rate of flow from zero to maximum capacity flow of the pressure regulator with the inlet pressure remaining constant

3.10
hysteresis
<valves> lagging of the outlet pressure (effect) when the flow (cause) is varied so that at a constant inlet pressure the values of outlet pressure measured with increasing flow do not coincide with the values of outlet pressure measured with decreasing flow

3.11
orifice
restriction of known cross-section that delivers a constant flow of gas when supplied with gas at a constant upstream pressure and temperature

3.12
pressure characteristic
variation of the outlet pressure with variation of the inlet pressure under specific initial flow conditions

3.13
pressure relief valve
valve designed to release excess pressure at a pre-set value

3.14
test inlet pressure
p_3
inlet pressure at which the standard discharge of the pressure regulator, Q_1, is measured

3.15
test outlet pressure
p_5
highest or lowest value of the outlet pressure resulting from a variation in the inlet pressure between p_1 and p_3 at previously adjusted conditions p_1, p_2, Q_1

3.16
nominal discharge
Q_n
<VIPR with flow metering devices> discharge specified by the manufacturer

Note 1 to entry: It is measured downstream of the flow-adjusting and measuring devices.

3.17
pressure outlet
outlet intended to deliver gas at a controlled pressure

3.18
filling connection closing device
closing device located in the filling connection

EXAMPLE Non-return valve, isolating valve.

3.19
flow metering device
device that measures and indicates the flow of a specific gas or gas mixture

4 Symbols and descriptions

The symbols used for the physical characteristics are given in Table 1.

Table 1 — Symbols and descriptions

Symbol	Term	Characteristic
i	irregularity coefficient	$i = (p_5 - p_2) / p_2$ Test method given in 6.12.5.
p_1	inlet pressure to the pressure regulating system	For compressed gases $p_1 = p_w$ For acetylene p_1 = 25 bar [a] For CO_2 p_1 = 200 bar For other gases not listed above, p_1 shall be specified by the manufacturer.
p_2	nominal outlet pressure	As required by the VIPR application. To be specified by the manufacturer.
P_{2m}	inter-stage pressure	To be specified by the manufacturer.
p_3	test inlet pressure (see also 3.14)	For VIPR without RPD: $p_3 = (2\ p_2 + 1\ \text{bar})$ For VIPR with RPD: $p_3 = (2\ p_2 + 6\ \text{bar})$ For VIPR with $p_2 > 20$ bar: p_3 to be specified by the manufacturer.
p_4	closing pressure after stopping the standard discharge downstream of the VIPR	Test method given in 6.12.3.
p_{4max}	maximum closing pressure (see 3.8)	Test method given in 6.12.3.2.
p_5	test outlet pressure	The highest or lowest outlet pressure during a test for determining i.
p_{vt}	valve test pressure	As given in the relevant closure standard, e.g. ISO 10297, ISO 17871, ISO 17879 and ISO 23826.
p_{vht}	valve hydraulic test pressure	As given in the relevant closure standard, e.g. ISO 10297, ISO 17871, ISO 17879 and ISO 23826.
p_w	valve working pressure	As given in the relevant closure standard, e.g. ISO 10297, ISO 17871, ISO 17879 and ISO 23826.
Q_1	standard discharge of a pressure regulator with a pressure outlet	To be specified by the manufacturer.
Q_{max}	maximum discharge	Test method given in 6.12.3.2.
Q_n	nominal discharge (see 3.16) of a pressure regulator with a flow-metering device	To be specified by the manufacturer.
Q_{RV}	discharge of the pressure relief valve	Test method given in 6.14.
R	coefficient of pressure increase upon closure	$R = (p_4 - p_2) / p_2$ Test method given in 6.12.4.
T_{or}	overtorque for the pressure adjusting device	Test method given in Annex C.

[a] 1 bar = 0,1 MPa = 10^5 Pa; 1 MPa = 1 N/mm^2.

NOTE See ISO 2503 for definitions for p_1, p_2, p_4, Q_1, Q_{max} and Q_{rv}.

5 Design requirements and considerations

5.1 General

Unless otherwise specified, all requirements will apply to all types of valves with integrated pressure regulator (VIPR), i.e. VIPR type A, VIPR type B and VIPR type C.

A VIPR shall meet the requirements given in the relevant closure standards (e.g. ISO 10297, ISO 17871, ISO 17879 or ISO 23826).

5.2 Description

A VIPR typically comprises

— a body,

— an inlet connection to the pressure receptacle,

— a primary valve operating mechanism,

— a valve operating device,

— a filling connection,

— the pressure regulating system,

— a pressure relief valve on the low-pressure side of the regulating system,

— an outlet connection (for the end user).

A VIPR can also be fitted with

— a mechanism to set the outlet flow,

— a pressure relief device, e.g. burst disc, on the high-pressure side to protect the pressure receptacle,

— a dip tube,

— a screwed plug or cap on the outlet and/or the filling connection,

— an excess flow limiting device,

— a means of preventing the ingress of atmospheric air,

— a residual pressure device (see ISO 15996),

— pressure indicator(s) on the high and/or low-pressure sides of devices,

— a flow indicator (e.g. flowmeter or flow gauge),

— contamination prevention measures, e.g. filters, anti-dust tube.

5.3 Materials

The material compatibility and lubricant requirements are given in the relevant closure standard (e.g. ISO 10297, ISO 17871, ISO 17879 or ISO 23826).

5.4 Pressure and flow indicating devices

5.4.1 General

Pressure and flow indicating devices shall be of the fail-safe type (in case of a failure due to pressure, the gas shall be released safely and no parts that are able to cause injuries shall be ejected). Examples of these devices can be found in ISO 2503:2009, Figure A.2.

Pressure and flow indicating devices should be designed to minimize moisture ingress and to prevent moisture accumulation.

5.4.2 Flowmeters

Such devices shall not rupture when tested in the installed condition in accordance with 6.10.

5.4.3 Pressure indicators and flow gauges

There is a need to prevent a dangerous discharge of gas if an indicating device is damaged. When bourdon tube indicators are used, the inlet orifice of such devices shall be limited to a maximum of 0,1 mm^2 and the orifice shall always be retained within the valve if the indicator is sheared off.

EXAMPLE The orifice can be within the valve body itself or within the part of the indicator that is retained in the valve body if the rest of the indicator is sheared off.

Such devices shall be tested for overpressure and leakage in the installed condition in accordance with 6.11.

Design and manufacturing requirements from ISO 5171 should be applied, if relevant to the design of VIPR and indicating devices.

5.5 Outlet connection

The connection shall be either

a) a welding hose connection (e.g. ISO/TR 28821 for a threaded connection or ISO 7289 for a quick connection or other regional or national standards), or

b) a proprietary fitting; if a quick connection is used, it shall comply with the endurance tests of ISO 7289.

If a device (e.g. check valve) is fitted within the outlet connection, it shall be designed so that it does not interfere with a gas withdrawal connection made in accordance with the relevant standard.

5.6 Outlet pressure for acetylene

For acetylene, p_{4max} shall not exceed 1,5 bar.

5.7 Flow control valve (flow controller)

If a flow control valve is fitted, the flow control knob and the valve spindle shall be captive such that they cannot be dismantled without the use of a tool.

Compliance shall be tested by attempting to remove the knob and spindle without the use of a tool.

5.8 Pressure adjusting device

The pressure adjusting device, if fitted, shall be captive and shall be removable only by the use of a tool.

It shall be demonstrated that the pressure regulator valve cannot be held in the open position as a consequence of the pressure regulator spring being compressed to its solid length or by being bound by ice, thereby allowing gas to pass from the high-pressure to the low-pressure side.

It shall also be demonstrated that the bonnet cannot be disassembled without the use of a tool during normal operation of the pressure adjustment device. For a VIPR designed to allow filling of the pressure receptacle through the outlet connection, a special tool may be used to hold the pressure regulating system open for filling only.

Using the pressure adjusting device, it shall not be possible to set a pressure at which the pressure relief valve opens.

Compliance shall be verified by visual inspection.

5.9 Filtration

The pressure regulator valve seat shall be protected from particulate contamination. A dust filter, having an effective cross-section compatible with the discharge, shall be mounted within the VIPR upstream of the pressure regulator valve. The filter shall retain particles greater than or equal to 0,1 mm (100 µm).

5.10 Endurance of the VIPR pressure regulating system

The pressure regulating system shall function satisfactorily after 10 000 operational cycles as given in 6.16. Subsequent to the test, the requirements given in 5.11.2, 5.11.3, 5.12 shall be met, where applicable, depending on whether the VIPR has a pressure outlet or flow metering device. Subsequently, 5.14 shall be met.

After the endurance test and the subsequent leak tightness and performance tests have been performed, a visual examination according to 6.18 shall be carried out to ensure that no component is displaced (no longer in the place where it was installed), loosened, non-functional (e.g. broken) or missing.

5.11 Flow and pressure performance for a VIPR with a pressure outlet

5.11.1 Flow performance and characteristics

The standard discharge, Q_1, and the nominal outlet pressure, p_2, shall be in accordance with the values stated by the manufacturer.

The test method for the standard discharge, Q_1, and nominal outlet pressure, p_2, is given in 6.12.2.

The test method for the maximum discharge, Q_{max}, is given in 6.12.2.

The test method for the flow characteristic is given in 6.12.3.

5.11.2 Coefficient of pressure increase upon closure *R*

The coefficient *R* shall be less than 0,3 when determined in accordance with 6.12.4.

5.11.3 Irregularity coefficient *i*

The coefficient *i* shall be within the limits ±0,3 when determined in accordance with 6.12.5.

5.12 Flow performance for a VIPR with a flow metering device

The accuracy class and flow stability required depend on the application and shall be agreed between the manufacturer and the customer. Typical accuracy classes and flow stability requirements used for welding applications can be found in ISO 2503.

Flow metering devices shall be tested in accordance with 6.13.

5.13 Pressure relief valve

A pressure relief valve shall be provided as a component part of the VIPR to protect the VIPR in case of malfunction of the pressure regulating system, except if prohibited by regulation. For acetylene service, such a valve is optional and its performance shall be specified by the manufacturer. For specific applications, e.g. flammable or toxic gases, no pressure relief valve is required if the low-pressure chamber of the VIPR can withstand p_{vht}.

The pressure relief valve shall be pre-set by the manufacturer to a fixed value or to a fixed differential value above the reduced pressure, and not be able to be adjusted by the user.

The pressure relief valve, if fitted, shall lift automatically to relieve excess pressure and after lifting shall re-seat at a pressure greater than p_{4max}.

For the whole inlet pressure range, the pressure relief valve shall remain gas tight according to 5.14 when the flow is stopped with the adjusting pressure device in the fully open position. The test shall be performed at least at p_1, p_3 and at the inlet pressure corresponding to p_5, if p_5 is greater than p_2.

The minimum discharge of the relief valve Q_{RV} shall be equal to or greater than the standard discharge Q_1 at a pressure p_{RV} equal to $2 \cdot p_2$. If a pressure relief valve is placed between regulating stages, p_{RV} is equal to $2\ p_{2m}$. The test for the pressure relief valve is described in 6.14.

The pressure relief valve and other protection devices shall be fitted in such a way that gas will be discharged safely.

5.14 Leakage

5.14.1 The total external leakage (to the atmosphere) shall not exceed 12 cm^3/h.

NOTE Lower permitted leakage rates are normally agreed upon between manufacturer and customer, e.g. for toxic gases.

5.14.2 The internal leakage through the pressure regulator valve shall not exceed 12 cm^3/h.

The test for leakage is described in 6.17.

5.15 Mechanical strength

The low-pressure chamber shall be capable of withstanding the following pressure without rupturing or showing any sign of deformation:

— for compressed and liquefied gases the greater value of

  — four times its maximum closing pressure, $p_{4,max}$ with a maximum value corresponding to p_{vht}, or

  — 60 bar;

— for acetylene: 30 bar.

For multistage designs, the above requirements shall be applied to the low-pressure chamber of each intermediate regulation stage by using the stage outlet pressure declared by the manufacturer instead of p_2.

If there is no pressure relief valve fitted to the VIPR, the upstream and downstream sides of the regulating system of the VIPR shall withstand p_{vht}.

The test for mechanical strength is described in 6.8.

NOTE This strength test of the regulating stage(s) is in addition to the hydraulic pressure test on the inlet side required by ISO 10297, ISO 17871, ISO 17879 or ISO 23826.

5.16 Pressure resistance

A VIPR shall be designed so that, if the low-pressure chamber of the pressure regulating system is exposed to full inlet pressure, for example, if the pressure regulator valve is held in the open position and the outlet connection is closed, the high-pressure gas shall either be safely retained or vented. This is also applicable to any inter stage chamber for a VIPR with a multi stage pressure regulating system.

The test for the pressure resistance is described in 6.9.

5.17 Resilience to ignition

A VIPR for

— oxygen at any pressure,

— other oxidizing gases (as defined in ISO 10156) requiring a minimum valve test pressure p_{vt} of 30 bar,

— gas mixtures, which are not pre-mixed, containing oxygen at any oxygen partial pressure or other oxidizing gases with a partial pressure greater than 30 bar.

shall be designed to reduce the consequences of an ignition.

Specific consideration shall be given to material selection, because some materials are known to have better resistance to burning following an ignition (e.g. Cu or Ni based alloy), while others are known to resist less so (e.g. aluminium). For more information, see ASTM G63 for non-metallic materials and ASTM G94 for metallic materials.

However, as well as material selection, the consequences of an ignition are also dependent on other design parameters (e.g. geometry and flow paths). Therefore, a promoted ignition test, as given in Annex D, should be performed, which is able to provide a general result of the resilience of a VIPR after an ignition and, in addition, able to provide valuable input for a risk assessment.

5.18 Design requirements for manufacture

A VIPR shall be designed and manufactured in such a way that, during normal customer use, it is not possible to

— dismantle the VIPR or its component parts,

— alter the factory settings.

The test for operating and loosening torques is given in 6.15. Torques are given in the documentation requested from the manufacturer (see 6.2).

5.19 Resistance to vibration

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

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

5.20 Resistance to shock

A VIPR should resist leakage of gas due to shock that can be experienced in transport and handling.

An example of a shock test is given in Annex B.

After the shock test, the pressure receptacle should be checked for leaking at the valve/pressure receptacle neck joint. The VIPR should remain functional to the manufacturer's specification and any pressure or flow indicators should remain intact and functional.

5.21 Over torque of the pressure adjusting device

An example of an overtorque test for the pressure adjusting device is given in Annex C.

For a VIPR that has a regulator adjustment mechanism that is separate to the primary valve operating mechanism, i.e. VIPR type A and VIPR type C, the manufacturer should specify the over torque for the pressure adjusting device (T_{or}). T_{or} should be at least two times the maximum torque needed for regular operation of the pressure adjusting device.

The valve should resist T_{or} without any sign of damage or failure of any component(s) of the pressure adjusting device. This should be checked by visual examination after dismantling the valve. Above T_{or}, no failure should result in ejection of internal valve components. It should prevent the pressure regulating system to be adjusted to an outlet pressure that would activate the pressure relief valve on the low-pressure chamber of the regulating system, if fitted.

6 Type testing

6.1 General

6.1.1 Tests and examinations performed to demonstrate compliance with this document shall be conducted using instruments calibrated before being put into service and thereafter according to an established programme.

6.1.2 To comply with this document, a VIPR shall be type tested.

A type test is valid for a given VIPR/regulator design.

6.1.3 Changes within the valve design which can adversely affect valve performance and would require tests to be repeated using the number of test samples quoted in Table 3 include:

a) repetition of all tests except the mechanical strength test of the low-pressure chamber, tests of pressure and flow indicating devices located in the low-pressure area, operating and loosening torque test, resistance to vibration, resistance to shock, over torque of the pressure adjusting device.

b) change in gas service (addition of oxygen pressure surge or acetylene tests, if intended for such service); in addition, the compatibility between each new gas or gas mixture and the used materials shall be verified,

c) changes of the valve body material (repetition of any tests to be decided case by case depending on changes of chemical composition and mechanical properties),

d) changes of the basic design dimensions of the VIPR components [e.g. inner spindle diameter, spindle thread pitch, seat diameter, dimension of o-ring(s), diaphragm thickness] (repetition of tests to be decided case by case depending on the change),

e) changes of material of the pressure regulating system (repetition of tests to be decided case by case depending on the change),

f) integration or removal of optional components like residual pressure device and non-return valve or functions such as pressure regulating system (repetition of any tests to be decided case by case depending on the change).

6.2 Documentation

The manufacturer shall make the following documents available to the test body:

— a set of drawings consisting of the general arrangement, parts list, material specifications and detail drawings including assembly and loosening torques and detail of thread sealing/locking components; any type variant within the given family shall be clearly identified;

— description of and how to operate the VIPR;

— information on the field of application of the VIPR (gases and gas mixtures, pressures, use with or without valve protection device, etc.); it shall be clearly indicated which gases and gas mixtures can be used with each type variant.

6.3 Test samples

A VIPR designed to incorporate pressure gauges or pressure indicators, shall have these devices fitted during type testing where their performance can influence the outcome of the test with the exception of the mechanical strength test (low pressure chamber).

A VIPR designed to incorporate other devices (e.g. pressure gauge, flow gauge, RPD) can necessitate these devices to be removed or replaced during the endurance test of the VIPR pressure regulating system according to the manufacturer's specification. The number of test samples for testing a valve design is given in Table 3. Additional test samples can be required for changes or for material variants within the valve design in accordance with the requirements of 6.1.

After being tested, the test samples shall be rendered unserviceable or shall be clearly marked as test samples to avoid them entering into service.

6.4 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 6.2 and, if applicable, number of endurance cycles and service conditions (if other than required).

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

6.5 Test temperatures

The test temperatures are given in Table 3.

6.6 Test gas

6.6.1 Gas quality

Gas quality shall correspond to the requirements specified in ISO 10297.

When a VIPR is tested with a gas other than that for which it is intended, convert the flows as shown in Table 2.

Table 2 — Conversion coefficients

Test gas [a]	Coefficient for										
	Air	O_2	N_2	Ar	H_2	CO_2	N_2O	He	Xe	C_2H_2	C_3H_8
Air	1	0,950	1,02	0,851	3,81	0,808	0,81	2,695	0,47	1,05	0,800
N_2	0,983	0,930	1	0,837	3,75	0,792	0,79	2,65	0,46	1,03	0,784

[a] Flow of intended gas = Flow of test gas × conversion coefficient.

NOTE Where applicable, the coefficients are the same as those given in ISO 2503.

6.6.2 Reference conditions

Flows shall be corrected to 23 °C and 101,3 kPa.

6.6.3 Leak tightness tests

In general, the leak tightness tests should be carried out with air or nitrogen. Alternatively, helium, hydrogen or inert 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 for the leak tightness tests shall be a choice of helium, hydrogen or a non-flammable 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.

6.6.4 Endurance of a VIPR pressure regulating system

In general, the operational performance and 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.

6.7 Test schedule

The tests shall be carried out in accordance with the schedule given in Table 3.

Table 3 — Test schedule for type testing

Test no.	Test	Relevant subclause	Condition of test sample	Test temperature °C	Quantity of test samples
1	Mechanical strength (test of the low-pressure chamber)	6.8	As received	Room temperature [a]	1
2	Pressure resistance test of the low-pressure chamber	6.9	As received	Room temperature [a]	1
3	Mechanical strength test of flow meters	6.10	As received	Room temperature [a]	1
4	Overpressure and leak tightness test for pressure indicators and flow gauges	6.11	As received	Room temperature [a]	1
5	Flow and pressure performance test for a VIPR with a pressure outlet (if applicable)	6.12	As received	Room temperature [a]	1
6	Accuracy and flow stability test of a VIPR with a flow metering device (if applicable)	6.13	As received	Room temperature [a]	1
7	Pressure relief valve test	6.14	One sample from relevant sequence 5 or 6 (as applicable), two samples as received	Room temperature [a]	3
8	Operating and loosening torques	6.15	From sequence 7	Room temperature [a]	1
9	Leak tightness test	6.17	As received	Room temperature	1
10	Endurance of the VIPR pressure regulating system	6.16	From sequence 9	Room temperature [a]	1
11	Leak tightness	6.17	From sequence 10	Room temperature [a]	1
12	Flow and pressure performance test for a VIPR without a flow metering device (if applicable)	6.12	From sequence 11	Room temperature [a]	1
13	Accuracy and flow stability test of a VIPR with a flow metering device (if applicable)	6.13	From sequence 12	Room temperature [a]	1
14	Visual examination	6.18	From relevant sequence 13 or 14 (as applicable)	Room temperature [a]	1
15 (optional / if required, see 5.17)	Resilience to ignition test	Annex D	As received	Annex D	5
16 (optional)	Vibration test	Annex A	As received	Room temperature [a]	See Annex A
17 (optional)	Shock test	Annex B	As received	Room temperature [a]	See Annex B
18 (optional)	Overtorque test for the pressure adjusting device	Annex C	As received	Room temperature [a]	2

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

6.8 Mechanical strength test of the low-pressure chamber

For an adjustable pressure VIPR, ensure that the pressure adjusting device is in the position where the pressure regulator valve is closed.

For a VIPR design where overpressure in the low-pressure chamber can pass through the regulating system and can be released through the high-pressure side of the valve, the inlet shall be plugged. If the outlet is fitted with a secondary shut-off mechanism (any type, including self-closing valve), this shut-off valve shall be kept open during the test by a means recommended by the manufacturer. For this test, it is permitted to replace the diaphragm, pressure relief valve and low-pressure gauge, if fitted, with plugs.

Pressurize the low-pressure chamber of the VIPR from the outlet with the pressure indicated in 5.15 for 2 min.

6.9 Pressure resistance test of the low-pressure chamber

The pressure regulating system within the VIPR shall be held permanently open. Pressure gauges, if fitted, shall be replaced by blind plugs and the outlet plugged. If the outlet is fitted with a shut-off valve (any type, including self-closing valve), the test shall be performed with the shut-off valve in the open and closed position. When the shut-off valve is in the open position it shall be kept open during the test by a means recommended by the manufacturer.

A pneumatic pressure of p_{vt} shall be applied to the VIPR inlet through a remote valve which is opened quickly, with the VIPR primary valve operating mechanism being in the fully open position, if located upstream of the pressure regulating system.

If no rupture of the VIPR occurs, the test is satisfactory. If rupture occurs, no piece shall be ejected. Venting of gas through pressure relief valves, if fitted, is permitted.

WARNING — Adequate protection for personnel is required during this test.

6.10 Mechanical strength test of flowmeters

The test shall be performed on one sample.

Apply an increasing pressure to the inlet side of the flowmeter up to the value $4 \times p_2$. After 2 min, check that the flowmeter has not ruptured. If a pressure relief valve is fitted immediately upstream of the flowmeter and it limits the pressure to below $4 \times p_2$, the flowmeter is considered to comply with 5.4.2.

6.11 Overpressure and leak tightness test for pressure indicators and flow gauges

The tests of ISO 5171:2019, 8.6, shall be performed.

6.12 Flow and pressure performance test for a VIPR with a pressure outlet

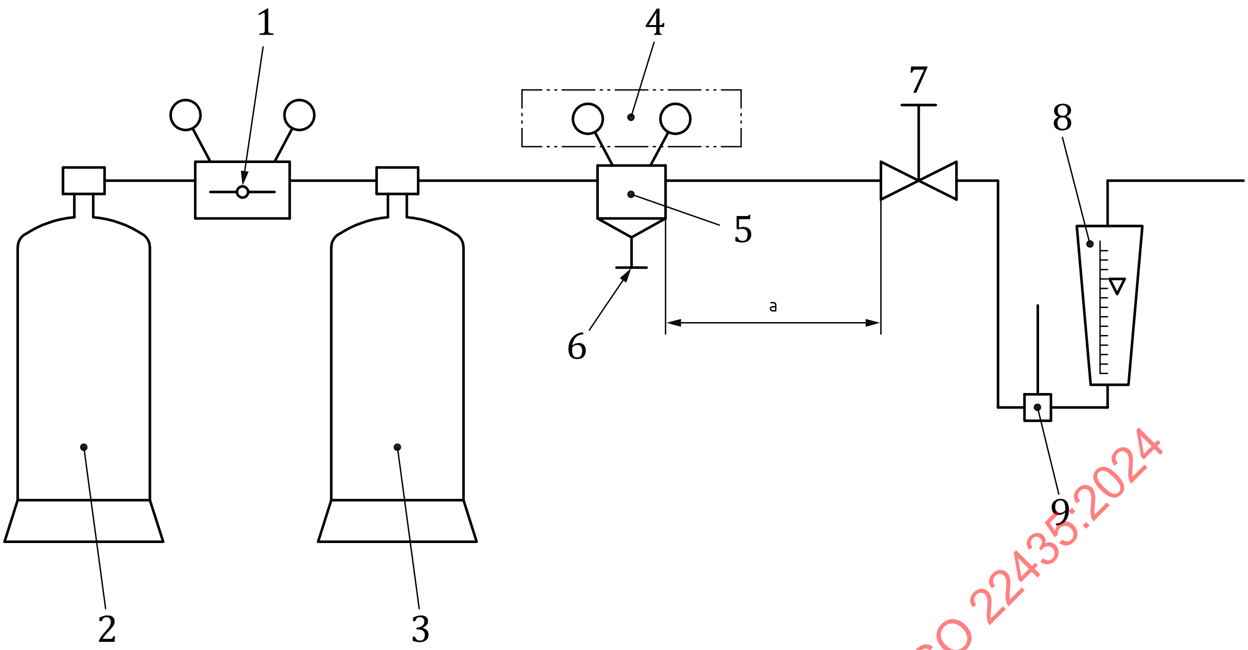
6.12.1 General

If the outlet is fitted with a shut-off valve (any type, including self-closing valve), this shut-off valve shall be kept open during the test by a means recommended by the manufacturer.

All tests shall be performed on one sample.

6.12.2 Standard discharge, Q_1, nominal outlet pressure, p_2, and maximum discharge Q_{max} test

An example of a test apparatus for this test is given in Figure 4. The apparatus should be manufactured in such a way that the inlet and outlet pressures can be regulated separately. The equipment may be operated by remote control.



Key

1 auxiliary pressure regulator
2 gas supply
3 buffer cylinder
4 calibrated gauges
5 test sample
6 pressure adjusting device
7 test apparatus flow control valve
8 flowmeter
9 thermometer

[a] 1 m maximum.

Figure 4 — Example of the test apparatus set-up for the measurement of flow discharge

The gas supply for the inlet pressure to the regulating system, p_1, and the test inlet pressure, p_3, shall have sufficient capacity for the tests.

All the pipelines of the pressure installation together with the valve controlling the flow shall have a flow capacity greater than that of the VIPR being tested. The VIPR can be supplied from a buffer cylinder.

Carry out the test at the standard discharge, Q_1, and the outlet pressure, p_2, both of which are stated by the manufacturer.

With the test apparatus flow control valve closed, apply an inlet pressure, p_3. Using the VIPR pressure adjusting device, set the outlet pressure to p_2. Gradually, open the test apparatus flow control valve until the standard discharge, Q_1, is attained. If the outlet pressure has decreased, readjust it to the value of p_2 on an adjustable VIPR. This is not possible with a pre-set VIPR.

The method to determine Q_{max} is given in ISO 2503:2009, 9.5.2.

6.12.3 Flow characteristic test

6.12.3.1 General

A flow characteristic curve shows the change of outlet pressure caused by variation of the flow from zero to full flow at a constant inlet pressure. Different curves are obtained at different starting pressures and different inlet pressures, see Figures 5 and 6. An example of a test apparatus for this test is given as Figure 7.

6.12.3.2 Adjustable VIPR

Record the flow characteristic under the following initial conditions:

a) starting with a test inlet pressure, p_3, outlet pressure, p_2, and standard discharge, Q_1, close the test apparatus flow control valve and record the closure pressure, p_4, after 60 s;

b) starting with the inlet pressure to the regulating system, p_1, outlet pressure, p_2, and standard discharge, Q_1, close the test apparatus flow control valve and record the closure pressure, p_4, after 60 s;

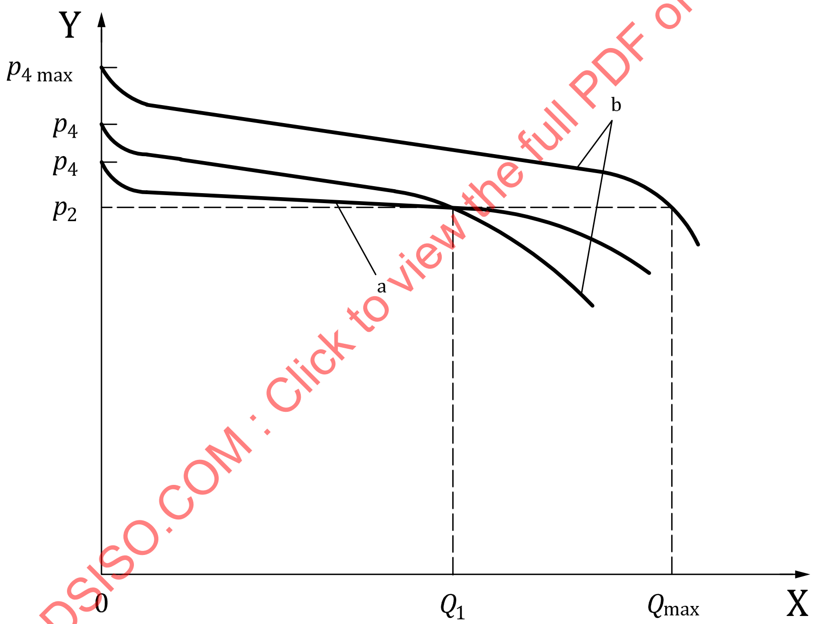
c) starting with a test inlet pressure set at p_3, outlet pressure, p_2, and maximum discharge, Q_{max}, close the test apparatus flow control valve and record the closure pressure, p_4, after 60 s;

d) starting with a test inlet pressure that corresponds to the outlet pressure of p_5 and maximum discharge, Q_{max}, close the test apparatus flow control valve and record the closure pressure, p_4, after 60 s.

The maximum closing pressure p_{4max} is the highest of the pressure values measured in steps a) to d).

In each case, to record the flow characteristic curve, at the end of the initial conditions given above, gradually open the test apparatus flow control valve in steps and record the outlet pressure and flow at each step until the outlet control valve is fully opened.

Plot the values of flow and pressure as shown in Figure 5.



Key

X flow

Y outlet pressure

[a] Inlet pressure, p_1.

[b] Inlet pressure, p_3.

Figure 5 — Typical flow characteristic curve for an adjustable pressure regulating mechanism

NOTE Values of flow and pressure measured with increasing outlet pressure (which results from a decreasing flow) can produce a curve at higher pressures due to hysteresis.

6.12.3.3 Pre-set VIPR

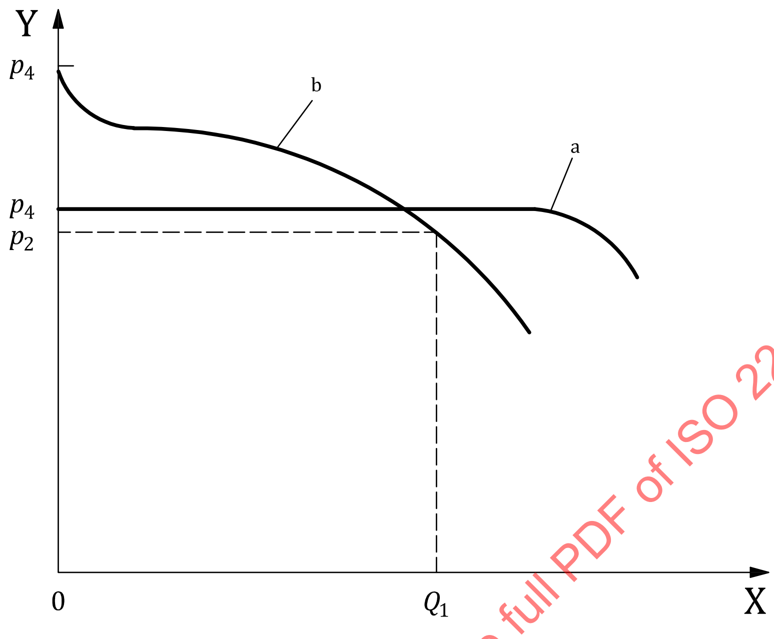
Record the flow characteristic using the procedure described in 6.12.3.2 under the following conditions:

a) starting at the closure pressure, p_4, resulting from the test inlet pressure, p_3, and the standard discharge, Q_1;

b) starting at the closure pressure, p_4, resulting from the inlet pressure to the regulating system, p_1, and the standard discharge, Q_1.

NOTE 1 The closure pressure obtained depends on the pressure characteristic of the pressure regulator (rising or falling).

Plot the values of flow and pressure as shown in Figure 6.



Key

X flow

Y outlet pressure

a Inlet pressure, p_1.

b Inlet pressure, p_3.

Figure 6 — Typical flow characteristic for a pre-set pressure regulating mechanism

NOTE 2 Figure 6 shows a typical flow characteristic for a pre-set VIPR with a rising pressure characteristic in which an increasing inlet pressure tends to hold the pressure regulator valve closed.

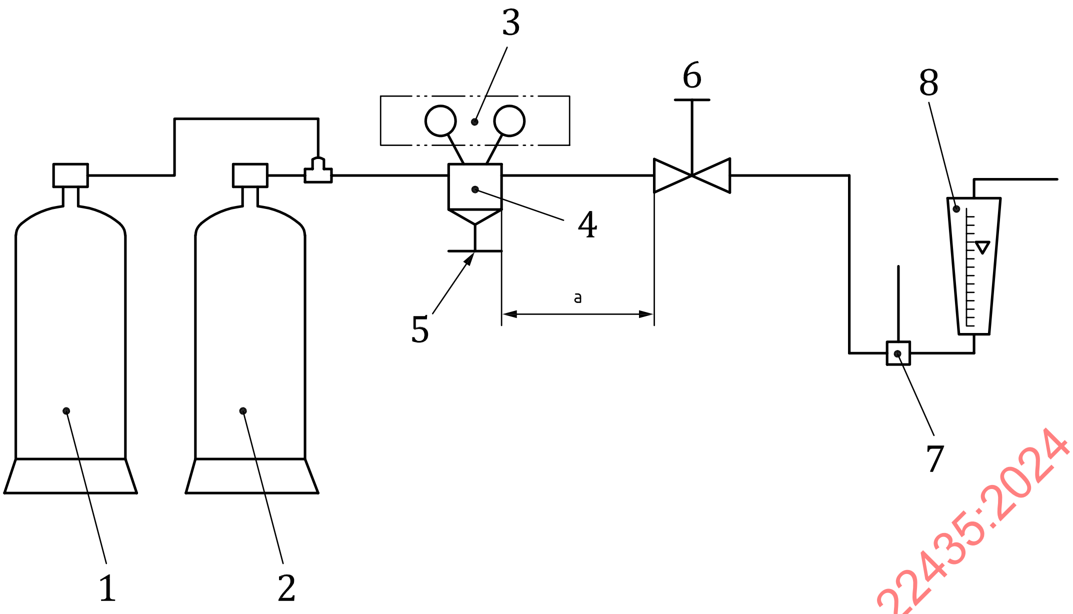
6.12.4 Coefficient of pressure increase upon closure *R* test

An example of a test apparatus for this test is given in Figure 7. Adjust the test VIPR to the standard initial conditions, with inlet pressure, p_3, outlet pressure, p_2, and standard discharge, Q_1. Stop the discharge by closing the test apparatus flow control valve. The indicator on the low-pressure gauge will move to a higher value and stabilize. Note the closure pressure, p_4, after 60 s and from it determine the value of R using Formula (1):

$$R = \frac{p_4 - p_2}{p_2} \quad (1)$$

6.12.5 Irregularity coefficient *i* test

An example of a test apparatus for this test is given in Figure 7.



Key

1 auxiliary gas cylinder
2 primary gas cylinder
3 calibrated gauges
4 test sample
5 pressure adjusting device
6 test apparatus flow control valve
7 thermometer
8 flowmeter
a 1 m maximum.

Figure 7 — Example of the test apparatus set-up for the determination of the pressure characteristics

For the determination of the irregularity coefficient, *i*, and correct mechanical functioning, plot a curve (see Figures 8 and 9). The curve indicates the variation of outlet pressure as a function of the inlet pressure.

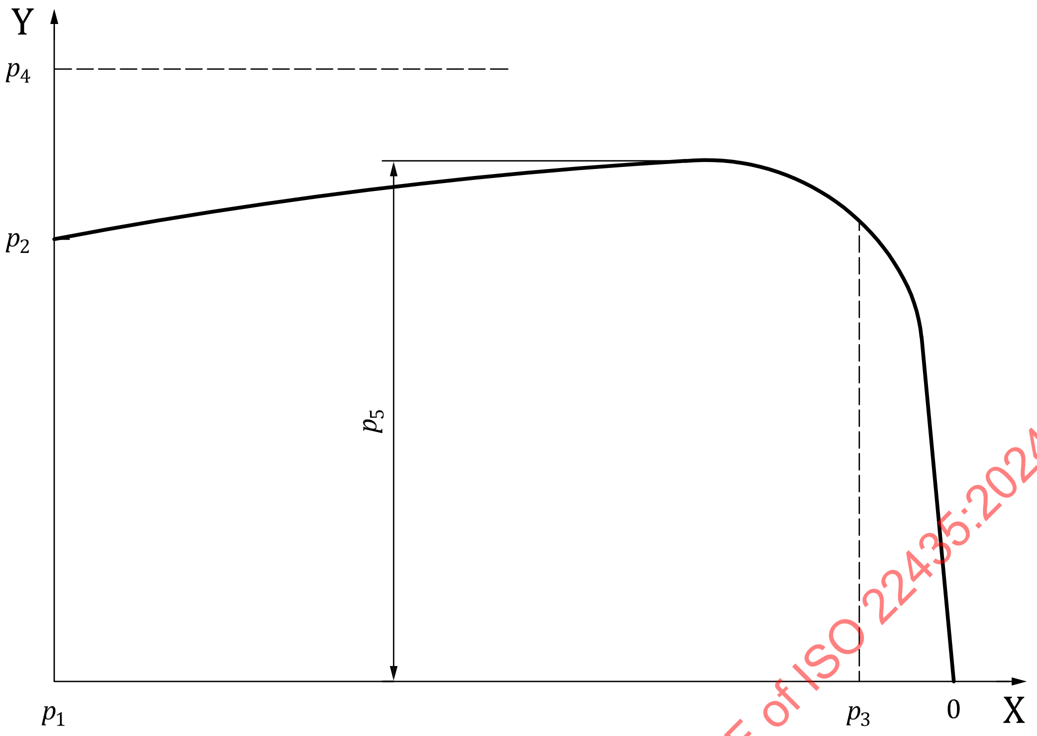
Equip the test VIPR with two calibrated gauges or recording equipment. Control the discharge of the test VIPR by the test apparatus flow control valve and measure it by a flowmeter. With the inlet pressure to the regulating system, p_1, operate the pressure adjusting device (if fitted) on the test pressure regulator and the test apparatus flow control valve to obtain the standard discharge, Q_1, at the outlet pressure, p_2, taking into account the corrections given in Table 2. For a pre-set VIPR, the test is started at the inlet pressure to the regulating system, p_1, with the test apparatus flow control valve adjusted so that the VIPR delivers its standard discharge, Q_1.

Record the value of the inlet and outlet pressures whilst the inlet pressure is varied through the range p_1 to p_3. This process shall take at least 15 min. Ensure that sufficient gas is available in the gas supply to complete the test in one session.

During this test, there should be a smooth regular curve, either rising to a maximum (see Figure 8) or falling (see Figure 9).

The pressure, p_5, for the irregularity coefficient, *i*, is the highest or lowest value of the outlet pressure during the test in which the inlet pressure varies from p_1 to p_3. Determine the value of coefficient *i* using Formula (2):

$$i = \frac{p_5 - p_2}{p_2} \tag{2}$$

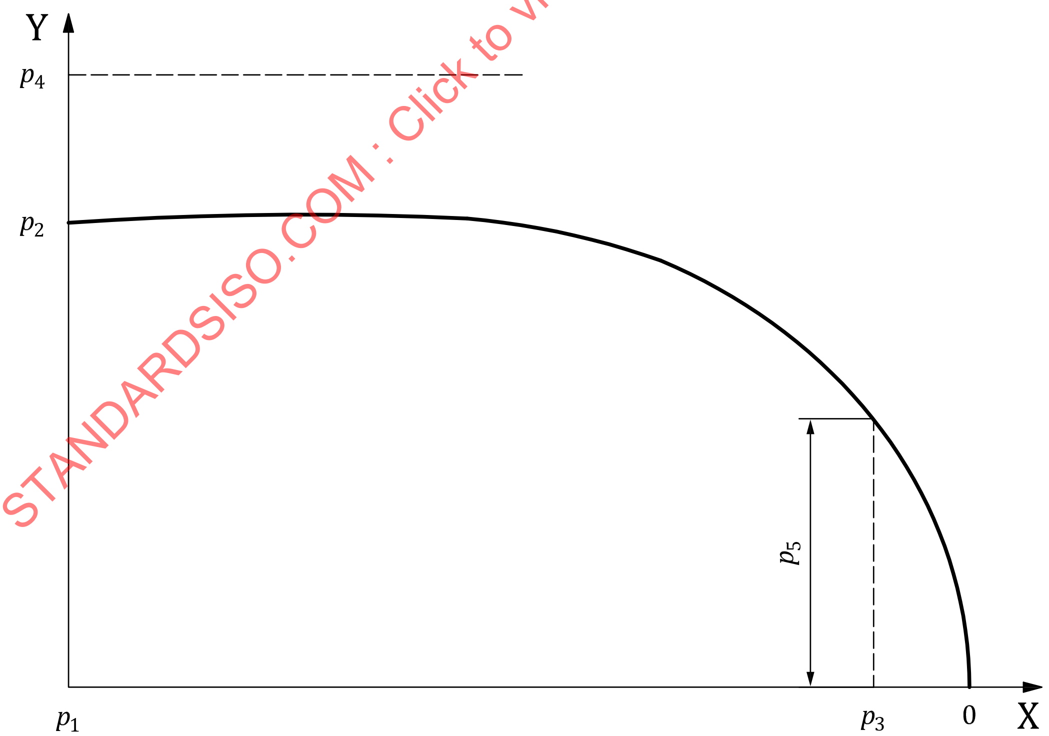


Key

X inlet pressure

Y outlet pressure

Figure 8 — Typical rising pressure characteristic



Key

X inlet pressure

Y outlet pressure

Figure 9 — Typical falling pressure characteristic

6.13 Accuracy and flow stability of a VIPR with a flow metering device test

The test shall be performed on one sample according to ISO 2503:2009, 9.6.

6.14 Pressure relief valve test

The test shall be performed on three samples.

If the outlet is fitted with a shut-off valve (any type, including self-closing valve), this shut-off valve shall be kept open during the test by a means recommended by the manufacturer.

Through the outlet connection, an increasing pressure shall be applied up to:

— p_{4max} for an adjustable VIPR, as derived from 6.12.3.2,

— highest value of p_4 for a pre-set VIPR, as derived from 6.12.3.3.

At this pressure, the pressure relief valve shall meet the requirements of 5.14.1. The pressure shall then be increased up to the opening pressure of the pressure relief valve, which shall be noted. The pressure shall be increased up to the pressure $p_{RV} = 2 \times p_2$. At this pressure, the discharge, Q_{RV}, of the pressure relief valve shall be measured (see 5.13). The pressure shall be decreased, and the closing pressure of the pressure relief valve shall be noted (see 5.13).

6.15 Operating and loosening torques test

The test shall be performed on one sample.

Measure the operating torques of devices not covered by ISO 10297 and loosening torques. Use an appropriate torque spanner and check that they conform with the manufacturer's specification given in the documentation (see 6.2).

6.16 Endurance of the VIPR pressure regulating system

The test shall be performed on one sample.

For this test the VIPR shall be installed so that the valve inlet connection is connected to a source of test gas at minimum of 80 % of the p_1 of the VIPR.

If the VIPR is fitted with a pressure outlet, the pressure shall be set at p_2 and the flow at the pressure outlet shall be controlled downstream of the outlet at standard discharge Q_1.

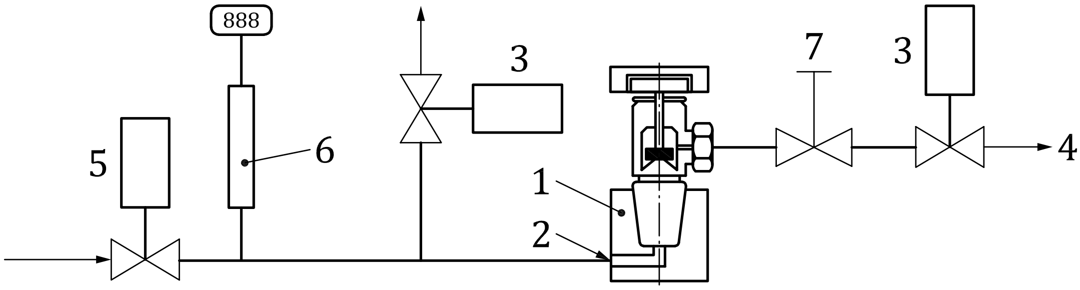
If the VIPR is fitted with a flow meter or flow gauge/indicator or one fixed orifice, the flow shall be set at the nominal discharge Q_n. In case of multiple fixed orifices, the flow shall be set at the maximum discharge setting.

The pressure regulating system shall then be subjected to the required number of test cycles as specified in 5.10.

Each cycle consists of pressurization to the inlet connection of the sample using test pressure with a minimum of 80 % of p_1 with the venting valve closed, then depressurization of both the high- and low-pressure chambers to atmospheric pressure.

The test apparatus shall incorporate valves upstream and downstream of the VIPR being tested to permit introduction and venting of the test gas. An example of a test apparatus for this test is given as Figure 10.

The cycle rate shall be set to a minimum of three cycles per minute. The inlet test pressure shall not decrease by more than 5 % during the test period.



Key

1 test sample with adapter
2 input test medium
3 venting valve
4 outlet
5 valve
6 inlet high pressure transducer with display for monitoring of p_{vt}
7 flow control valve

Figure 10 — Example of the test apparatus set-up for the endurance test of the pressure regulating system

6.17 Leak tightness test

6.17.1 Number of samples

The test shall be performed on the number of samples given in Table 3.

6.17.2 Internal leakage across the regulating valve seat

6.17.2.1 Conditions

With the primary valve operating mechanism open, carry out the following leak tightness test.

6.17.2.2 Adjustable VIPR

The gas tightness of the regulator valve assembly shall be tested under the following two conditions:

a) The gas tightness of the regulator valve seat is tested at the maximum inlet pressure to the regulating system, p_1, for 5 min. The regulator valve shall be closed (pressure adjusting screw completely unscrewed) and the outlet open.

b) The gas tightness of the regulator valve is also tested with the outlet plugged and the pressure in the low-pressure chamber adjusted to the value of p_2 with the pressure adjusting screw. The value of p_2 shall be constant during the test period of 5 min.

Both tests shall be repeated with the inlet pressure, p_3.

6.17.2.3 Pre-set VIPR

The gas tightness of the regulator valve seat is tested at the maximum inlet pressure to the regulating system, p_1, with the outlet connection plugged. The value of the outlet pressure shall be constant during the test period of 5 min.

The test shall be repeated with the inlet pressure, p_3.

6.17.3 External leakage

Gas tightness to the atmosphere shall be tested in accordance with ISO 9090.