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Safety and control devices for gas burners and gas-burning appliances — Particular requirements —

Part 2: Pressure regulators

Dispositifs de commande et de sécurité pour brûleurs à gaz et appareils à gaz — Exigences particulières —

Partie 2: Régulateurs de pression

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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

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

ISO 23551-2 was prepared by Technical Committee ISO/TC 161, *Control and protective devices for gas and oil burners and gas and oil burning appliances*.

ISO 23551 consists of the following parts, under the general title *Safety and control devices for gas burners and gas-burning appliances — Particular requirements*:

— *Part 1: Automatic valves*

— *Part 2: Pressure regulators*

— *Part 3: Gas/air ratio controls, pneumatic type*

— *Part 4: Valve-proving systems for automatic shut-off valves*

Introduction

This part of ISO 23551 is designed to be used in conjunction with ISO 23550:2004.

This part of ISO 23551 either references existing requirements of ISO 23550:2004 or indicates that there has been an “addition”, “modification” or “replacement” in the cited requirement of ISO 23550:2004.

Safety and control devices for gas burners and gas-burning appliances — Particular requirements —

Part 2: Pressure regulators

1 Scope

This part of ISO 23551 specifies safety, constructional and performance requirements for pressure regulators intended for use with gas burners and gas-burning appliances. It also describes the test procedures for checking compliance with these requirements and provides information necessary for the purchaser and user.

This part of ISO 23551 applies to pressure regulators for gas burners and gas-burning appliances of nominal connection size up to and including DN 250 that can be used and tested independently of these appliances. These regulators are suitable for fuel gases, such as natural gas, manufactured gas or liquefied petroleum gas (LPG) at inlet pressures up to and including 50 kPa.

This part of ISO 23551 covers type testing only.

This part of ISO 23551 does not cover

a) regulators connected directly to the mains pipe work or to a container that maintains a standard distribution pressure;

b) regulators installed outdoors and exposed to the environment;

c) regulators which use electrical auxiliary energy.

2 Normative references

The following referenced documents are indispensable for the application 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 23550:2004, *Safety and control devices for gas burners and gas-burning appliances — General requirements*

3 Terms, definitions and symbols

For the purpose of this document, the terms and definitions given in ISO 23550:2004 and the following apply.

3.1 Regulators

3.1.1
pressure regulator
device that maintains the outlet pressure constant within given limits, independently of the variations in inlet pressure and/or flow rate

3.1.2
adjustable pressure regulator
regulator provided with means for changing the outlet pressure setting

3.2 Pressures

3.2.1
test pressure
pressure to be applied during a test

3.2.2
pressure drop
differential pressure with valve open to its fullest extent

3.2.3
maximum inlet pressure

p_{1max}
highest inlet pressure at which tests have been conducted to determine that the regulator is able to control the outlet pressure within acceptable limits as declared by the manufacturer

3.2.4
minimum inlet pressure

p_{1min}
lowest inlet pressure at which tests have been conducted to determine that the regulator is able to control the outlet pressure within acceptable limits declared by the manufacturer

3.2.5
inlet pressure range
range of inlet pressure between the maximum and minimum values

3.2.6
maximum outlet pressure

p_{2max}
highest outlet pressure at which tests have been conducted to determine that the regulator is able to control the outlet pressure within acceptable limits declared by the manufacturer

3.2.7
minimum outlet pressure

p_{2min}
lowest outlet pressure at which tests have been conducted to determine that the regulator is able to control the outlet pressure within acceptable limits declared by the manufacturer

3.2.8
outlet pressure range
range of outlet pressure between the maximum and minimum values

3.2.9
setting point
inlet and outlet pressures declared by the manufacturer, at which the regulator is initially adjusted for test purposes at a declared flow rate

NOTE The respective pressures and flow rate are termed “inlet setting pressure”, “outlet setting pressure” and “setting flow rate”.

3.3 Flow rates

3.3.1
maximum flow rate
q_{max}
maximum rate, as a function of inlet and outlet pressures, declared by the manufacturer and expressed in $m^3 \cdot h^{-1}$ of air at standard conditions

NOTE For a non-adjustable regulator, there is only one maximum flow rate.

3.3.2
minimum flow rate
q_{min}
minimum rate, as a function of inlet and outlet pressures, declared by the manufacturer and expressed in $m^3 \cdot h^{-1}$ of air at standard conditions

NOTE For a non-adjustable regulator, there is only one minimum flow rate.

3.3.3
flow rate range
range of flow rate between the maximum and minimum values

3.4 Component parts

3.4.1
breather hole
orifice that allows atmospheric pressure to be maintained in a compartment of variable volume

3.4.2
diaphragm
flexible member which, under the influence of the forces arising from loading and pressure, operates the valve

3.4.3
diaphragm plate
stiffening plate fitted to the diaphragm

3.4.4
valve
device which varies the gas flow directly

3.5 Performance

3.5.1
lock-up pressure
outlet pressure at which a regulator closes when the outlet of the regulator is sealed

NOTE The increase in outlet pressure is expressed either in kilopascals or as a percentage.

3.5.2
put out of action
⟨verb⟩ inactivate a regulator, thereby ensuring that this setting does not undergo any changes

4 Classification

4.1 Classes of control

Pressure regulators are classified as class A, class B or class C, according to the appropriate inlet pressure and flow rate limits, as given in Table 1.

NOTE 1 In the USA, regulators are classified either for main burner load application or for main burner and pilot load application.

NOTE 2 In Japan, pressure regulators are not classified.

Table 1 — Deviation of outlet pressure from outlet setting pressure

Class of regulators		Maximum outlet pressure deviation [a] %		
		Manufactured gas	**Natural gas**	**Liquefied petroleum gas**
Class A:	q_{max} to q_{min} and p_{1max} to p_{1min}	± 15	± 15	± 15
Class B:	by variation of the inlet pressure for each of the flow rates	+ 15 − 20	+ 10 − 15	± 10
	by variation of flow rates from q_{max} to q_{min} (constant inlet pressure) for each of the inlet pressures	+ 40 0	+ 40 0	+ 40 0
Class C:	at constant q (within the flow rate range)	+ 15 − 20	+ 10 − 15	± 10
NOTE 1 Classification of fuel gases see Annex A.				
[a] See Annex A.				

4.2 Groups of controls

A regulator is classified as group 1 or group 2, according to the bending stresses that it is required to withstand in accordance with ISO 23550:2004, Table 3.

— Group 1 regulators: Regulator intended for use in an appliance and/or installation where it is not subjected to bending stresses imposed by the pipe work (e.g. by the use of rigid adjacent supports);

— Group 2 regulators: Regulator for use in any situation, either internal or external to the appliance, typically without support.

NOTE A regulator that complies with the requirements for group 2 can be deemed to comply also with the requirements for group 1 regulators.

5 Test conditions

ISO 23550:2004, Clause 5, shall apply.

NOTE Specific requirements for testing are given in Annexes B and C.

6 Construction

6.1 General

ISO 23550:2004, 6.1, shall apply.

6.2 Construction requirements

ISO 23550:2004, 6.2, shall apply, except as in 6.2.1 to 6.2.3:

6.2.1 Breather holes

ISO 23550:2004; 6.2.3, shall apply with the addition of 6.2.1.1 and 6.2.1.2:

6.2.1.1 Vent limiters

Vent limiters used with regulators shall limit the flow through the vent of the regulator as shown in Table 2 when tested at room temperature.

Table 2 — Maximum allowable vent limiter venting rate

Type of vent limiter	Specific gravity	Maximum allowable flow rate	
		cm^3/s	(ft^3/h)
Vent limiter for use only with natural, manufactured, mixed gases and LP gas-air mixtures	0,64	19,7	(2,5)
Vent limiter for use with liquefied petroleum gas	1,53	7,87	(1,0)

6.2.1.2 Separate vent limiters test

Separate vent limiters shall be installed in an upright position in a gas-tight piping system so that the test medium passes through the vent limiter. It shall then be determined that there is no leakage at the points other than through the vent limiter. The rate of flow through the test meter shall be determined at pressures from 498 Pa (2 in water column) up to and including the maximum working pressure of the regulator and corrected for a specific gravity of 1,53 for vent limiters for use with liquefied petroleum gases, and a specific gravity of 0,64 for vent limiters for use only with natural, manufactured, mixed gases and LP gas-air mixtures. The corrected flow rate shall not exceed the maximum allowable specified values. If the vent limiter is not a limiting orifice type and is designed for use in positions other than upright, additional test to determine the rate of flow shall be conducted when the vent limiter is installed in other positions.

When the vent limiter is an integral part of the regulator, the regulator diaphragm shall be substantially removed to permit the test medium to flow feely through the vent limiter. With the regulator installed in a gas-tight piping system in the manufacturer's specified upright position, the flow rate through the integral vent limiter shall be determined as described for separate vent limiters. The corrected flow rate shall not exceed the maximum allowable specified values. Additional tests to determine the rate of flow shall be conducted with the regulator in any other position for which compliance with this standard is desired.

6.2.2 Sealing caps

ISO 23550:2004, 6.2.7, shall be replaced with the following:

Sealing caps on field adjustable regulators shall be capable of being removed and replaced using standard tools and shall be capable of being sealed (e.g. by lacquer). A sealing cap shall not hinder adjustment with the outlet pressure range declared by the manufacturer.

ISO 23550:2004, 6.2, shall apply with the addition of 6.2.3.

6.2.3 Adjustment means

Adjustable type regulators and the adjustable stages of multi-stage regulators shall be provided with means for making any necessary adjustment of outlet pressure. The adjustment means of spring-type regulators shall be concealed. Suitable means for maintaining the positions of all adjustments shall be provided. Locknuts or adjusting nuts held by springs or compression are considered satisfactory, except when their adjustment can be accidentally disturbed. Factory adjustment means not intended for field adjustment shall be sealed by means suitable for both continuous and intermittent exposure at the manufacturer's specified minimum and maximum ambient temperatures.

Suitability of the sealing means shall be judged before and after completion of all tests specified in this standard. Mechanical sealing means shall require the use of special tools.

6.3 Materials

6.3.1 General material requirements

ISO 23550:2004, 6.3.1, shall apply.

6.3.2 Housing

6.3.2.1 Housing design

ISO 23550:2004, 6.3.2.1, shall apply with the following addition:

When a diaphragm inside a housing separates the gas-carrying compartment from atmosphere, then the gas-carrying compartment is considered to be indirectly separated.

6.3.2.2 Test for leakage of housing after removal of non-metallic parts

Carry out the test given in ISO 23550:2004, 6.3.2.2.

6.4 Gas connections

ISO 23550:2004, 6.4, shall apply.

7 Performance

7.1 General

ISO 23550:2004, 7.1, shall apply.

7.2 Leak-tightness

7.2.1 Criteria

ISO 23550:2004, 7.2.1, shall apply with the following modification of Table 2:

Internal leakage rates shall not apply.

Replace "controls" with "assembled regulators".

7.2.2 Test for leak-tightness

7.2.2.1 Performance of the test

Carry out the test given in ISO 23550:2004, 7.2.2.1, with the following modification:

The test shall be carried out using a pressure equal to 1,5 times the maximum inlet pressure, but at least 15 kPa.

NOTE Specific regional test conditions in Japan are given in D.1.

7.2.2.2 External leak-tightness

Replace ISO 23550:2004, 7.2.2.2, as follows:

The assembled regulator is to be mounted on the test equipment. It shall then be subjected to the test pressure given in 7.2.2.1; the inlet valve of the test equipment and the valve downstream of the sample shall be in the closed position.

If there are any signs of leakage of the sample, the leakage rate is to be measured.

Closure parts that are intended to be dismantled for servicing or adjustment shall be dismantled and reassembled five times, using standard tools according to the manufacturer's instructions, after which the leak tightness is to be checked.

NOTE Specific regional test conditions in Canada and USA are given in Annex C.

7.3 Torsion and bending

7.3.1 General

ISO 23550:2004, 7.3.1, shall apply, except that only the external leakage shall be applicable.

After testing, there shall be no permanent deformation, and the leakage shall not exceed that measured before the test.

7.3.2 Torsion

7.3.2.1 Torsion — Group 1 and group 2 regulators with threaded connections

The regulator shall be subjected to the torque specified in ISO 23550:2004, Table 4, and tested according to ISO 23550:2004, 7.3.4.2.

7.3.2.2 Torsion — Group 1 and group 2 regulators with compression fittings

The regulator shall be subjected to the torque specified in ISO 23550:2004, Table 4, and tested according to ISO 23550:2004, 7.3.4.3.

7.3.3 Bending — Group 1 and group 2 regulators

The regulator shall be subjected to the bending moment specified in ISO 23550:2004, Table 4, and tested according to ISO 23550:2004, 7.3.4.4. For group 1 devices, the test as described in ISO 23550:2004, 7.3.4.5, shall additionally be carried out.

7.3.4 Torsion and bending tests

Carry out the tests given in ISO 23550:2004, 7.3.4.

7.4 Rated flow rate

No requirements.

7.5 Durability

ISO 23550:2004, 7.5, shall apply.

7.6 Functional requirements

Alternative methods for functional requirements and testing are given in Annexes B and C.

NOTE 1 Specific requirements in EU countries are given in Annex B.

NOTE 2 Specific requirements in Canada and USA are given in Annex C.

7.7 Putting the regulator out of action

7.7.1 Criteria

If it is claimed that a regulator can be put out of action, the method shall be given in the manufacturer's instructions and shall result in the valve being fixed in the fully open position.

When the regulator is put back into operation, it shall comply with the requirements of this part of ISO 23551.

7.7.2 Test putting the regulator out of action

The regulator shall be deactivated in accordance with the procedure described in the manufacturer's instructions. After it has been visually checked that the valve is in its fully open position, the leak tightness is to be determined in accordance with the method given in 7.2.2.2.

After it has been made operative again, the regulator is to be tested by the methods given in this part of ISO 23551.

It is recommended that this test is made before the performance tests.

7.8 Long-term performance

7.8.1 Criteria

The leak tightness and performance shall remain within the limits specified in 7.2 and 7.3, respectively, after testing in accordance with 7.8.2.

7.8.2 Test of long-term performance

Position the regulator in a temperature-controlled chamber with an air supply at ambient temperature and at the maximum inlet pressure as declared by the manufacturer. With a quick-acting shut-off valve both upstream and downstream, for example as shown in Figure B.1, connect the valves to a suitable time switch so that as one opens the other one closes, with a complete cycle of 10 s.

The test consists of 50 000 cycles, in each of which the diaphragm is to be fully flexed and held in this position for at least 5 s. Of the 50 000 cycles:

— 25 000 cycles shall be with the regulator environment at the maximum ambient temperature declared by the manufacturer, but at least 60 °C;

— 25 000 cycles shall be with the regulator environment at the minimum ambient temperature declared by the manufacturer, but at most 0 °C.

After cycling, the regulator is to be subjected to testing as described in 7.2 and 7.6, without further adjustment of the setting point of the regulator.

NOTE 1 Alternatively, see C.2.6.

NOTE 2 Specific requirements in Japan are given in D.2.

7.9 Lock-up pressure

7.9.1 Criteria

When a regulator is claimed by the manufacturer to have the ability to lock up, the outlet pressure shall not rise by more than 15 % or 0,75 kPa, whichever is greater, above an outlet pressure equal to 5 % of q_{max}. Such a regulator shall be tested in accordance with the test method described in 7.9.2.

7.9.2 Lock-up pressure test

Proceed as follows.

a) Install the regulator in the apparatus shown for example in Figure B.1.

b) Adjust the inlet pressure to p_{1max} and adjust the control valve 6 to q_{max}/20.

c) Measure the outlet pressure.

d) Slowly close control valve No. 6 in not less than 5 s.

e) 30 s after the control valve No. 6 has been completely closed, measure the outlet pressure.

8 EMC/Electrical requirements

If regulators are of mechanical types there are no requirements.

9 Marking, installation and operating instructions

9.1 Marking

The following information, at least, shall be durably marked on the regulator in a clearly visible position:

a) manufacturer and/or trade mark;

b) model designation;

c) in EU, class and group references; in USA and Canada, delta P or circle P, as applicable;

d) date of manufacture (at least the year); this may be in coded form;

e) direction of gas flow; in EU by an arrow (e.g. cast or embossed);

f) maximum working pressure;

g) outlet pressure setting.

9.2 Installation and operating instructions

One set of instructions shall be supplied with each consignment, written in the language(s) of the country into which the controls are delivered.

They shall include all relevant information on use, installation, operation and servicing, in particular, the following:

a) regulator class and group;

b) gas families for which the regulator is suitable;

c) performance curves including inlet pressure range, outlet pressure range and flow rate range (see, for example, Figures B.1 and B.2) according to the declared classification;

d) setting point (inlet pressure, outlet pressure and flow rate);

e) ambient temperature range, in °C;

f) mounting position(s);

g) instructions for changing from one gas family to another (e.g. changing the spring or putting the regulator out of action);

h) lock-up pressure, if applicable.

9.3 Warning notice

ISO 23550:2004, 9.3, shall apply.

Annex A
(informative)

Classification of fuel gases into gas families

A.1 Gas families used in European countries

Gases are classified into three families, each family may be divided into groups, (themselves being divided into ranges), as a function of the Wobbe index, according to the values given in Table A.1.

Table A.1 — Classification of gases

Gas families and groups	Gross Wobbe index [a] MJ/m^3	
	Minimum	Maximum
Manufactured gas		
Group A	22,4	24,8
natural gas	39,1	54,7
Group H	45,7	54,7
Group L	39,1	44,8
Group E	40,9	54,7
Liquefied petroleum gas	72,9	87,3
Group B/P	72,9	87,3
Group P	72,9	76,8
Group B	81,8	87,3

[a] At 15 °C and 101,325 kPa.

A gas family is a group of fuel gases with similar burning behaviour linked together by a range of Wobbe-indices.

A gas group is a specified range of Wobbe index within that of the first, second or third families of gas. This range is selected on the general principle that appliances utilizing this gas group operate safely when burning all gases within this range without adjustment.

NOTE 1 Adjustment of the appliance can be permitted in accordance with the special national or local conditions that apply in some countries.

NOTE 2 As ISO/TC 28 *Petroleum products and lubricants* and ISO/TC 193 *Natural gas* are working on gas specifications, this table will be replaced when an appropriate ISO International Standard is available.

A.2 Gas families used in Japan and South Korea

Table A.2 — Classification of gases

Gas families and groups	Gross Wobbe index [a] MJ/m^3	
	Minimum	Maximum
Manufactured gas	16,2	28,9
Natural gas	49,2	57,8
Liquefied petroleum gas	81,3	92,8

[a] At 0 °C and 101,325 kPa.

Annex B
(normative)

Functional requirements and regulator performance testing — Method A

B.1 Requirements

B.1.1 General

Regulators shall be tested as described in B.2 for outlet pressure variations over the range of inlet pressure from p_{1max} to p_{1min} and/or over the range of flow rate from q_{min} to q_{max}.

If the inlet pressure range includes two corresponding values for the minimum and maximum pressure as given in Table B.1, then the inlet setting pressure shall be the respective nominal pressure according to that table. Otherwise, the inlet setting pressure and the inlet pressure range shall be declared by the manufacturer.

The deviation of the outlet pressure from the outlet setting pressure shall not exceed $\pm$ 0,1 kPa.

B.1.2 Pressure drop

The pressure drop measured by the method specified in B.2.5 shall not exceed that declared by the manufacturer by more than + 10 %.

B.1.3 Class A

Over the full range of inlet pressure, p_{1min}, to p_{1max}, and over the full gas flow rate range, q_{max} to q_{min}, the deviation of the outlet pressure from the outlet setting pressure shall not exceed the values given in Table 1 or $\pm$ 0,1 kPa, whichever is greater. The declared minimum flow rate, q_{min}, shall not exceed 10 % of q_{max}.

B.1.4 Class B

For any change of inlet pressure within the range of inlet pressure p_{1min} to p_{1max} at any flow rate within the declared flow range q_{min} to q_{max}, the deviation of the outlet pressure from the outlet setting pressure shall not exceed the values given in Table 1 or $\pm$ 0,1 kPa, whichever is greater.

Table B.1 — Gas pressure at regulator inlet

Type of gas	Gas pressure at inlet to regulator kPa		
	Nominal pressure	Minimum pressure	Maximum pressure
Manufactured gas	0,8	0,6	1,5
Natural gas Group 2H	2,0	1,7	2,5
Natural gas Group 2L	2,5	2,0	3,0
Natural gas Group 2E	2,0	1,7	2,5
Liquefied petroleum gas	2,9 2,9 3,7 5,0 6,7 11,2 14,8	2,0 2,5 2,5 4,25 5,0 6,0 10,0	3,5 3,5 4,5 5,75 8,0 14,0 18,0

For any change of flow rate within the declared range of flow rate q_{min} to q_{max} at any inlet pressure within the permissible inlet pressure range p_{1min} to p_{1max}, the deviation of the outlet pressure from the outlet setting pressure shall not exceed the values given in Table 1 or $\pm$ 0,1 kPa, whichever is greater.

B.1.5 Class C

For any change of inlet pressure within the range of inlet pressure p_{1min} to p_{1max} at any flow rate within the manufacturer's declared flow range q_{min} to q_{max}, the deviation of the outlet pressure from the outlet setting pressure shall not exceed the values given in Table 1 or $\pm$ 0,1 kPa, whichever is the greater.

B.2 Test procedure

The regulator shall be tested in the sequence shown in Table B.2.

Table B.2 — Sequence of testing

Clause no.	Test
7.7.2	Putting the regulator out of action
7.2.2	External leak tightness of assembled regulator
7	Regulator performance
7.8	Long-term performance
7.9	Lock-up pressure
7.3	Torsion and bending
ISO 23550:2004, 7.5.4.2	Test for marking resistance
ISO 23550:2004, 7.5.5.29	Scratch test
ISO 23550:2004, 7.5.6.2	Humidity test
6.3.2.2	External leak tightness of regulator with non-metallic part(s) removed
ISO 23550:2004, 7.5.1	Elastomers in contact with gas
6.2	Construction requirements

If adhesive labels are used, it is necessary to provide two additional parts carrying the label.

If special equipment is necessary for the test, it should be supplied with the samples.

B.2.1 General

Classes A, B and C regulators shall be tested in accordance with the test sequences given in B.2.2, B.2.3, B.2.4, respectively (see also B.3).

Equilibrium conditions shall always be reached before readings are taken.

Examples of performance curves with p_2 as ordinate and p_1 as abscissa, with variable inlet pressure, are shown in Figure B.3 and those with variable flow rate, in Figure B.2.

Dimensions in millimetres

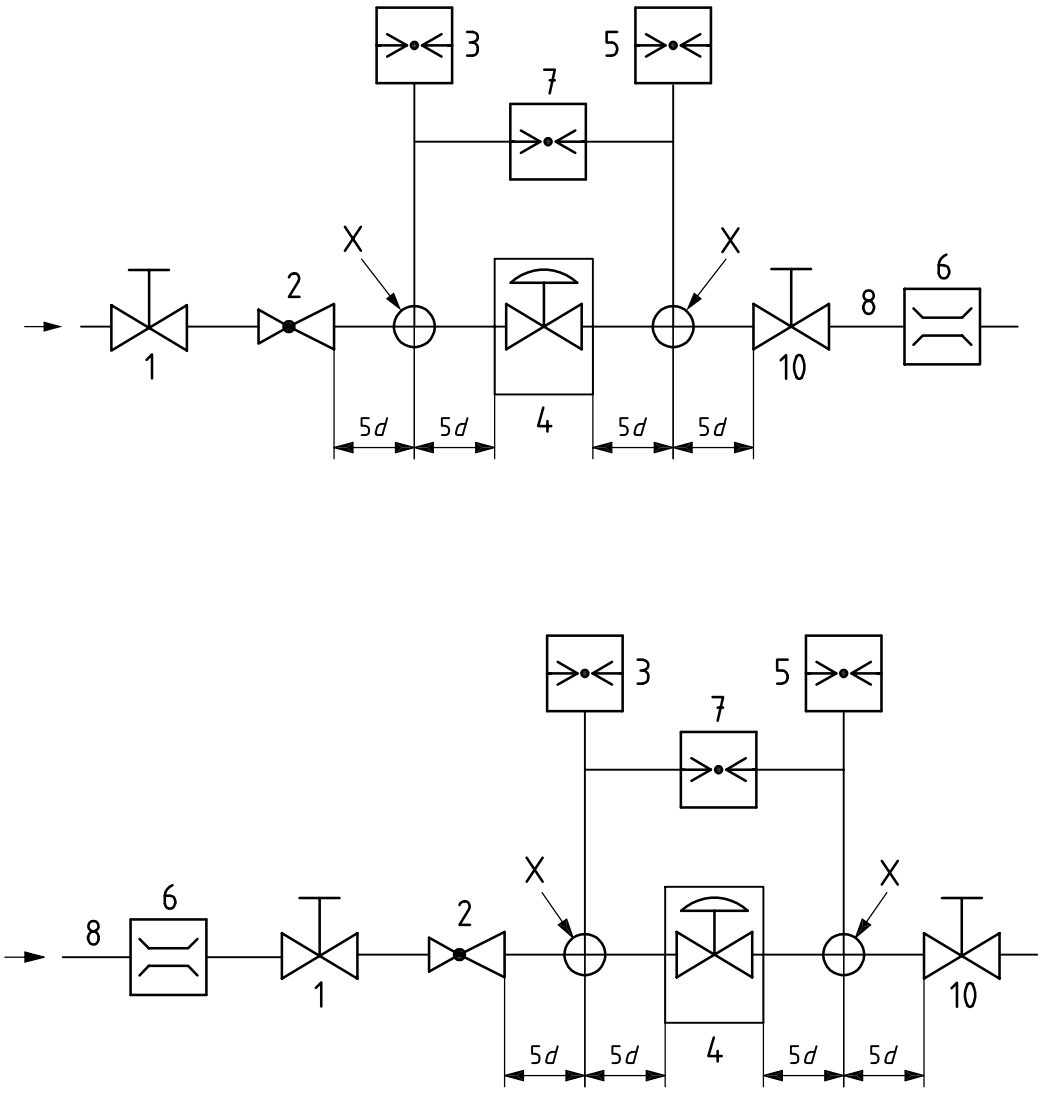
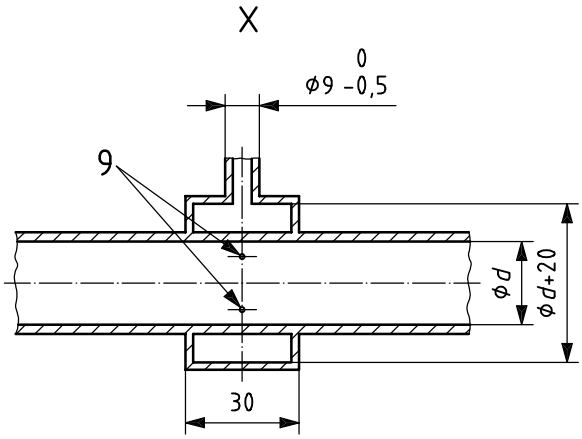


Figure B.1 — Regulator performance test rig

Dimensions in millimetres



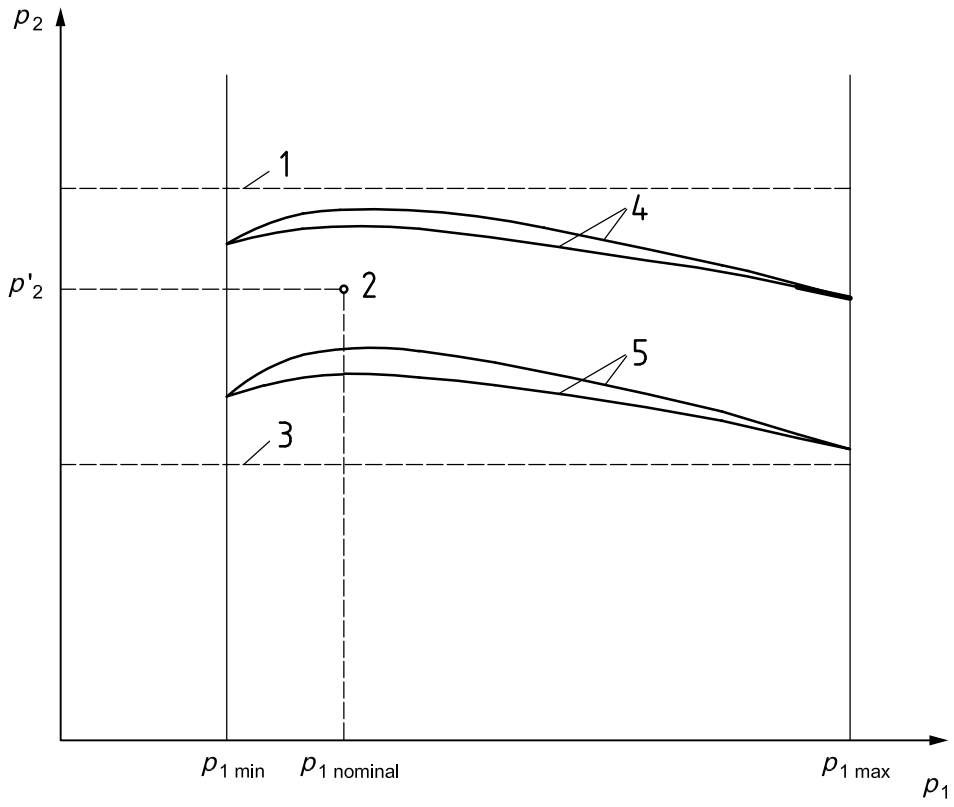
Key

1 inlet control tap
2 regulator for inlet pressure
3 inlet pressure gauge
4 test sample
5 outlet pressure gauge
6 flow meter
7 differential pressure gauge
8 temperature measuring point
9 holes, four, 1,5 mm diameter
10 outlet control tap

Relation of nominal size to internal diameter

Nominal size DN	**Internal diameter** d mm
6	6
8	9
10	13
15	16
20	22
25	28
32	35
40	41
50	52
65	67
80	82
100	106
125	131
150	159

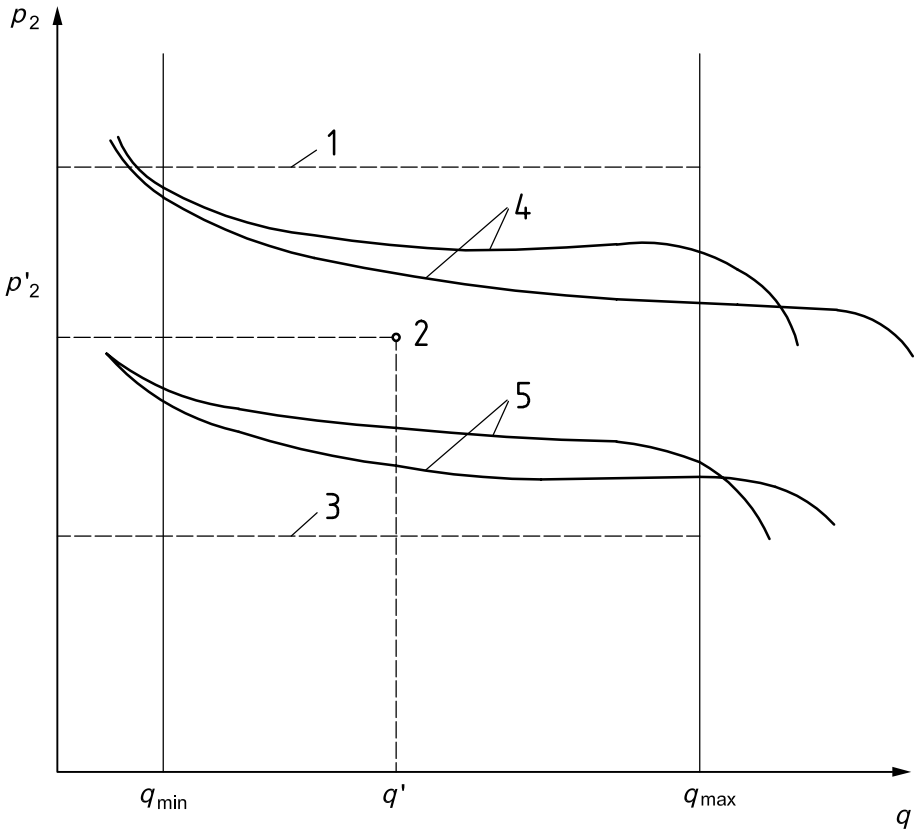
Figure B.1 (*continued*)



Key

1 upper tolerance limit
2 setting point
3 lower tolerance limit
4 control characteristic at q_{min}
5 control characteristic at q_{max}

Figure B.2 — Graph of performance using inlet pressure variation



Key

1 upper tolerance limit
2 setting point
3 lower tolerance limit
4 control characteristic at p_{1max}
5 control characteristic at p_{1min}

Figure B.3 — Graph of performance using flow rate variation

B.2.2 Class A pressure regulators

Proceed as follows for the variation of the inlet pressure, p_1, and of the flow rate, q:

a) Adjustment of regulator outlet setting pressure: set the outlet control tap to obtain a flow rate of 0,5 q_{max} (or any other value declared by the manufacturer). For adjustable regulators, adjust the outlet setting pressure to the maximum value (p_{2max}), the inlet pressure, p_1, being the nominal pressure (or any other value declared by the manufacturer).

b) The outlet setting pressure being set, there shall be no further adjustment of the regulator.

c) Vary the inlet pressure, p_1, from the nominal value over the minimum (p_{min}) to the maximum value (p_{1max}) and back to the minimum value, and record the outlet pressure, p_2, for at least five values of p_1, in each direction, without resetting the flow rate.

d) With inlet pressure, p_{1min}, kept constant, vary the flow rate from q_{max} to q_{min} and back to q_{max} by using the outlet control tap, the outlet pressure, p_2, being recorded for at least five values of q in each case. Make sure that there is no change of the inlet pressure throughout this procedure.

e) Readjust the inlet pressure from p_{1min} to p_{1max} and then vary the flow rate from q_{max} to q_{min} [as in step c)].

f) For adjustable regulators, repeat steps b) to d) after the outlet setting pressure has been readjusted according to step a) to the value p_{2min}.

B.2.3 Class B regulators

Proceed as follows for the variation of the inlet pressure, p_1, and of the flow rate, q:

a) Adjustment of regulator outlet setting pressure: set the flow rate to q_{max} by adjusting the outlet control tap. For adjustable regulators, adjust the outlet setting pressure to the maximum value (p_{2max}), the inlet pressure, p_1, being the nominal pressure (or another value declared by the manufacturer).

b) The outlet setting pressure being set, there shall be no further adjustment of the regulator.

c) Vary the inlet pressure, p_1, from the nominal value over the minimum (p_{1min}) to the maximum value (p_{1max}) and back to the minimum value, and record the outlet pressure, p_2, for at least five values of p_1 in each direction, without resetting the flow rate.

d) With inlet pressure, p_1, kept constant, readjust the flow rate, q_{max}, by using the outlet control tap without any other adjustment of the already set value of the outlet pressure to q_{min}.

e) Repeat step b).

f) For adjustable regulators repeat steps b) to d), the outlet setting pressure as per step a) having been readjusted to the value p_{2min}.

B.2.4 Class C regulators

Proceed as follows for the variation of the inlet pressure p_1:

a) Adjustment of regulator outlet setting pressure: set the flow rate to q_{max} by means of the outlet control tap. For adjustable regulators, adjust the outlet setting pressure to the maximum value (p_{2max}), the inlet pressure, p_1, being the nominal pressure (or any other value declared by the manufacturer).

b) The outlet pressure being set, there shall be no further adjustment of the regulator.

c) Vary the inlet pressure, p_1, from the minimum value (p_{1min}) to the maximum value (p_{1max}) and back to the minimum value, and record the outlet pressure, p_2, for at least five values of p_1 in each direction, without resetting the flow rate.

d) By means of the outlet control tap, adjust the flow rate to q_{min}, the outlet setting pressure having been readjusted as in step a).

e) Repeat step b).

f) For adjustable regulators repeat steps b) to d), the outlet setting pressure having been readjusted as in step a) to the value p_{2min}.

B.2.5 Pressure drop

Adjust the inlet pressure, p_1, to 0,1 kPa less than the value of the outlet pressure obtained at minimum inlet pressure and at maximum flow. The regulator valve shall then be fully open.

Measure the differential pressure between the inlet and outlet pressures under these conditions.

For regulator that may be set over a range, measure the differential pressure for the lowest setting pressure.

B.3 Summary of requirements and test procedures

B.3.1 Requirements

Table B.3 — Requirements

<table>
<tr><th rowspan="3">Parameter</th><th colspan="9">Outlet pressure, p_2</th></tr>
<tr><th colspan="3">Class A regulator</th><th colspan="3">Class B regulator</th><th colspan="3">Class C regulator</th></tr>
<tr><th>First family</th><th>Second family</th><th>Third family</th><th>First family</th><th>Second family</th><th>Third family</th><th>First family</th><th>Second family</th><th>Third family</th></tr>
<tr><td>Tolerance on the outlet pressure, p_2, (as a percentage of the outlet setting pressure)</td><td>± 15</td><td>± 15</td><td>± 15</td><td>+ 15
− 20</td><td>+ 10
− 15</td><td>± 10</td><td>+ 15
− 20</td><td>+ 10
− 15</td><td>± 10</td></tr>
<tr><td>— with change of inlet pressure from p_{1min} to p_{1max}</td><td colspan="3" rowspan="2">or ± 0,1 kPa</td><td colspan="3">or ± 0,1 kPa</td><td colspan="3">or ± 0,1 kPa</td></tr>
<tr><td>— with change of flow rate from q_{max} to q_{min}</td><td>+ 40</td><td>+ 40</td><td>+ 40</td><td colspan="3"></td></tr>
<tr><td>Setting pressure</td><td colspan="9">Nominal pressure according to Table B.1 or as declared by the manufacturer</td></tr>
<tr><td>Inlet pressure range</td><td colspan="9">According to Table B.1 or as declared by the manufacturer</td></tr>
<tr><td>Maximum inlet pressure</td><td colspan="9">As declared by the manufacturer</td></tr>
</table>

B.3.2 Test procedure

Table B.4

Setting or testing		Class A regulator	Class B regulator	Class C regulator
1	Setting			
	Set the outlet pressure, p_2, to	p_{2max}	p_{2max}	p_{2max}
1.1	at an inlet pressure, p_1, equal to	Nominal pressure according to Table B.1 or as declared by the manufacturer		
1.2	and at a flow rate, q, equal to	0,5 q_{max}	q_{max}	q_{max}
		Once the outlet pressure has been set, there shall be no further adjustment of the regulator.		
2	Testing	After each change of p_1 or q, record the outlet pressure, p_2		
2.1	Change p_1 to	p_{1min}	p_{1min}	p_{1min}
2.2	Change q from → to	0,5 $q_{max} \rightarrow q_{min} \rightarrow q_{max}$	No change	No change
2.3	Change p_1 to	p_{1max}	p_{1max}	p_{1max}
2.4	Change q from → to	$q_{max} \rightarrow q_{min} \rightarrow q_{max}$	No change	No change
2.5	Change p_1 to	—	p_{min}	—
2.6	Change q from → to	—	$q_{max} \rightarrow q_{min}$	—
3	Setting			
	Set the outlet pressure, p_2, to			p_{2max}
3.1	at an inlet pressure, p_1,	—	—	as indicated in 1.1
3.2	and at a flow rate, q, of	—	—	q_{min}
		Once the outlet pressure has been set, there shall be no further adjustment of the regulator.		
4	Testing	After each change of p_1 or q, record the outlet pressure, p_2		
4.1	Change p_1 to	—	p_{1min}	p_{1min}
4.2	Change q from → to	—	No change	No change
4.3	Change p_1 to	—	p_{1max}	p_{1max}
4.4	Change q from → to	—	No change	No change
4.5	Change p_1 to	—	p_{1min}	p_{1min}

For all regulators, irrespective of their class, repeat the complete test procedure, including steps 1 to 4, but with the outlet pressure reset to p_{2min}.

Annex C
(normative)

Functional requirements and regulator performance testing — Method B

C.1 Requirements

C.1.1 Mounting regulator for test

The regulator shall be installed in the appropriate test rig shown in Figure C.1. The regulator shall be placed in the mounting position specified for the particular test to be conducted.

C.1.2 Outlet pressure range

Nonadjustable regulators shall be tested as described in C.2.2.1 for outlet pressure performance as specified in Table C.2. Adjustable regulators shall be tested for outlet pressure performance as specified.

C.1.3 Range of regulation capacity

The range of regulation capacity as determined by test described in C.2.3 shall include the upper and lower limits specified by the manufacturer.

C.1.4 Regulators designated to operate at pilot flow rate

The specified maximum regulation capacity for main burner and pilot load application shall not be greater than the specified maximum regulation capacity for main burner load only. The pressure variation in the pilot line, resulting from the change of flow rate through the regulator from the specified regulation capacity for main burner and pilot load to a pilot flow rate, shall not exceed 373 Pa (1,5 in water column) or 20 %, whichever is greater, when tested per C.2.4.1.

The pressure in the pilot line resulting from changing the flow through the regulator from pilot rate to the maximum individual load capacity shall not be less than 65 % of the stabilized pilot line pressure at pilot rate when examined under the test specified in C.2.4.2.

C.1.5 Integrity of operation

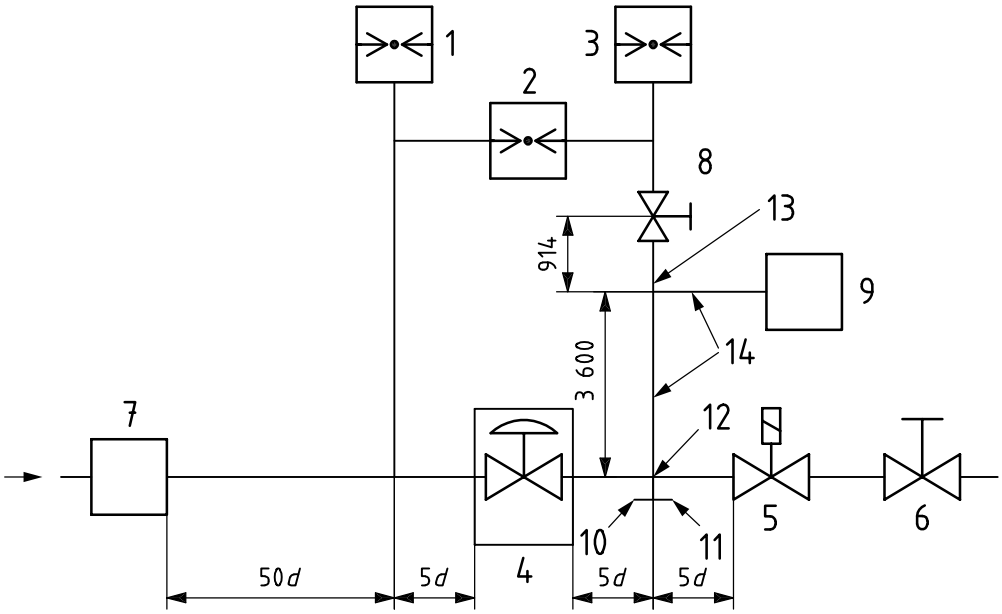
The opening characteristics of the outlet pressure of the regulator shall stay within the tolerances specified in C.2.5 at the extreme temperature and mounting position conditions specified.

A regulator with a separate vent limiter shall have curves developed for outlet pressure versus time with and without the vent limiter installed. If more than one vent limiter is used with the regulator, an additional curve shall be developed with each vent limiter in place. A convertible regulator shall have a curve developed for each operating pressure range. A multi-stage regulator shall have curves developed at the settings which deliver the maximum and minimum outlet pressure, respectively.

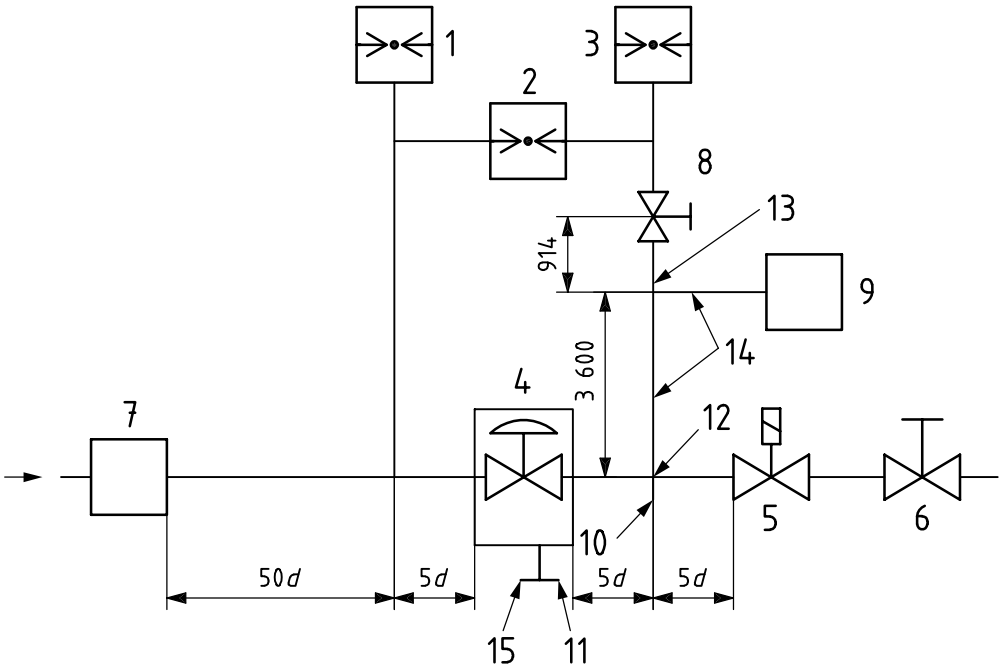
C.1.6 Long-term performance

The performance and leak tightness of the regulator shall remain within the limits specified in C.2.6 and 7.2.2 after testing in accordance with C.2.6.

Dimensions in millimetres



a) Regulator without pilot take-off



b) Regulator with pilot take-off

key

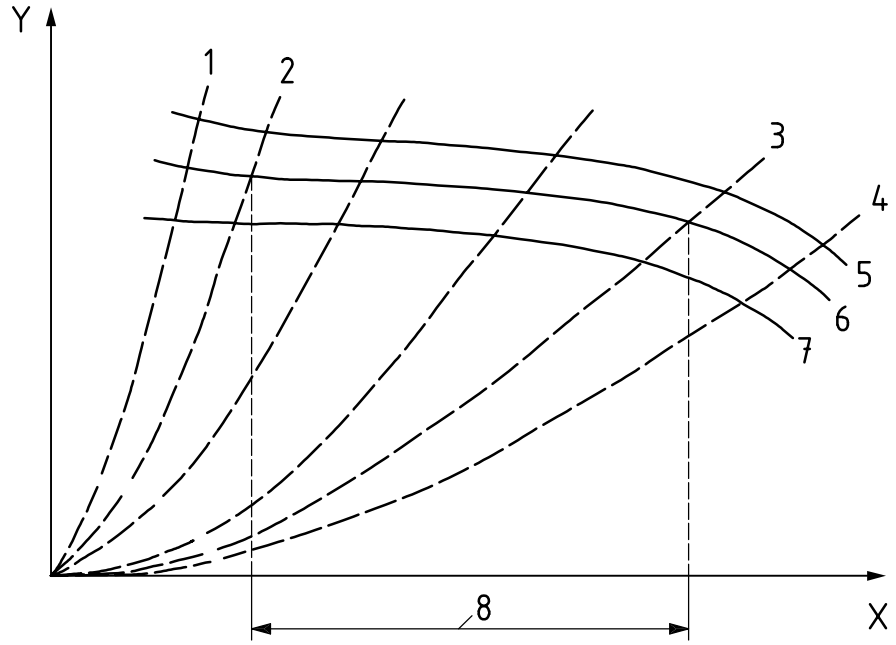
1 inlet pressure measuring device
2 differential pressure measuring device
3 outlet pressure measuring device
4 regulator under test
5 instantaneous opening automatic valve
6 outlet adjustment control valve
7 constant pressure source
8 shut-off valve
9 pressure transducer
10 optional tap
11 pilot flow line, length 69,9
12 outlet pressure tap for manometer or pressure transducer (hole through pipe wall, diameter 1,6)
13 type II tube
14 type I tube
15 tap for manometer or pressure transducer, (hole trough pipe wall, diameter 1,6 mm)

Figure C.1 — Typical arrangement of test apparatus

C.2 Test

C.2.1 General test procedures

Regulators shall be tested in accordance with the test sequences specified in C.2.2 to C.2.6. Unless otherwise noted, equilibrium conditions shall always be reached before readings are taken. Examples of “Range of regulation” are shown in Figures C.2 and C.3 and “Opening characteristics” curves are shown in Figures C.2 and C.5, respectively.



Key

X flow rate

Y outlet pressure

1 orifice curves at which maximum obtainable outlet pressure varies from minimum obtainable outlet pressure by 20 %

2 orifice curves at which outlet pressure at maximum inlet test pressure varies from minimum obtainable outlet pressure by 20 %

3 orifice curves at which maximum obtainable outlet pressure varies from minimum obtainable outlet pressure by 20 %

4 orifice curves at which outlet pressure at maximum inlet test pressure varies from minimum obtainable outlet pressure by 20 %

5 curve B, maximum obtainable outlet pressure curve

6 curve A, minimum obtainable outlet pressure curve

7 curve C, outlet pressure curves at maximum inlet test pressure

8 range of regulation

Figure C.2 — Range of regulation curves for nonadjustable regulators

C.2.2 Outlet pressure range

These tests shall be conducted at room temperature. The regulator initially shall be mounted in the upright position.

C.2.2.1 Nonadjustable regulator

The inlet pressure and flow rate shall be established as specified by the manufacturer.

The outlet pressure shall be observed and shall be within the tolerances specified in Table C.1.

The above test shall be repeated with the regulator mounted in each mounting position specified by the manufacturer.

The regulator mounting position that produces the minimum outlet pressure shall be designated position A.

The regulator mounting position that produces the maximum outlet pressure shall be designated position B.

These are the two mounting positions used for the tests in accordance with C.2.3.

C.2.2.2 Convertible regulator

Convertible regulators shall be tested with the same test method used for nonadjustable regulators, as described above.

The outlet pressure, at each outlet pressure setting, of convertible regulators for use other than on domestic gas ranges shall be within the tolerances in accordance with Table C.1 of the outlet pressure as specified by the manufacturer.

C.2.2.3 Adjustable regulator

Adjustable regulators shall be tested twice using the same test method used for nonadjustable regulators, as described above: once with the regulator adjusted to deliver its minimum outlet pressure and once with the regulator adjusted to deliver its maximum outlet pressure.

The regulator mounting position that produces the minimum outlet pressure shall be designated position A. The regulator mounting position that produces the maximum outlet pressure shall be designated position B.

These are the two mounting positions used for the tests in accordance with C.2.3.

C.2.3 Range of regulation capacity

These tests are to be conducted at room temperature.

C.2.3.1 Nonadjustable regulator

The regulator shall be mounted as for test specified in C.1. in position A (as determined in C.2.2.1).

The inlet test pressure shall be adjusted to the appropriate minimum value specified in Table C.2. If this minimum value exceeds the rated inlet pressure, the rated inlet pressure shall be used as the minimum inlet test pressure. The initial flow rate shall be set at a value less than the lower limit of the manufacturer's specified range of regulation capacity. The lower limit of the range of regulation capacity shall be 1,18 cm^3/s (0,15 ft^3/h) for regulators designated by the symbol “circle P” and 3,93 cm^3/s (0,50 ft^3/h) for regulators designated by the symbol “delta P”.

The inlet test pressure shall be gradually increased to the rated inlet pressure. Over this range of inlet pressures, the minimum and maximum obtainable outlet pressures observed and their corresponding flow rates shall be recorded and used to construct a smooth orifice curve.

The inlet test pressure shall then be increased to the maximum inlet test pressure (see Table C.2) and the outlet pressure observed shall be recorded.

This procedure shall be repeated for increased flow rates to a flow rate exceeding the upper limit of the manufacturer's specified range of regulation capacity. A sufficient number of readings shall be recorded to establish smooth curves when minimum obtainable outlet pressures are joined (Figure C.2, curve A), maximum obtainable outlet pressures are joined (Figure C.2, curve B), and outlet pressures obtained at the maximum inlet test pressure are joined (Figure C.2, curve C).

Pressure variations and flow rates shall be examined along the orifice curves.

a) Examine the minimum and maximum obtainable outlet pressure curves to determine the minimum and maximum flow rates between which the outlet pressure variation does not exceed 20 % of the minimum obtainable outlet pressure. (See Figure C.2).

b) Examine the maximum inlet test pressure curve to determine the minimum and maximum flow rates between which the pressure does not vary more than $\pm$ 20 % from the minimum obtainable outlet pressure. (See Figure C.2).

The largest minimum flow rate and the smallest maximum flow rate determined from “a” and “b” above shall include the lower and upper limits of the manufacturer's specified range of regulation capacity.

C.2.3.2 Convertible regulator

Each outlet pressure setting of a convertible regulator shall be evaluated independently as a nonadjustable regulator.

C.2.3.3 Adjustable Regulator

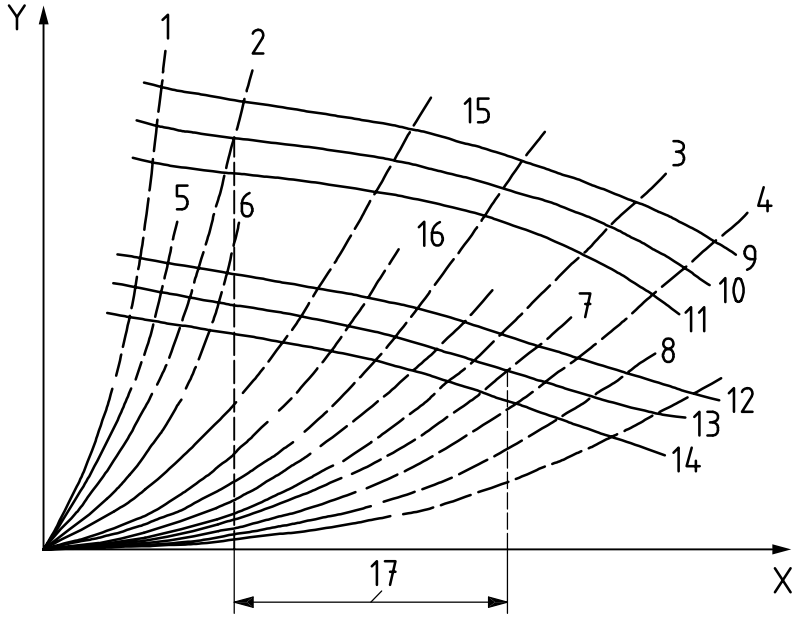
The regulator shall be mounted in position B (as determined in C.2.2.3).

Adjust the regulator to deliver the manufacturer's specified maximum outlet pressure at the manufacturer’s specified inlet pressure and flow rate.

The procedure outlined above for nonadjustable regulators shall then be followed to develop curves A, B and C. (See Figure C.3).

The regulator shall then be mounted in position A (as determined in C.2.2.3). Adjust the regulator to deliver the manufacturer's specified minimum outlet pressure at the manufacturer’s specified inlet pressure and flow rate. The procedure outlined above for nonadjustable regulators shall then be followed to develop curves D, E and F. (See Figure C.3).

The largest minimum flow rate and the smallest maximum flow rate determined from all of the tests above shall include the lower and upper limits of the manufacturers specified range of regulation capacity.



Key

X flow rate

Y outlet pressure

1 orifice curves at which maximum obtainable outlet pressure varies from minimum obtainable outlet pressure by 20 %

2 orifice curves at which outlet pressure at maximum inlet test pressure varies from minimum obtainable outlet pressure by 20 %

3 orifice curves at which maximum obtainable outlet pressure varies from minimum obtainable outlet pressure by 20 %

4 orifice curves at which outlet pressure at maximum inlet test pressure varies from minimum obtainable outlet pressure by 20 %

5 orifice curves at which maximum obtainable outlet pressure varies from minimum obtainable outlet pressure by 20 %

6 orifice curves at which outlet pressure at maximum inlet test pressure varies from minimum obtainable outlet pressure by 20 %

7 orifice curves at which maximum obtainable outlet pressure varies from minimum obtainable outlet pressure by 20 %

8 orifice curves at which outlet pressure at maximum inlet test pressure varies from minimum obtainable outlet pressure by 20 %

9 curve B, maximum obtainable outlet pressure curve

10 curve A, minimum obtainable outlet pressure curve

11 curve C, outlet pressure curve at maximum inlet test pressure

12 curve E, maximum obtainable outlet pressure curve

13 curve D, minimum obtainable outlet pressure curve

14 curve F, outlet pressure curve at maximum inlet test pressure

15 maximum outlet pressure adjustment

16 minimum outlet pressure adjustment

17 range of regulation

Figure C.3 — Range of regulation curves for adjustable regulators

C.2.3.4 Multi-stage regulator

Multi-stage regulators are tested at the highest and lowest stages.

These stages may be adjustable or nonadjustable. The minimum inlet test pressure is determined by the highest stage.

The regulator shall then be mounted in position B (as determined in either C.2.2.1 or C.2.2.3, as applicable) and set to the highest pressure stage.

If the highest pressure stage is nonadjustable, the procedure outlined above for nonadjustable regulators shall be followed to construct curves A, B and C.

If the highest pressure stage is adjustable, the procedure outlined above for adjustable regulators shall be followed to construct curves A, B, C, D, E and F.

The regulator shall be mounted for test in position A (as determined in C.2.2) and set at the lowest pressure stage.

If the lowest pressure stage is nonadjustable, the procedure outlined above for nonadjustable regulators shall be followed.

If the lowest pressure stage is adjustable, set the regulator to deliver the manufacturer's specified minimum outlet pressure at the manufacturer's specified inlet pressure and flow rate. The procedure outlined above for nonadjustable regulators shall be followed, except that it is not necessary for the maximum flow rate to exceed the flow rate on the orifice curve for the maximum regulation capacity determined for the highest pressure stage.

Within the limits of the flow rates obtained from the orifice curves at the lower and upper limits of the manufacturer's specified range of regulation capacity, the observed outlet pressure shall not vary by more than 20 % of the lower outlet pressure reading or 74,7 Pa (0,3 in water column), whichever is greater. In no case shall the observed outlet pressure be less than 50 Pa (0,2 in water column).

C.2.4 Regulators designated to operate at pilot flow rate

These tests shall be conducted at room temperature.

C.2.4.1 Regulation capacity

The regulator and pilot flow line shall be installed as specified in C.1, except that a manometer shall be installed at either the inlet pressure measuring device (Figure C.1, key item 1) or the outlet pressure measuring device (Figure C.1, key item 3).

Convertible regulators shall be tested at each outlet pressure setting.

With a flow rate through the regulator equivalent to the maximum specified regulation capacity and the pilot flow adjusted to 1,18 cm^3/s (0,15 ft^3/h) for regulators designated by the symbol "circle P", or 3,93 cm^3/s (0,50 ft^3/h) for regulators designated by the symbol "delta P", the settings specified below shall be made within the rated inlet pressure of the regulator and the minimum inlet test pressure specified in C.2.3. The main flow shall be cycled off and on to establish the reliability of the setting. The pilot line pressure at each of the established settings shall be recorded.

a) Mount the regulator in position B (in accordance with either C.2.2.1 or C.2.2.3, as applicable).

b) Adjust the regulator, if adjustable, to deliver the manufacturer's specified maximum outlet pressure, with the related inlet pressure and flow rate established as specified by the manufacturer. Then set the inlet pressure to produce the maximum outlet pressure.

c) Adjust the regulator, if adjustable, as described in “b.” Then set the inlet pressure to produce the minimum outlet pressure.

d) Then mount the regulator in position A (in accordance with C.2.2).

e) Adjust the regulator, if adjustable, to deliver the manufacturer's specified minimum outlet pressure, with the related inlet pressure and flow rate established as specified by the manufacturer. Then set the inlet pressure to produce the maximum outlet pressure.

f) Adjust the regulator, if adjustable, as described in “e.” Then set the inlet pressure to produce the minimum outlet pressure. At the end of the established settings, the instantaneous opening valve shall be closed and, without reopening the valve, the stabilized pilot line pressure shall again be noted. The pressure shall be within 373 Pa (1,5 in water column) or 20 %, whichever is greater, of the previously recorded pilot line pressure.

C.2.4.2 Pressure variation

The regulator shall be installed as specified in C.2.4.1, except the manometer shall be replaced by a pressure transducer coupled to a fast response recording voltmeter or other equivalent instrumentation to measure pilot line pressure, the vent limiter, if supplied, shall be in place.

Convertible regulators shall be tested at each outlet pressure setting.

The regulator shall be mounted in position A (in accordance with either C.2.2.1 or C.2.2.3, as applicable).

a) The regulator, if adjustable, shall be adjusted to deliver the manufacturer's specified minimum outlet pressure, with the related inlet pressure and flow rate established as specified by the manufacturer. The inlet pressure shall then be adjusted to the minimum inlet test pressure specified in Table C.2, at a flow rate equivalent to the maximum individual load capacity specified and the pilot flow adjusted to 1,18 cm^3/s (0,15 ft^3/h) for regulators designated by the symbol “circle P” or (3,93 cm^3/s) (0,50 ft^3/h) for regulators designated by the symbol “delta P”. The instantaneous opening valve shall be closed. The pressure in the pilot line shall be measured and recorded as the initial outlet pressure. With the inlet pressure held constant within $\pm$ 24,9 Pa ($\pm$ 0,1 in water column), the instantaneous opening valve shall be opened and, starting at 0,25 s after flow has been initiated, the outlet pressure shall be noted until it has become stabilized. At least two more tests shall be conducted to definitely establish the minimum outlet pressure. The minimum outlet pressure noted in the pilot line after 0,25 s of flow shall not be less than 65 % of the initial outlet pressure.

b) The inlet pressure shall then be adjusted to the rated inlet pressure of the regulator. No change in any flow adjustment shall be made. The outlet pressure curve shall be developed and evaluated as specified in “a” above. The regulator shall then be mounted in position B (in accordance with either C.2.2.1 or C.2.2.3, as applicable).

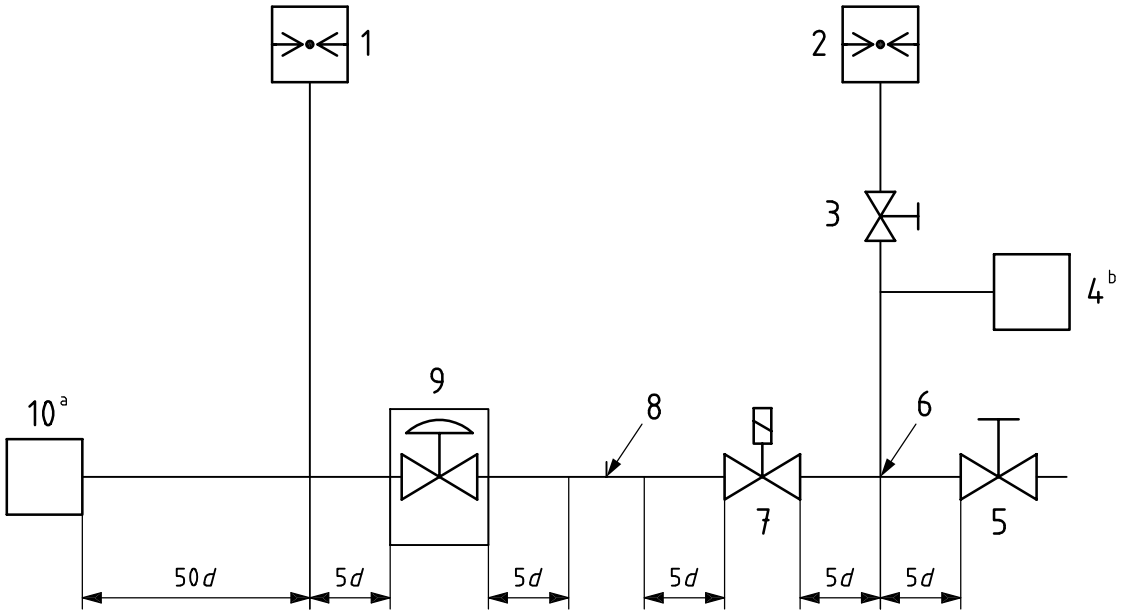
c) The regulator, if adjustable, shall be adjusted to deliver the manufacturer's specified maximum outlet pressure, with the related inlet pressure and flow rate established as specified by the manufacturer. The inlet test pressure shall then be adjusted to the minimum inlet test pressure specified in Table C.2, and flow rates adjusted as specified in “a” above. The outlet pressure curve shall be developed and evaluated as specified in “a” above.

d) The inlet pressure shall then be adjusted to the rated inlet pressure of the regulator. No change in any flow adjustment shall be made. The outlet pressure curve shall be developed and evaluated as specified in “a” above.

C.2.5 Integrity of operation

C.2.5.1 Creating base curve

This test shall be conducted at room temperature. The regulator shall be installed in the manufacturer's specified upright position as shown in Figure C.4 and, where applicable, according to the equipment specifications under C.1.



Key

1 inlet pressure measuring device
2 outlet pressure measuring device
3 shut-off valve
4 pressure transducer
5 outlet adjustment control valve
6 tap for pressure transducer
7 instantaneous opening automatic valve
9 regulator under test
10 constant pressure source

a The constant-pressure source shall not permit a pressure variation for no flow to full flow, of more than ± 24,9 Pa for each 2,83 m^3/h of air flow at full flow.

b Pressure transducer coupled to a fast response recording voltmeter or other equivalent instrumentation.

Figure C.4 — Arrangement for integrity of operation test

The inlet test pressure for each curve to be developed shall be set as indicated in Table C.1.

a) For each operating pressure range, the pressure regulator shall be set to obtain the manufacturer's specified minimum outlet pressure at a flow rate equivalent to the midpoint of the specified range of regulation capacity. For purpose of this initial setting, the pressure tap (Figure C.4, key item 1) shall be used. After the initial setting, the pressure measuring device used at this tap shall be isolated from the system for the remainder of these tests. The instantaneous opening valve shall then be closed. The instantaneous opening valve shall be energized and the outlet pressure, p_2, versus time, t, recorded until steady state outlet pressure is attained.

   The following points shall then be determined by examination of this curve:

   — $p_{2,1}$ is the outlet pressure after 1 s of gas flow;

   — $p_{2,2}$ is the outlet pressure after 2 s of gas flow;

   — $p_{2,3}$ is the outlet pressure after 3 s of gas flow;

   — $p_{2,4}$ is the outlet pressure after 4 s of gas flow;

   — $p_{2,SS}$ is the steady state outlet pressure;

   — t_1 is the time at which the curve crosses either 90 % $p_{2,SS}$ or 110 % $p_{2,SS}$ and remains within these limits;

   — After 1 s of gas flow, the outlet pressure shall not exceed 120 % $p_{2,SS}$;

   — After 4 s of gas flow, the outlet pressure shall be at least 50 Pa (0,2 in water column);

   — Figure C.5 is an example of this curve when $p_{x,SS} = p_{2,SS}$ and $t_x = t_1$.

b) For a regulator designed for operation in mounting positions other than the manufacturer's specified upright position, an additional base curve(s) of the outlet pressure, p'_2, versus time, t, shall be developed in the manner prescribed above with no change in the flow rate adjustment and with the regulator mounted in the mounting position(s) that produces the extreme(s) of outlet pressure.

   The following points shall then be determined by examination of this curve:

   — $p'_{2,1}$ is the outlet pressure at 1 s of gas flow;

   — $p'_{2,2}$ is the outlet pressure at 2 s of gas flow;

   — $p'_{2,3}$ is the outlet pressure at 3 s of gas flow;

   — $p'_{2,4}$ is the outlet pressure at 4 s of gas flow;

   — $p'_{2,SS}$ is the steady state outlet pressure;

   — t_2 is the time at which the curve crosses either 90 % $p'_{2,SS}$ or 110 % $p'_{2,SS}$ and remains within these limits;

   — After 1 s of gas flow, the outlet pressure shall not exceed 120 % $p'_{2,SS}$;

   — After 4 s of gas flow, the outlet pressure shall be at least 50 Pa (0,2 in water column);

   — Figure C.5 is an example of this curve when $p'_{x,SS} = p_{2,SS}$ and $t_x = t_2$.

C.2.5.2 For a regulator designed for operation at temperatures above 51,5 °C (125 °F), a curve(s) of the outlet pressure, p_{2a}, versus time, t, shall be developed in accordance with C.2.5.1 a) or b), as appropriate, with no change in the flow rate adjustment and with the ambient temperature equal to the manufacturer's specified maximum ambient temperature.

a) The following points shall then be determined by examination of the curve(s):

- $p_{2a,1}$ is the outlet pressure at 1 s of gas flow.
- $p_{2a,2}$ is the outlet pressure at 2 s of gas flow.
- $p_{2a,3}$ is the outlet pressure at 3 s of gas flow.
- $p_{2a,4}$ is the outlet pressure at 4 s of gas flow.
- $p_{2a,SS}$ is the steady state outlet pressure.
- t_a is the time at which the curve crosses either 75 % $p_{2,SS}$ or 120 % $p_{2,SS}$ and remains within these limits.

b) The outlet pressure readings for each second of time determined from this/these curve(s) shall be compared with the corresponding outlet pressure points determined from the appropriate curve(s) developed in C.2.5.1 and shall comply with the following:

- $p_{2a,1}$ shall be within ± 75 % $p_{2,1}$ or $p'_{2,1}$, as applicable.
- $p_{2a,2}$ shall be within ± 70 % $p_{2,2}$ or $p'_{2,2}$, as applicable.
- $p_{2a,3}$ shall be within ± 60 % $p_{2,3}$ or $p'_{2,3}$, as applicable.
- $p_{2a,4}$ shall be within ± 50 % $p_{2,4}$ or $p'_{2,4}$, as applicable.

In addition, t_a shall not be greater than $t_1 + 1$ min or $t_2 + 1$ min, as applicable. After 1 s of gas flow, the outlet pressure shall not exceed 120 % $p_{2a,SS}$. After 4 s of gas flow, the outlet pressure shall be at least 50 Pa (0,2 in water column). Only the values determined from curves developed under similar test conditions (i.e., without a vent limiter or with the same vent limiter, upright or worst case mounting position) shall be compared.

Figure C.5 is an example of this curve when $p_{x,SS} = p_{2,SS}$ and $t_y = t_{1a}$.

C.2.5.3 For a regulator designed for operation at temperatures below 0 °C (32 °F), a curve(s) shall be developed as described under C.2.5.1 a) and b), as appropriate, with no change in the flow rate adjustment and with the ambient temperature equal to the manufacturer's specified minimum ambient temperature.

a) The following points shall then be determined by examination of this curve:

- $p_{2b,1}$ is the outlet pressure at 1 s of gas flow;
- $p_{2b,2}$ is the outlet pressure at 2 s of gas flow;
- $p_{2b,3}$ is the outlet pressure at 3 s of gas flow;
- $p_{2b,4}$ is the outlet pressure at 4 s of gas flow;
- $p_{2b,SS}$ is the steady state outlet pressure.
- t_b is the time at which the curve crosses either 75 % $p_{2,SS}$ or 120 % $p_{2,SS}$ and remains within these limits.

b) The outlet pressure readings for each second of time determined from this/these curve(s) shall be compared with the corresponding outlet pressure points determined from the appropriate curve(s) developed in C.2.5.1 and shall comply with the following:

- $p_{2b,1}$ shall be within ± 75 % $p_{2,1}$ or $p'_{2,1}$, as applicable.

— $p_{2b,2}$ shall be within ± 70 % $p_{2,2}$ or $p'_{2,2}$, as applicable.

— $p_{2b,3}$ shall be within ± 60 % $p_{2,3}$ or $p'_{2,3}$, as applicable.

— $p_{2b,4}$ shall be within ± 50 % $p_{2,4}$ or $p'_{2,4}$, as applicable.

In addition, t_b shall not be greater than $t_1 + 1$ min or $t_2 + 1$ min, as applicable. After 1 s of gas flow, the outlet pressure shall not exceed 120 % $p_{2b,SS}$. After 4 s of gas flow, the outlet pressure shall be at least 50 Pa (0,2 in water column). Only the values determined from curves developed under similar test conditions (i. e., without a vent limiter or with the same vent limiter, upright or worst case mounting position) shall be compared.

Figure C.5 is an example of this curve when $p_{x,SS} = p_{2,SS}$ and $t_y = t_{1b}$.

C.2.6 Long-term performance

Prior to conducting the number of cycles specified below, a baseline curve(s) of outlet pressure versus time shall be developed as described in C.2.5.1 a). For this test, the highest setting of the regulator shall be used with no change in the adjustment(s) established in C.2.5.1 a). The regulator shall be installed in the manufacturer's specified upright position.

The inlet of the regulator shall be connected to a clean gas or air supply which is controlled in such a manner that gas pressures of zero and the maximum inlet test pressure specified for its rated inlet pressure are alternately exerted at the inlet of the regulator. The flow rate through the regulator shall be adjusted to a rate sufficient to assure full opening and closing of the valve. The outlet connection of the regulator shall be provided with a suitable mechanism which closes the outlet when the maximum inlet test pressure is applied at the inlet, and opens the outlet when no pressure is applied at the inlet.

This test shall be conducted at a rate not greater than that specified by the manufacturer and in the following sequence according to the manufacturer's specified ambient temperatures(s):

a) 10 000 cycles at the minimum specified ambient temperature below 0 °C (32 °F) and 90 000 cycles at the maximum specified ambient temperature above 51,5 °C (125 °F);

b) 90 000 cycles at room temperature and 10 000 cycles at the minimum specified ambient temperature below 0 °C (32 °F);

c) 10 000 cycles at room temperature and 90 000 cycles at the maximum specified ambient temperature above 51,5 °C (125 °F);

d) 100 000 cycles at room temperature if the specified ambient temperature range is 0 °C to 51,5 °C (32 °F to 125 °F).

At the completion of 100 000 cycles, the regulator shall comply with the room temperature tests specified in 7.2 and, if equipped with a vent limiting device of other than the fixed orifice type, with 6.2.1.2. Also, after the completion of 100 000 cycles, the procedure to develop the baseline curve(s) prior to the start of the long-term performance test, shall be repeated with no change in the regulator adjustments(s).

The outlet pressure readings, $p_{2A,a}$, for each second of time, t, determined from this curve(s) shall be compared with the corresponding outlet pressure points determined from the baseline curve(s) developed at the start of this test and shall comply with the following:

— $p_{2A,a,1}$ shall be within ± 75 % $p_{2B,a,1}$.

— $p_{2A,a,2}$ shall be within ± 70 % $p_{2B,a,2}$.

— $p_{2A,a,3}$ shall be within ± 60 % $p_{2B,a,3}$.

— $p_{2A,a,4}$ shall be within ± 50 % $p_{2B,a,4}$.

In addition, $t_{A,a}$ shall be determined as the time at which the curve crosses either 80% $p_{2B,a,SS}$ and remains within these limits. $t_{A,a}$ shall not be greater than $t_{B,a}$ + 1 min. After 1 s of gas flow the outlet pressure shall not exceed 120 % $p_{2A,a,SS}$. After 4 s of gas flow the outlet pressure shall be at least 50 Pa (0,2 in water column).

Figure C.5 is an example of this curve when $p_{x,SS} = p_{3,SS}$ and $t_y = t_4$.

Table C.1 — Allowable outlet pressure tolerances — Nonadjustable regulators

Manufacturers specified outlet pressure		Tolerance			
		Pilot burner load application only [a]		All others regulators	
kPa	(in water column)				
< 0,249	(< 1)	Specified by manufacturer		Specified by manufacturer	
0,249 to 1,4	(1 to 6)	± 124 Pa	(± 0,5 in water column)	± 74,7 Pa	(± 0,3 in water column)
> 1,49	(> 6)	± 10 %		± 5 %	

[a] 23,6 cm^3/s (3 ft^3/h) or less.

Table C.2 — Inlet test pressure

Inlet pressure				Inlet test pressure increment [a,b,c]	
Rated		Maximum			
kPa	(psi)	kPa	(psi)	Pa	(in water column)
3,48	(0,5)	5,23	(0,75)	75 to 249	(0,3 to 1,0)
13,8	(2)	20,7	(3)	249 to 1,74	(1,0 to 7,0)
34,5	(5)	51,7	(7,5)	249 to 3,48	(1,0 to 14,0)

[a] The minimum inlet pressure equals the manufacturer's specified outlet pressure plus manufacturer's specified increment given in Table 2.

[b] If the inlet test pressure determined by the table above is less than 747 Pa (3,0 in water column), the minimum inlet test pressure shall be 747 Pa (3,0 in water column).

[c] The inlet test pressure increment shall be as specified by the manufacturer and shall be within the range specified in Table 2. For nonadjustable regulators, the test pressure increment is added to the manufacturer's specified outlet pressure to determine the minimum inlet test pressure (see C 2.4.1). For adjustable regulators, the test pressure increment is added to the manufacturer's specified maximum and minimum outlet pressure to determine the minimum inlet test pressure for each setting of the regulator (see C.2.4.1).

Table C.3 — Set of inlet test pressures

Rated inlet pressure		Inlet test pressure [a]	
kPa	(psi)	kPa	(psi)
3,5	(0,5)	0,498	(0,072)
13,8	(2)	3,5	(0,5)
34,5	(5)	6,9	(1)

[a] Manufacturer's specified minimum outlet pressure for each range plus the following increment.

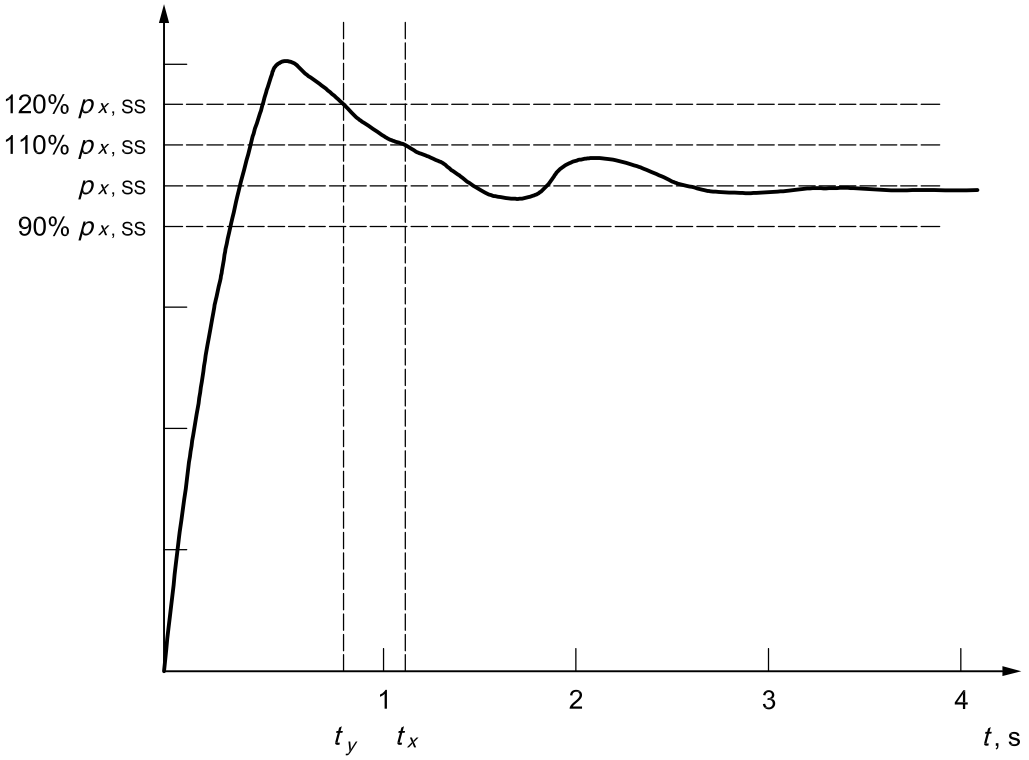


Figure C.5 — Integrity of operation curve

Annex D
(normative)

Specific performance testing in Japan

D.1 Test for leak-tightness

Change the second paragraph of 7.2.2.1 as follows:

Test shall be carried out at the pressure of 1,5 times the maximum inlet pressure.

D.2 Long-term performance

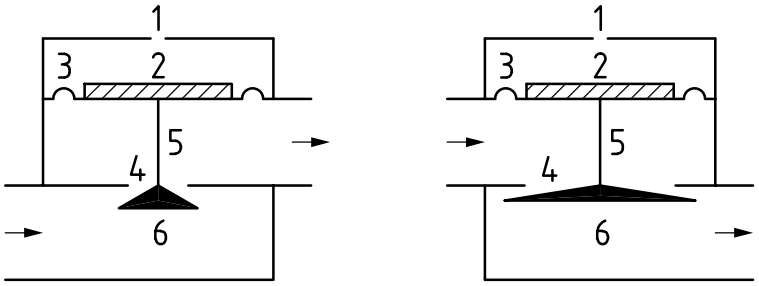
Test of long-term performance shall be carried out under the condition of the maximum working pressure with the minimum flow rate and with a shut-off valve provided upstream of the regulator.

The test method, such as the number of cycles, shall be in accordance with 7.8.2. A quick-acting valve is provided at the outlet side for the test of a governor with lock-out function.

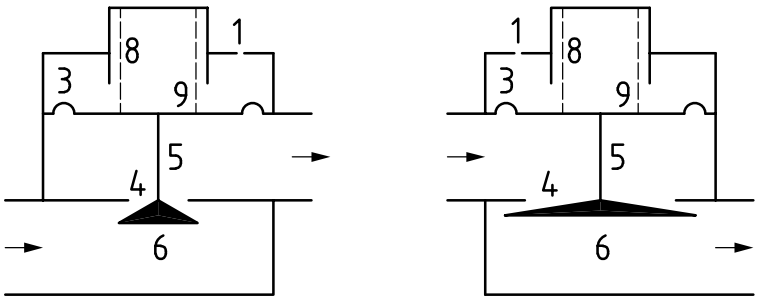
Annex E
(informative)

Typical regulators and regulator parts

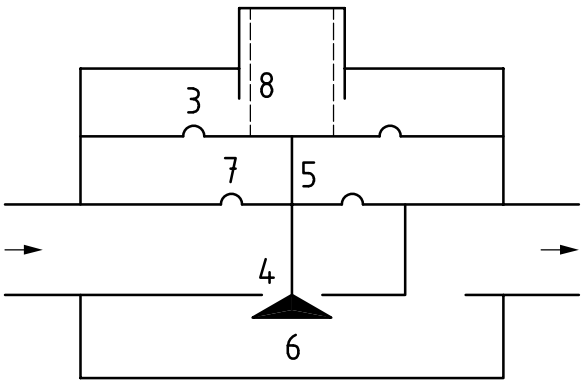
These diagrams are provided for information; regulators can operate on other principles and be composed of different components.



a) Weight-loaded



b) Spring-loaded



c) Spring-loaded, with compensating diaphragm

Key

1	breather	6	valve bob
2	weights	7	compensating diaphragm
3	main diaphragm	8	spring
4	valve seat	9	diaphragm plate
5	valve stem		

Figure E.1 — Schematic diagram of types of constant pressure regulators

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