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SANS 50334:2020
Edition 1

EN 334:2019
Edition 3

SOUTH AFRICAN NATIONAL STANDARD

Gas pressure regulators for inlet pressure up to 10 MPa (100 bar)

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This document references other documents normatively.

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SANS 50334:2020
Edition 1
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Table of changes

Change No.	Date	Scope

National foreword

This South African standard was prepared by National Committee SABS/TC 1019, *Gas supply, handling and control (fuel, industrial and medical gases)*, in accordance with procedures of the South African Bureau of Standards, in compliance with annex 3 of the WTO/TBT agreement.

This document was approved for publication in November 2020.

Compliance with this document cannot confer immunity from legal obligations.

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 334

August 2019

ICS 23.060.40

Supersedes EN 334:2005+A1:2009

English Version

Gas pressure regulators for inlet pressure up to 10 MPa (100 bar)

Régulateurs de pression de gaz pour des pressions amont jusqu'à 10 MPa (100 bar)

Gas-Druckregelgeräte für Eingangsdrücke bis 10 MPa (100 bar)

This European Standard was approved by CEN on 23 April 2019.

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European foreword

This document (EN 334:2019) has been prepared by Technical Committee CEN/TC 235 “Gas pressure regulators and associated safety devices for use in gas transmission and distribution”, the secretariat of which is held by UNI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2020, and conflicting national standards shall be withdrawn at the latest by February 2020.

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

This document supersedes EN 334:2005+A1:2009.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document.

In comparison with the previous edition, the following technical modifications have been made:

— normative references have been updated;

— terms and definitions have been added;

— flange ratings as per the available European Standards both with PN and class designations have been included: PN 20 and PN 50 flanges, as per ISO 7005-2, concern spheroidal graphite cast iron only, because at the time of writing, there was no EN standard available for class designation;

— minimum requirements for elastomeric materials following the approach already have been adopted for metallic materials;

— “fail open” and “fail close” characteristics have been improved as per the CEN rules i.e. implementing for each characteristics, where originally missed, the relevant requirement/test method/ acceptance criteria;

— provisions for surveillance in use have been included, as already done for SSDs in EN 14382;

— closing force for stand-by monitor when classified as safety accessory to PED as already done for SSD when classified as safety accessory to PED;

— antistatic characteristics;

— statistical strength test on the basis of PED provisions;

— definition of Cg flow coefficient and an improvement of KG flow coefficient by adding the definition/test method/notice of its limits;

— improvement of the functional performance classification;

— Annex G – Materials has been updated;

— requirements/test procedure and acceptance criteria for non-metallic materials have been updated;

— vent limiter as possible fixture to be assembled in the pressure regulators;

— integration of environmental requirements;

— alignment of Normative references (Clause 2), Annex G, Annex ZA and its relevant clauses to CEN rules;

— the standard has been editorially revised.

This document can be used as a guideline for gas pressure regulators outside the ranges specified in this standard. This edition has introduced the application of statistical strength testing for series produced pressure and safety accessories on the basis of EU Directive 2014/68/EU, Annex I, Article 3.2.2 and Guideline H-14. Gas pressure regulators dealt with in this document are considered as standard pressure equipment in accordance with Clause 2 a) of Art. 1 of Pressure Equipment Directive 2014/68/EU (PED).

Gas pressure regulators according to this European Standard do not have their own source of ignition. However, the manufacturer is responsible to identify any potential ignition sources of his product which could be effective during the intended use[1)].

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1) Therefore gas pressure regulators are usually not within the scope of ATEX European legislation on equipment and protective systems intended for use in potentially explosive atmospheres. Any additional component (e.g. proximity switch, travel transducer etc.) should be independently considered in the framework of assemblies as per ATEX 2014/34/EU Guidelines – 2nd Edition - December2017 clauses § 44 “Combined equipment (assemblies)”, § 46 “Components” and § 94 “Written attestation of conformity for components”.

1 Scope

This document specifies constructional, functional, testing, marking, sizing and documentation requirements of gas pressure regulators:

— for inlet pressures up to 100 bar and nominal diameters up to DN 400;

— for an operating temperature range from – 20 °C to +60 °C,

which operate with fuel gases of the 1st and 2nd family as defined in EN 437:2018 [1], used in the pressure control stations in accordance with EN 12186 or EN 12279, in transmission and distribution networks and also in commercial and industrial installations.

“Gas pressure regulators” hereafter will be called “regulators” except in the titles.

For standard regulators when used in pressure control stations complying with EN 12186 or EN 12279, the Annex ZA lists all applicable essential safety requirements of the European legislation on pressure equipment except external and internal corrosion resistance for applications in corrosive environment.

This document considers the following temperature classes/types of regulators:

— temperature class 1: operating temperature range from −10 °C to 60 °C;

— temperature class 2: operating temperature range from −20 °C to 60 °C;

— type IS: (integral strength type);

— type DS: (differential strength type).

This document applies to regulators which use the pipeline gas as a source of control energy unassisted by any external power source.

The regulator may incorporate a second regulator, used as monitor, complying with the requirements in this document.

The regulator may incorporate a safety shut off device (SSD) complying with the requirements of EN 14382.

The regulator may incorporate a creep (venting) relief device, complying with the requirements in Annex E and/or a vent limiter, complying with the requirements in Annex I.

This document does not apply to:

— regulators upstream from/on/in domestic gas-consuming appliances which are installed downstream of domestic gas meters;

— regulators designed to be incorporated into pressure control systems used in service lines[2)] with volumetric flow rate ≤ 200 m^3/h at normal conditions and inlet pressure ≤ 5 bar;

— regulators for which a specific document exists (e.g. EN 88-1 and EN 88-2, etc.);

— industrial process control valves in accordance with EN 1349.

2) The services lines are those defined in EN 12279.

The informative Annex G of this document lists some suitable materials for pressure bearing parts, inner metallic partition walls, auxiliary devices, integral process and sensing lines, connectors and fasteners. Other materials may be used when complying with the restrictions given in Table 5.

Continued integrity of gas pressure regulators is ensured by suitable surveillance checks and maintenance. For periodic functional checks and maintenance it is common to refer to national regulations/standards where existing or users/manufacturers practices.

This document has introduced the reaction of the pressure regulators to the specified reasonable expected failures in terms of "fail close" and "fail open" pressure regulator types, but it should be considered that there are other types of failures whose consequences can bring to the same reactions (these risks are covered via redundancy as per EN 12186) and that residual hazards will be reduced by a suitable surveillance in use / maintenance.

In this document, both pressure regulators that can be classified as "safety accessories" by themselves (monitors) according to European legislation on pressure equipment as well as regulators that can be used to provide the necessary pressure protection through redundancy (e.g. pressure regulator with integrated safety shut-off device, pressure regulator + in-line monitor, pressure regulator + safety shut off device) are considered.

The provisions in this document are in line with the state of art at the moment of writing.

This document does not intend to limit the improvement of actual provisions (materials, requirements, test methods, acceptance criteria, etc.) or the developing of new provisions for gas pressure regulators where they are suitable to ensure an equivalent level of reliability.

Some clauses of this standard should be re-considered at the time when characteristics for non-conventional gases will be available.

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.

EN 549:1994, *Rubber materials for seals and diaphragms for gas appliances and gas equipment*

EN 1092-1:2018, *Flanges and their joints - Circular flanges for pipes, valves, fittings and accessories, PN designated - Part 1: Steel flanges*

EN 1092-2:1997, *Flanges and their joints - Circular flanges for pipes, valves, fittings and accessories, PN designated - Part 2: Cast iron flanges*

EN 1092-3:2003, *Flanges and their joints - Circular flanges for pipes, valves, fittings and accessories, PN designated - Part 3: Copper alloy flanges*

EN 1092-4:2002, *Flanges and their joints - Circular flanges for pipes, valves, fittings and accessories, PN designated - Part 4: Aluminium alloy flanges*

EN 1349:2009, *Industrial process control valves*

EN 1759-1:2004, *Flanges and their joint - Circular flanges for pipes, valves, fittings and accessories, Class designated - Part 1: Steel flanges, NPS 1/2 to 24*

EN 1759-3:2003, *Flanges and their joints - Circular flanges for pipes, valves, fittings and accessories, Class designated - Part 3: Copper alloy flanges*

EN 1759-4:2003, *Flanges and their joint - Circular flanges for pipes, valves, fittings and accessories, class designated - Part 4: Aluminium alloy flanges*

EN 10204:2004, *Metallic products - Types of inspection documents*

EN 10226-1:2004, *Pipe threads where pressure tight joints are made on the threads - Part 1: Taper external threads and parallel internal threads - Dimensions, tolerances and designation*

EN 10226-2:2005, *Pipe threads where pressure tight joints are made on the threads - Part 2: Taper external threads and taper internal threads - Dimensions, tolerances and designation*

EN 12186:2014, *Gas infrastructure - Gas pressure regulating stations for transmission and distribution - Functional requirements*

EN 12279:2000/A1:2005, *Gas supply systems - Gas pressure regulating installations on service lines - Functional requirements*

EN 12516-1:2014+A1:2018, *Industrial valves - Shell design strength - Part 1: Tabulation method for steel valve shells*

EN 12516-2:2014, *Industrial valves - Shell design strength - Part 2: Calculation method for steel valve shells*

EN 12516-4:2014+A1:2018, *Industrial valves - Shell design strength - Part 4: Calculation method for valve shells manufactured in metallic materials other than steel*

EN 13445-4:2014/A1:2016, *Unfired pressure vessels - Part 4: Fabrication*

EN 13906-1:2013, *Cylindrical helical springs made from round wire and bar - Calculation and design - Part 1 : Compression springs*

EN 13906-2:2013, *Cylindrical helical springs made from round wire and bar - Calculation and design - Part 2: Extension springs*

EN 13906-3:2014, *Cylindrical helical springs made from round wire and bar - Calculation and design - Part 3: Torsion springs*

EN 14382:2019, *Safety devices for gas pressure regulating stations and installations – Gas safety shut-off devices for inlet pressures up to 10 MPa (100 bar)*

EN 60534-2-1:2011, *Industrial-process control valves - Part 2-1: Flow capacity - Sizing equations for fluid flow under installed conditions*

EN 60534-2-3:2016, *Industrial-process control valves - Part 2-3: Flow capacity - Test procedures (IEC 60534-2-3:2016)*

EN 60534-3-1:2000, *Industrial-process control valves - Part 3-1: Dimensions - Face-to-face dimensions for flanged, two-way, globe-type, straight pattern and centre-to-face dimensions for flanged, two-way, globe-type, angle pattern control valves*

EN ISO 148-1:2016, *Metallic materials - Charpy pendulum impact test - Part 1: Test method (ISO 148-1:2016)*

EN ISO 175:2010, *Plastics - Methods of test for the determination of the effects of immersion in liquid chemicals (ISO 175:2010)*

EN ISO 9606-1:2017, *Qualification testing of welders - Fusion welding - Part 1: Steels (ISO 9606-1:2012 including Cor 1:2012 and Cor 2:2013)*

EN ISO 9606-2:2004, *Qualification test of welders - Fusion welding - Part 2: Aluminium and aluminium alloys (ISO 9606-2:2004)*

EN ISO 9606-3:1999, *Approval testing of welders - Fusion welding - Part 3: Copper and copper alloys (ISO 9606-3:1999)*

EN ISO 9606-4:1999, *Approval testing of welders - Fusion welding - Part 4: Nickel and nickel alloys (ISO 9606-4:1999)*

EN ISO 9712:2012, *Non-destructive testing - Qualification and certification of NDT personnel (ISO 9712:2012)*

EN ISO 12156-1:2018, *Diesel fuel - Assessment of lubricity using the high-frequency reciprocating rig (HFRR) - Part 1: Test method (ISO 12156-1:2018)*

EN ISO 14732:2013, *Welding personnel - Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials (ISO 14732:2013)*

EN ISO 15607:2003, *Specification and qualification of welding procedures for metallic materials - General rules (ISO 15607:2003)*

EN ISO 15609-1:2004, *Specification and qualification of welding procedures for metallic materials - Welding procedure specification - Part 1: Arc welding (ISO 15609-1:2004)*

EN ISO 15610:2003, *Specification and qualification of welding procedures for metallic materials - Qualification based on tested welding consumables (ISO 15610:2003)*

EN ISO 15611:2003, *Specification and qualification of welding procedures for metallic materials - Qualification based on previous welding experience (ISO 15611:2003)*

EN ISO 15612:2018, *Specification and qualification of welding procedures for metallic materials - Qualification by adoption of a standard welding procedure (ISO 15612:2018)*

EN ISO 15613:2004, *Specification and qualification of welding procedures for metallic materials - Qualification based on pre-production welding test (ISO 15613:2004)*

EN ISO 15614-1:2017, *Specification and qualification of welding procedures for metallic materials - Welding procedure test - Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys (ISO 15614-1:2017, Corrected version 2017-10-01)*

EN ISO 15614-2:2005/AC:2009, *Specification and qualification of welding procedures for metallic materials - Welding procedure test - Part 2: Arc welding of aluminium and its alloys (ISO 15614-2:2005/Cor 2:2009)*

EN ISO 17637:2016, *Non-destructive testing of welds - Visual testing of fusion-welded joints (ISO 17637:2016)*

ISO 1817:2015, *Rubber, vulcanized or thermoplastic — Determination of the effect of liquids*

ISO 3419:1981, *Non-alloy and alloy steel butt-welding fittings*

ISO 7005-2:1988, *Metallic flanges — Part 2: Cast iron flanges*

MSS SP 55:2011, *Quality standard for steel castings for valves, flanges and fittings and other piping components (Visual method)*

Recommended Practice N. SNT-TC-1A:2016*, Personnel Qualification and Certification in Nondestructive Testing*

3 Terms and definitions

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

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

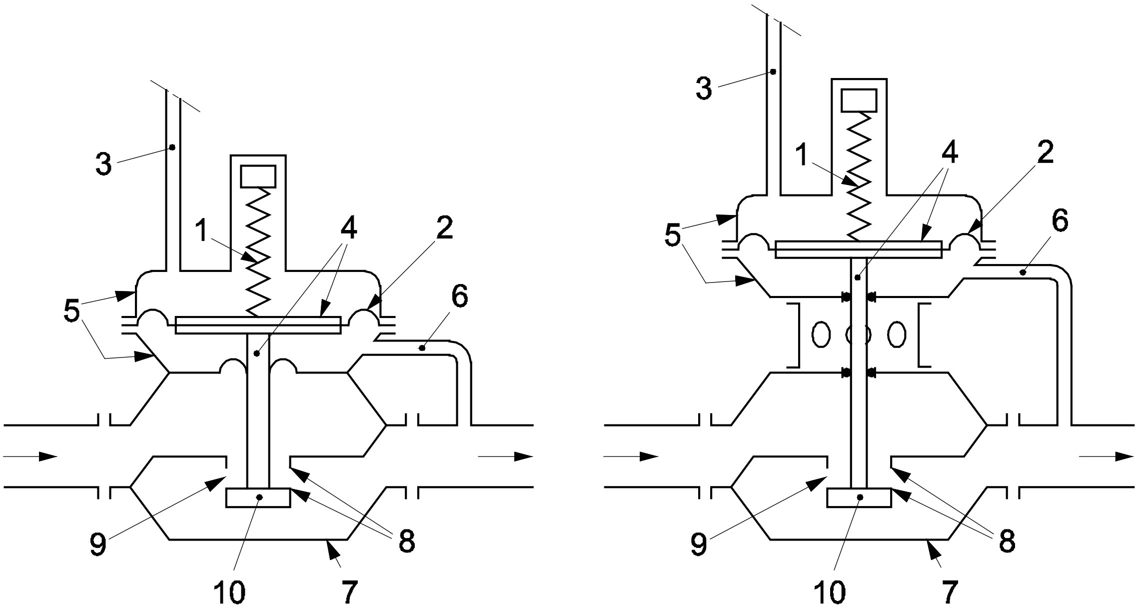
- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1 General terms and definitions of types of gas pressure regulators

3.1.1
gas pressure regulator
device whose function is to maintain the value of the controlled variable (see 3.3.4.1) within its tolerance field irrespective of disturbance variables

3.1.2
direct acting gas pressure regulator
regulator in which the net force required to move the control member is supplied directly by the controlled variable

Note 1 to entry: See Figure 1, for example.



a) b)

a) Direct acting regulators – Type Integral Strength

b) Direct acting regulators – Type Differential Strength

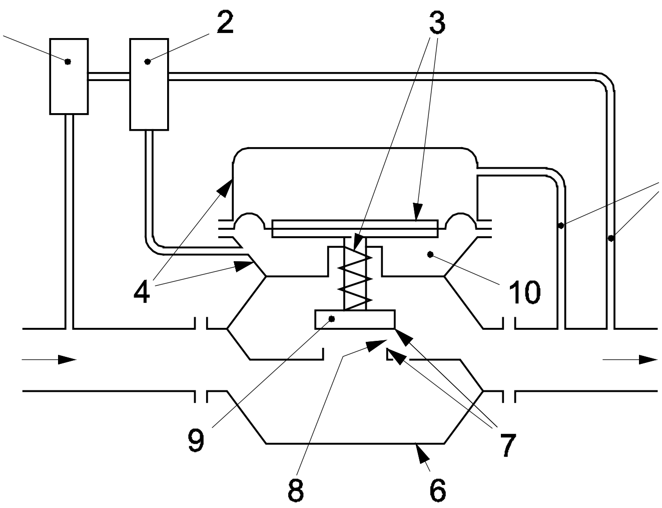
Key

1 + 2	= controller		
1	setting element	6	sensing line
2	pressure detecting element	7	regulator body
3	breather/exhaust line	8	valve seats
4	actuator	9	seat ring
5	casing of actuator	10	control member

Figure 1 — Examples of a direct acting regulator

3.1.3
indirect acting pilot controlled gas pressure regulator
regulator in which the net force required to move the control member is supplied by a pilot

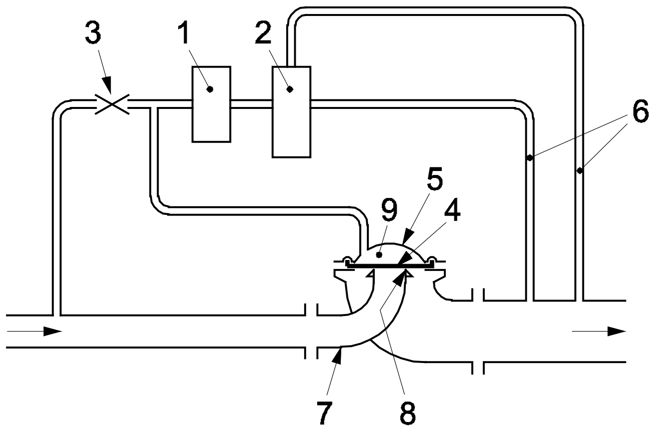
Note 1 to entry: See Figures 2 and 3, for example.



Key

1 auxiliary device
2 pilot
3 actuator
4 casing of actuator
5 sensing/process line
6 regulator body
7 valve seats
8 seat ring
9 control member
10 motorization chamber

Figure 2 — Example of a pilot controlled regulator



Key

1 auxiliary device
2 pilot
3 throttle
4 control member
5 casing of control member
6 sensing / process lines
7 regulator body
8 valve seat
9 motorization chamber

Figure 3 — Example of a pilot controlled regulator with a diaphragm as control member

3.1.4
monitor
second regulator installed in series with an active regulator, normally upstream, which has the task of maintaining the controlled variable within allowable limits in the event of its value exceeds pre-established values

3.1.5
fail close regulator
regulator whose control member automatically tends to close or close when failures occur

Note 1 to entry: The definition in this clause is based on typical control failure modes.

3.1.6
fail open regulator
regulator whose control member automatically tends to open or open when failures occur

Note 1 to entry: The definition in this clause is based on typical control failure modes.

3.1.7
regulator size
nominal size DN of the inlet connection in accordance with EN ISO 6708 [4]

3.1.8
series of regulators
regulators with the same design concept but differing only in size

3.2 Terms and definitions of components of gas pressure regulators

3.2.1
main component
control member, regulator body, actuator, casing of actuator, controller, pilot (only in pilot controlled regulators)

Note 1 to entry: The regulator includes additional devices such as a shut-off device, a monitor, a relief device and other auxiliary devices. The Figures 1 and 2 serve as examples.

3.2.1.1
control member
movable part of the regulator which is positioned in the flow path to restrict the flow through the regulator

EXAMPLE Plug, ball, disk, vane, gate, flexible element, etc.

3.2.1.2
body
main pressure bearing envelope which provides the gas flow passageway and the pipe end connections

3.2.1.3
valve seat
corresponding sealing surfaces within a regulator which make full contact only when the control member is in the closed position

3.2.1.4
seat ring
part assembled in a component of the regulator to provide a replaceable seat

3.2.1.5
actuator
device or mechanism which changes the signal from the controller into a corresponding movement controlling the position of the control member

Note 1 to entry: When the actuator consists of more than one chamber then the chamber where the pressure is highest is termed the "motorization chamber".

3.2.1.6
casing of actuator
part of the housing of the actuator

3.2.1.7
controller
device which normally includes:

— a setting element, normally a spring, to obtain the set value of the controlled variable;

— a pressure detecting element, normally a diaphragm, for the controlled variable

3.2.1.8
pilot
device which includes:

— a setting element to obtain the set value of the controlled variable;

— a pressure detecting element, normally a diaphragm, for the controlled variable;

— a unit which compares the set value of the controlled variable with its feedback value;

— a system which provides the motorization energy for the actuator

3.2.1.9
diaphragm
flexible part used to separate one chamber subjected to pressure into two or more volumes with different pressure (e.g. balancing diaphragm)

3.2.1.10
main diaphragm
diaphragm, whose function is:

— to detect the feedback of the controlled variable and/or;

— to provide the thrust to move the control member

Note 1 to entry: Diaphragms used as control members (see also 3.2.1.1) are not part of this group.

3.2.2
pressure bearing part
part whose failure to function would result in a sudden release of the retained fuel gas to the atmosphere

Note 1 to entry: These include bodies, control member, bonnets, the casing of the actuator, blind flanges and pipes for process and sensing lines but exclude compression fittings, diaphragms, bolts (unless their failure would result in a sudden discharge of pressure energy) and other fasteners.

3.2.3
inner metallic partition wall
metallic wall that separates a chamber into two individual pressure-containing chambers at different pressures under normal operating conditions

3.2.4
process and sensing line
line which connect impulse points to the regulator

Note 1 to entry: Sensing and process lines may be integrated into the regulator or external to the regulator. Those lines with no internal flow are termed “sensing lines”; those with internal flow are termed “process lines”. Sometimes “process lines” are called “discharge lines”.

3.2.5
breather line
line connecting the atmosphere side of the pressure detecting element to atmosphere

Note 1 to entry: In the event of a fault in the pressure detecting element this line may become an exhaust line.

3.2.6
exhaust line
line connecting the regulator or its auxiliary devices to atmosphere for the safe exhausting of gas in the event of failure of any part

3.2.7
auxiliary device
device of any type functionally connected to the main components of the regulator (see 3.2.1)

EXAMPLE Throttle devices, creep devices, etc.

3.3 Terms, symbols and definitions related to functional performance

3.3.1 Terms, symbols and definitions related to pressure

3.3.1.1
pressure
all pressures specified in this document are static gauge pressures unless otherwise stated

Note 1 to entry: Pressure is expressed in bar[3)], unless otherwise stated.

3.3.1.2
inlet pressure
p_u
gas pressure at the inlet of the regulator

3.3.1.3
outlet pressure
p_d
gas pressure at the outlet of the regulator

3) 1 bar = 1 000 mbar = 10^5 N/m^2 = 10^5 Pa = 10^{-1} MPa.

3.3.1.4
differential pressure
Δp
difference between two values of pressure at two different points

3.3.1.5
motorization pressure
$\boldsymbol{p_{\mathrm{m}}}$
gas pressure in the motorization chamber

3.3.1.6
pilot feeding pressure
$\boldsymbol{p_{\mathrm{up}}}$
gas pressure at the inlet of the pilot

3.3.1.7
atmospheric pressure
$\boldsymbol{p_{\mathrm{b}}}$
local static atmospheric pressure in bar (absolute pressure)

3.3.2 Terms, symbols and definitions related to flow

3.3.2.1
normal conditions
absolute pressure p_{n} of 1,01325 bar and temperature T_{n} of 273,15 K (0 °C)

3.3.2.2
gas volume
volume of gas at normal conditions

Note 1 to entry: Gas volume is expressed in m^3.

3.3.2.3
volumetric flow rate
$\mathbf{Q_{n}}$
volume of fluid at operating conditions which flows through the regulator per unit of time, recalculated at normal conditions

Note 1 to entry: Volumetric flow rate is expressed in m^3/h at normal conditions.

3.3.2.4
reference inlet temperature
$\boldsymbol{t_{\mathrm{ur}}}$
temperature at the inlet of regulator in the assessment of functional performance of regulators; this document considers as reference temperature 15 °C

Note 1 to entry: The use of reference inlet temperature is necessary to obtain homogeneous set of test results when comparing the functional performances of different type of regulators.

3.3.2.5
flow coefficient
[C_g]
non-SI regulator coefficient which is in widespread use in gas sector, numerically represented as the number of normal cubic feet per hour of air flowing through a regulator in critical conditions with inlet absolute pressure 1 psi and with a reference inlet temperature t_{ur} = 15 °C [4)]

Note 1 to entry: Numerically, Cg is represented as the number of normal cubic feet per hour of air flowing through a regulator in critical conditions with inlet absolute pressure 1 psia and with a reference inlet temperature tur = 15 °C [4].

Note 2 to entry: The above numerical value in SI units is equal to the number of m^3/h of air flowing through a regulator in critical conditions with inlet absolute pressure 2,43 bar and inlet temperature of 15 °C.

Note 3 to entry: EN 60534-2-1:2011, Clause 7 "Sizing equations for compressible fluids" and Annex B deals with this flow coefficient.

3.3.2.6
flow coefficient
[K_G]
characteristic value for the flow capacity of a regulator.

Note 1 to entry: The flow coefficient is equal to the volumetric flow rate at normal conditions through the regulator under the following reference conditions:

— reference natural gas at normal conditions with the relative density dr = 0,64 (density ρr = 0,827 5 kg/m^3)

— fully opened control member (mechanical stop);

— reference inlet temperature of t_{ur} = 15 °C;

— reference absolute gas inlet pressure p_{ur} = 2 bar;

— reference absolute gas outlet pressure p_{dr} = 1 bar.

Note 2 to entry: The K_G value is specified in (m^3/h)/bar.

3.3.3 Sound emission

3.3.3.1
sound pressure level
L_{pA}
sound pressure frequency weightings A in accordance with EN 61672-1 [8]

4) The definition of this flow coefficient is based on EN 60534-1

3.3.4 Variables in the controlling process

3.3.4.1
controlled variable
variable which is monitored by the controlling process

Note 1 to entry: In this document, only the outlet pressure "p_{d}" is considered as the controlled variable.

3.3.4.2
disturbance variable
variables acting from outside on the controlling process

Note 1 to entry: In the case of regulators with the outlet pressure as the controlled variable, the disturbance variables are essentially:

— changes in the inlet pressure;

— changes in the volumetric flow rate

3.3.5 Terms and definitions related to possible values of all variables

3.3.5.1
actual value
instantaneous value of any variable at any instant. It is specified by the index "i" added to the symbol of the variable

3.3.5.2
maximum value
highest value, which is specified by the subscript "max" added to the symbol of the variable:

— to which any variable can be adjusted or to which it is limited;

— any variable may reach during a series of measurements or during a certain time period

3.3.5.3
minimum value
lowest value, which is specified by the index "min" added to the symbol of the variable:

— to which any variable can be adjusted or to which it is limited;

— any variable may reach during a series of measurements or during a certain time period

3.3.6 Terms, symbols and definitions related to the controlled process

3.3.6.1
set point
p_{ds}
nominal value of the controlled variable under specified conditions

Note 1 to entry: The set point is not directly measurable but determined as shown in Figure 6.

3.3.6.2
set range
$w_{\mathbf{d}}$
whole range of set points which can be obtained from a regulator by adjustment and/or the replacement of some components (i.e. replacement of the valve seat or setting element, e.g. spring)

3.3.6.3
specific set range
$w_{\mathbf{ds}}$
whole range of set points which can be obtained from a regulator by adjustment and with no replacement of its components

3.3.6.4
regulation change
difference between the actual value of the controlled variable and the set point expressed as a percentage of the set point

3.3.7 Terms, symbols and definitions of functional performance

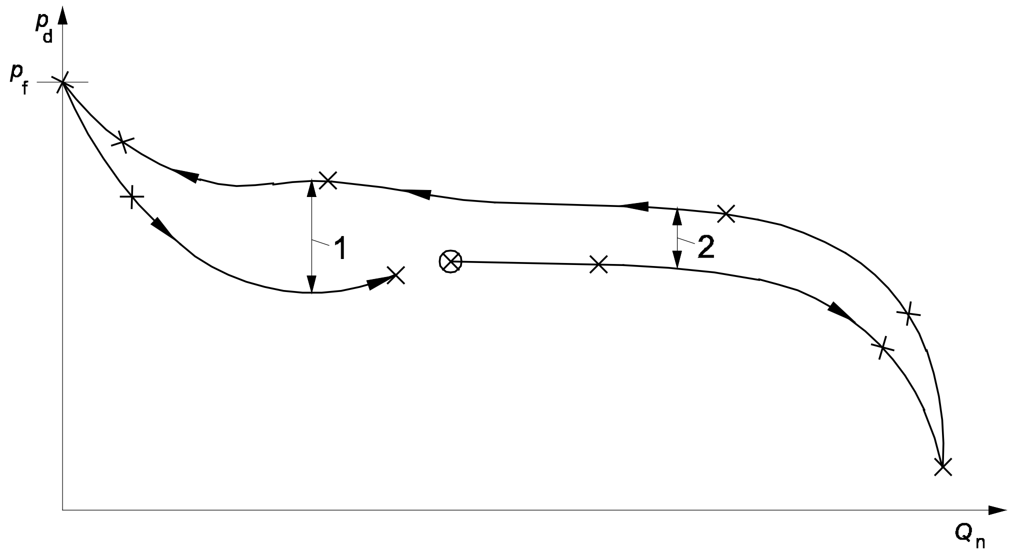
3.3.7.1
stable conditions
conditions where the controlled variable settles to a stable value after a disturbance has occurred

3.3.7.2
performance curve
graphic representation of the controlled variable as a function of the volumetric flow rate

Note 1 to entry: This curve is determined by increasing and then decreasing the volumetric flow rate with constant inlet pressure and set point (see Figure 4).

3.3.7.3
hysteresis band
difference between the two values of outlet pressure for a given volumetric flow rate

Note 1 to entry: See Figure 4.



Key

⊗	start setting	1	max hysteresis band
×	measured values	2	hysteresis band

Figure 4 — Performance curve (p_{ds} constant, p_u constant)

3.3.7.4
family of performance curves
set of the performance curves for each value of inlet pressure determined for a given set point

Note 1 to entry: See Figure 5.

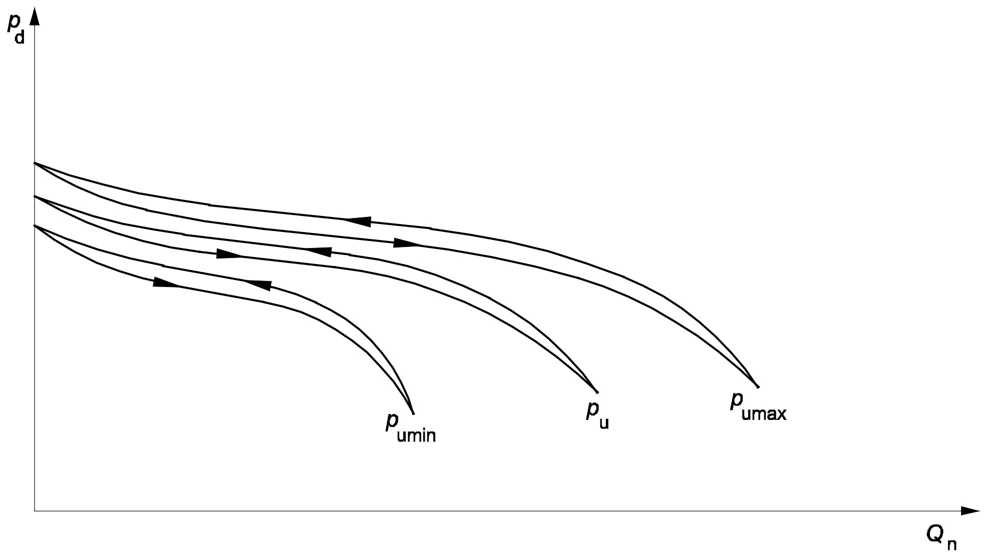


Figure 5 — Family of performance curves (p_{ds} constant)

3.3.8 Feature related to accuracy

3.3.8.1
accuracy
maximum absolute value of regulation change under specified operating range

3.3.8.2
accuracy class
AC
maximum permissible value of the accuracy under specified operating range

3.3.8.3
inlet pressure range
b_{pu}
range of the inlet pressure for which the regulator ensures a given accuracy class

Note 1 to entry: The inlet pressure range is characterized by its limit values p_{umax} and p_{umin}.

3.3.8.4
maximum accuracy flow rate
lowest value of the maximum volumetric flow rate up to which, for a given set point and within the ambient temperature range specified, a given accuracy class is ensured:

— at the lowest inlet pressure $Q_{n,max,pumin}$;

— at the highest inlet pressure $Q_{n,max,pumax}$;

— at an intermediate inlet pressure between p_{umax} and p_{umin} $Q_{n,max,pu}$

Note 1 to entry: See Figure 6.

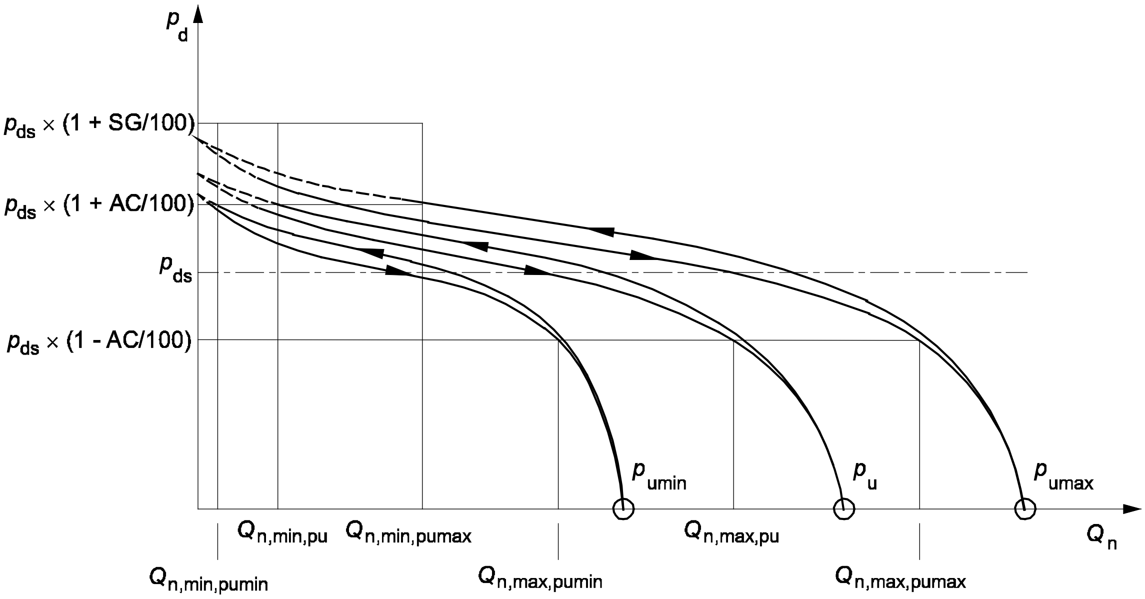


Figure 6 — Family of performance curves indicating maximum accuracy flow rates and minimum flow rates (p_{ds} constant, stable conditions)

3.3.8.5
minimum inlet pressure
p_{umin}
lowest inlet pressure at which the regulator can continuously operate within specified conditions

3.3.9 Terms, symbols and definitions related to lock-up behaviour

3.3.9.1
lock-up time
t_f
time taken for the control member to move from an open position to the closed position

3.3.9.2
lock-up pressure
p_f
pressure that occurs at the measuring point of the controlled variable when the control member is in the closed position

Note 1 to entry: The lock-up pressure corresponds to the outlet pressure at the volumetric flow rate $Q = 0$ in the performance curve (see Figure 4). It results when the time taken for a change in volumetric flow rate from Q to zero is greater than the lock- up time of the regulator.

3.3.9.3
lock-up pressure class
SG
maximum permissible positive difference between the actual lock-up pressure and the set point expressed as a percentage of the set point, e.g

$$SG = \frac{p_f - p_{ds}}{p_{ds}} \bullet 100 \qquad (1)$$

Note 1 to entry: For better understanding of $\left(p_f - p_{ds}\right)_{\max}$ see Figure 6.

3.3.9.4
minimum flow rate
largest value of the minimum volumetric flow rate, for a given set point and within the ambient temperature range specified, at which stable conditions as per 5.3.3 are obtained:

— at the lowest inlet pressure $Q_{n,min,pumin}$;

— at the highest inlet pressure $Q_{n,min,pumax}$;

— at an intermediate inlet pressure between p_{umax} and p_{umin} $Q_{n,min,pu}$

Note 1 to entry: See Figure 6.

3.3.9.5
lock-up pressure zone
zone between the volumetric flow rate $Q_n = 0$ and the minimum flow rate $Q_{n,min,pu}$ for each corresponding inlet pressure and set point

Note 1 to entry: See Figure 7.

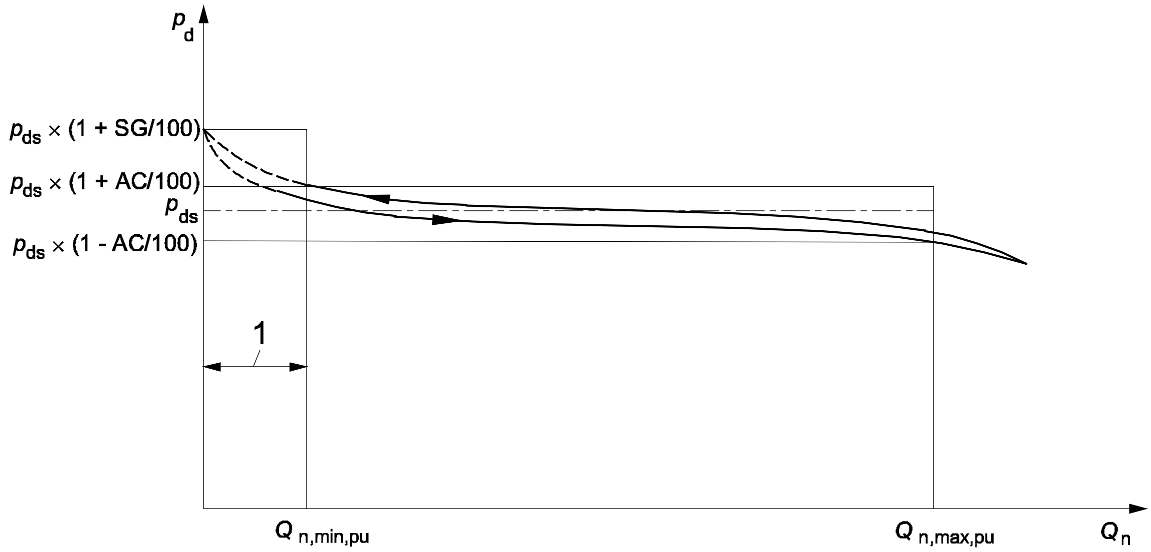
3.3.9.6
class of lock-up pressure zone
SZ
maximum permissible lock-up pressure zone for specified:

— inlet pressure p_u ;

— set point p_{ds},

which is expressed as the percentage of $Q_{n,min,pu}$ to $Q_{n,max,pu}$, i.e

$$SZ = \frac{Q_{n,min,pu}}{Q_{n,max,pu}} \bullet 100 \qquad (2)$$



Key
1 Lock-up pressure zone SZ

Figure 7 — Performance curve indicating lock-up pressure zone (stable condition)

3.4 Terms, symbols and definitions related to design and tests

3.4.1
component operating pressure
p
gas pressure occurring in any part of a regulator during operation

3.4.2
maximum component operating pressure
p_{max}
highest operating pressure at which a component of a regulator will continuously operate within specified conditions

3.4.3
maximum allowable pressure
PS
maximum pressure for which the body, its inner metallic partition walls and some other pressure bearing parts are designed in accordance with the strength requirements in this document

3.4.4
maximum/minimum allowable temperature
TS
maximum/minimum temperatures for which the body, its inner metallic partition walls and some other pressure bearing parts are designed in accordance with the strength requirements in this document

3.4.5
specific maximum allowable pressure
PSD
pressure for which some pressure bearing parts of differential strength regulators are designed where PSD < PS

3.4.6
test pressure
pressure applied to a section of the regulator for a limited period of time in order to prove certain characteristics

3.4.7
limit pressure
p_l
pressure at which permanent yielding becomes apparent in any main component of the regulator or its auxiliary devices

3.4.8
safety factor
ratio of the limit pressure p_l to the maximum allowable pressure PS or to the specific maximum allowable pressure PSD applied to:

— the regulator body: S_b (only PS);

— the other pressure bearing parts of the regulator: S (PS or PSD)

3.4.9
maximum inlet pressure
p_{umax}
highest inlet pressure at which the regulator can continuously operate within specified conditions

3.4.10
maximum outlet pressure
p_{dmax}
highest outlet pressure at which the regulator can continuously operate within specified conditions

3.4.11
minimum operating differential pressure
$\Delta p_{\mathbf{min}}$
minimum operating differential pressure between the inlet and outlet pressures below which the regulator will no longer function correctly within specified conditions

3.4.12
nominal pressure
PN
alphanumeric designation used for reference purposes related to a combination of mechanical and dimensional characteristics of flanges in accordance with the relevant parts of EN 1092 series and ISO 7005-2, which comprises the letters PN followed by a dimensionless whole number

EXAMPLE PN 16.

3.4.13
class
alphanumeric designation used for reference purposes related to a combination of mechanical and dimensional characteristics of flanges in accordance with the relevant parts of EN 1759 series, which comprises the word Class followed by a dimensionless whole number

EXAMPLE Class 150.

3.4.14
operating temperature range
temperature range at which the regulator components and auxiliary devices are capable of operating continuously

3.4.15
closing force
F_S
force acting on control member of the monitor in full open position in normal operating conditions to bring it to its control position after activation of the monitor itself

3.4.16
failure
termination of the ability of a functional unit to provide a required function

[Source: IEC 60050-191:1990]

3.5 Summary of symbols, terms, subclauses and units

The following table summarizes the symbols and relevant descriptions and unit considered in this chapter and/or used in this document. The symbols are listed in alphabetic order.

Symbol	Term	Subclause	Unit
AC	Accuracy class	3.3.8.2	%
b_{pu}	Inlet pressure range	3.3.8.3	bar
C_g	Flow coefficient	3.3.2.5	See definition
d	Relative density of natural gas at actual conditions	6.2.2	/
d_r	Relative density of natural gas at normal conditions	3.3.2.6	/
DN	Nominal size	3.1.7	/
DS	Differential strength	1	/
Δp	Differential pressure	3.3.1.3	bar
Δp_{min}	Minimum operating differential pressure	3.4.11	bar
F_S	Closing force	3.4.15	N
IS	Integral strength	1	/
K_G	Flow coefficient	3.3.2.6	See definition
L_{pA}	Sound pressure level	3.3.3.1	In accordance with EN 61672-1
MIP_d	Downstream maximum incidental pressure	9.4	bar
NDT	Non-Destructive Test	4.2.1.7	/
p	Component operating pressure	3.4.1	bar
p_b	Atmospheric pressure (absolute pressure)	3.3.1.7	bar abs
p_d	Outlet pressure	3.3.1.3	bar
p_{dmax}	Maximum outlet pressure	3.4.10	bar
p_{dr}	Reference absolute gas outlet pressure	3.3.2.6	bar abs
p_{ds}	Set point	3.3.6.1	bar
p_f	Lock-up pressure	3.3.9.2	bar
p_l	Limit pressure	3.4.7	bar
p_m	Motorization pressure	3.3.1.5	bar
p_{max}	Maximum component operating pressure	3.4.2	bar
p_n	Reference absolute pressure for normal conditions	3.3.2.1	bar abs

Symbol	Term	Subclause	Unit
PN	Nominal pressure	3.4.12	/
PS	Maximum allowable pressure	3.4.3	bar
PSD	Specific maximum allowable pressure	3.4.5	bar
p_u	Inlet pressure	3.3.1.2	bar
p_{umax}	Maximum inlet pressure	3.4.9	bar
p_{umin}	Minimum inlet pressure	3.3.8.5	bar
p_{up}	Pilot feeding pressure	3.3.1.6	bar
p_{ur}	Reference absolute gas inlet pressure	3.3.2.6	bar abs
Q_n	Volumetric flow rate	3.3.2.3	m^3/h at normal conditions
$Q_{nmin,pu}$	Minimum flow rate at inlet pressure p_u	3.3.9.4	m^3/h at normal conditions
$Q_{nmin,pumax}$	Minimum flow rate at inlet pressure p_{umax}		m^3/h at normal conditions
$Q_{nmin,pumin}$	Minimum flow rate at inlet pressure p_{umin}		m^3/h at normal conditions
ρ_r	Reference natural gas density at normal conditions	3.3.2.6	kg/m^3
S	Safety factor for all pressure bearing parts except bodies	3.4.8	/
S_b	Safety factor for body		/
SG	Lock-up pressure class	3.3.9.3	%
SZ	Class of lock-up pressure zone	3.3.9.6	%
t_f	Lock-up time	3.3.9.1	sec
t_n	Reference temperature for normal conditions	3.3.2.1	°C
T_n	Reference temperature for normal conditions		K
TS	Maximum/minimum allowable temperature	3.4.4	°C
t_{ur}	Reference inlet temperature for K_G	3.3.2.5	°C
W_d	Set range	3.3.6.2	bar
W_{ds}	Specific set range	3.3.6.3	bar

NOTE Annex M lists all terms in alphabetic order for English language, the relevant translation in French and German language.

4 Construction requirements

4.1 Basic requirements

4.1.1 General

With reference to 3.1.1 and 3.3.4.1, the main function of a regulator is to maintain the value of the outlet pressure p_d within its tolerance field, irrespective of the disturbance variables.

Regulators shall not have any continuous discharge of gas into the atmosphere, however, temporary discharges from auxiliary devices may occur.

Regulators shall be so designed that the external tightness and internal sealing meet the requirements of 5.2. If in the event of failure of the regulator (e.g. failure of a diaphragm) leakage to atmosphere is possible, the breather shall be provided with a threaded connection of at least DN 10 to enable an exhaust line to be connected[5]. This connection may be used for a specific device (e.g. a dumping device).

Pressure bearing parts including measuring and test points, which may be dismantled for servicing, adjustment or conversion shall be made pressure tight by mechanical means (e.g. metal to metal joints, o-rings, gaskets, etc.). Jointing compounds, such as liquids and pastes, shall not be used.

Jointing compounds, however, may be used for permanent assemblies and shall remain effective under normal operating conditions.

Pressure bearing parts not intended to be dismantled during servicing, adjustment or conversion shall be sealed by means which will show evidence of interference or tampering (e.g. lacquer).

When external protrusions or other external parts need special care to cover the hazards during transport and handling, the manual shall include the provisions to cover these risks.

The motorization energy in a pilot controlled regulator shall be provided by the gas upstream of the regulator.

For regulators used as stand-by monitor it shall be possible to check whether the control member is in fully open or in controlling position by a visual inspection.

4.1.2 Gas pressure regulators with associated safety devices

4.1.2.1 Gas pressure regulators with integrated safety devices

Additional integrated (same body) safety devices, i.e. gas safety shut-off devices (SSD)[6] and/or a monitor shall be functionally independent from the regulator.

This requirement is met if:

a) the regulator maintains its functionality in the event of the failure and/or loss of functionality of one or more of the following safety shut-off device/monitor components:

  — closure/control member;

  — seat ring;

  — actuator;

5) For proper operation of the regulator any exhaust line shall be designed in such a way to prevent the ingress of foreign materials.

6) For this subject see EN 14382.

— casing of actuator;

— controller;

— pilot (in case of pilot-controlled monitor type);

— sensing and process lines;

and if:

b) the function of the safety shut-off device/monitor is not affected in the event of the failure and/or loss of functionality of one or more of the following regulator components:

— control member;

— seat ring;

— actuator;

— casing of actuator;

— controller;

— pilot (in case of pilot-controlled regulator type);

— sensing and process lines.

When the regulator incorporates more than one safety device (e.g. a monitor and a SSD or two SSDs), the functional independence shall be met by each device from the other ones in similar way, as detailed above.

When the integrated safety device is a slam-shut device or a cut-off device or a monitor, the motorization energy for the regulator, when it is a pilot-controlled type, shall be provided by the gas downstream of the safety device.

4.1.2.2 Gas pressure regulators with in-line monitor

The system includes a regulator with the function of active regulator and a second (in series) regulator with the function of monitor. The monitor shall be installed directly upstream of the active regulator and both equipment shall control the pressure at the same location.

The associated in-line monitor shall be functionally independent from the active regulator.

This requirement is met if:

a) the function of the active regulator is not affected in the event of the failure and/or loss of functionality of one or more of the following monitor components:

— pilot (in case of pilot-controlled monitor type);

— sensing and process lines;

and if

b) the function of the monitor is not affected in the event of the failure and/or loss of functionality of one or more of the following active regulator components:

— pilot (in case of pilot-controlled regulator type);

— sensing and process lines.

The motorization energy for active regulator in case of pilot-controlled type shall be taken downstream of the monitor.

For monitor in fully open position in normal operating conditions, it is necessary to adopt appropriate design measures to avoid the possible effect of static friction (break away friction) at the first movement between movable and fixed parts.

4.1.2.3 Gas pressure regulator with in-line safety shut off device

The system includes a regulator with the function of active regulator and an in-line SSD (in series).

The SSD shall be installed directly upstream of active regulator and both devices shall control the pressure at the same location.

The associated in-line SSD shall be functionally independent from the active regulator.

The requirement is met if:

a) the function of active regulator is not affected in the event of the failure and/or loss of functionality of one or more of the following SSD components:

— controller;

— sensing and process lines;

and if:

b) the function of SSD is not affected in the event of the failure and/or loss of functionality of one or more of the following active regulator components:

— pilot (in case of pilot-controlled regulator type);

— sensing and process lines.

The motorization energy for active regulator, in case of pilot-controlled type, shall be taken downstream of the SSD.

4.1.3 End connections

End connections may be one of the following:

a) flanged connections in accordance with the applicable parts of EN 1092-1, EN 1092-2, EN 1092-3, EN 1092-4, ISO 7005-2, EN 1759-1, EN 1759-3 and EN 1759-4;

b) flangeless type (e.g. wafer body);

c) threaded connections in accordance with EN 10226-1 or EN 10226-2 for:

   1) DN ≤ 50;

   2) DN ≤ 80 and PS ≤ 16 bar;

d) compression fittings for DN ≤ 50;

e) butt weld connections in accordance with EN 12627.

4.1.4 Flange ratings

The ratings for flanges shall be selected from the following designations:

— PN designated flanges 6, 10, 16, 25, 40, 100 in accordance with EN 1092-1, EN 1092-2, EN 1092-3, EN 1092-4;

— PN designated flanges 20, 50[7)], in accordance with ISO 7005-2 only for spheroidal graphite cast iron and malleable cast iron;

— Class designated flanges 150, 300, 600 in accordance with EN 1759-1, EN 1759-3 and EN 1759-4.

The underlined designations are preferred.

4.1.5 Nominal sizes and face-to-face dimensions

Bodies with flange connections should have the same nominal size at inlet and outlet.

The nominal sizes and the face-to-face dimensions given in Table 1 are recommended.

Alternatively, the nominal sizes and the face-to-face dimensions may be taken from Table 2.

Flangeless bodies (regulators that have no line flanges but are intended to be installed by clamping between pipes flanges) are permitted as an alternative. In this case bodies should have the same nominal size at inlet and outlet and face-to-face dimensions should be taken from Tables 3 or 4.

The following bodies are permitted:

— flanged types with different nominal inlet and outlet sizes;

— those with face-to-face dimensions differing from those given in Tables 1 and 2;

— angle pattern bodies in accordance with ISO 5752.

7) The nominal pressure designations PN 20 and PN 50 are equivalent to class ratings 125/150 and 250/300, respectively.

Table 1 — Recommended face-to face dimensions for flanged bodies

Nominal size DN	Nominal pressure			Limit deviations for face-to-face dimensions in mm
	PN 10/16/20 [a] Class 150	PN 25/40/50 Class 300	PN 100 Class 600	
	Face-to-face dimensions in mm			
25	184	197	210	±2
40	222	235	251	
50	254	267	286	
65	276 (*)	292 (*)	311 (*)	
80	298	317	337	
100	352	368	394	
150	451	473	508	
200	543	568	610	
250	673	708	752	
300	737	775	819	±3
350	889	927	972	
400	1016	1057	1108	

Source: EN 60534-3-1:2000, Tables 1 and 2 except where indicated with (*) - nominal pressure in accordance with EN 1092-1, EN 1092-2, EN 1092-3, EN 1092-4, ISO 7005-2 and class designation in accordance with EN 1759-1, EN 1759-3, EN 1759-4.

[a] In some countries the group PN 10/16/20 includes also PN 6.

Table 2 — Alternative face-to-face dimensions for flanged bodies

Nominal size DN	Nominal pressure		Limit deviations for face-to-face dimensions in mm
	PN 10/16/25/40/50 [a] Class 150, 300	PN 100 Class 600	
	Face-to-face dimensions in mm		
25	160	230	±2
40	200	260	
50	230	300	
65	290 (*)	340 (*)	
80	310	380	
100	350	430	
150	480	550	
200	600	650	
250	730	775	
300	850	900	±3
400	1 100	1 150	

Source: Table 2 of EN 60534-3-1:2000 except where indicated with (*), with the addition of PN 10/16/25/40 - nominal pressure in accordance with EN 1092-1, EN 1092-2, EN 1092-3, EN 1092-4, ISO 7005-2 and class designation in accordance with EN 1759-1, EN 1759-3, EN 1759-4.

[a] In some countries the group PN 10/16/25/40/50 includes also PN 6.

Table 3 — Face-to-face dimensions for flangeless bodies

Nominal size DN	Face-to-face dimensions in mm	Limit deviations for face-to-face dimensions in mm
25	102	±2
40	114	±2
50	124	±2
80	165	±2
100	194	±2
150	229	±2
200	243	±2
250	297	±2
300	338	±3
400	400	±3

Source: EN 60534-3-2 (nominal pressure in accordance with EN 1092-1, EN 1092-2, EN 1092-3, EN 1092-4, ISO 7005-2 and class designation in accordance with EN 1759-1, EN 1759-3, EN 1759-4).

NOTE 1 Nominal pressure: PN 10/16/20/25/40/50/100 and class designation150/300/600. In some countries this group includes also PN 6.

NOTE 2 Face-to-face dimensions do not include any allowances for gaskets to seal the joints between the end connections and the pipeline flanges.

Table 4 — Alternative Face-to-face dimensions for flangeless bodies

Nominal size DN	Face-to-face dimensions in mm		Limit deviations for face-to-face dimensions in mm
	PN 10/16/20/25/40/50 [a] Class 150, 300	PN 100 Class 600	
25	77	86,5	±1,5
40	77	86,5	±1,5
50	77	86,5	±1,5
80	94	104	±1,5
100	114	133	±1,5
150	140	175	±1,5
200	171	205	±1,5
250	203	240	±2,5
300	240	280	±2,5
400	320	350	±2,5

NOTE 1 Face-to-face dimensions do not include any allowances for gaskets to seal the joints between the end connections and the pipeline flanges.

NOTE 2 Nominal pressure in accordance with EN 1092-1, EN 1092-2, EN 1092-3, EN 1092-4, ISO 7005-2 and class designation in accordance with EN 1759-1, EN 1759-3, EN 1759-4.

[a] In some countries the group PN 10/16/20/25/40/50 includes also PN 6.

4.1.6 Sealing of the adjusting device

A means for sealing the adjusting device shall be available (e.g. wire, plastic seal or lacquer). If requested in the order specification, the adjusting device shall be sealed.

4.1.7 Springs

Springs shall not be overstressed under any operating condition and there shall be sufficient free movement of the spring to allow satisfactory operation. Springs shall be designed such that buckling does not occur, in accordance to EN 13906-1:2013, EN 13906-2:2013 and EN 13906-3:2014.

4.1.8 Parts transmitting actuating forces

When the regulator is classified as a stand-alone safety accessory, parts transmitting actuating forces shall be made of metallic material or non-metallic materials other than elastomers and shall be designed with a safety factor of ≥ 3 against permanent deformation. Verification is made by proving the compliance of the actual safety factors specified above and the compliance of dimensions shown on drawings with values specified in the strength calculations. Alternatively, verification shall be made by an actual test.

4.1.9 Replaceable parts that may be affected by erosion or abrasion

The seat ring shall be replaceable where erosion or abrasion may occur.

4.2 Materials

4.2.1 Requirements for metallic materials

4.2.1.1 Pressure bearing parts and inner metallic partition walls

The pressure bearing parts, including those that become pressure bearing parts in the event of diaphragm or differential pressure seal failure, and the inner metallic partition walls shall be constructed of materials complying with national or international established material standards for pressure applications and with the restrictions given in Table 5.

All selected materials complying with Table 5 which are neither complying with EN harmonized material standards, nor object of an EAM, shall be submitted to a Particular Material Appraisal procedure.

Note 1: all selected materials complying with Table 5 shall meet all the other requirements of the relevant national or international established material standard.

Annex G, tables G1 and G2 includes a list of proposed materials.

4.2.1.2 Auxiliary devices, integral process and sensing lines, connectors, threaded sealing plug and fasteners

Auxiliary devices, integral process and sensing lines, connectors, threaded sealing plug and fasteners shall be constructed of materials complying with national or international established material standards and with the restrictions given in Table 5.

All selected materials complying with Table 5 which are neither complying with EN harmonized material standards, nor object of an EAM, shall be submitted to a Particular Material Appraisal procedure.

Note 1: all selected materials complying with Table 5 shall meet all the other requirements of the relevant national or international established material standard.

Annex G, Table G3 includes a list of proposed materials.

4.2.1.3 Other parts

The internal parts of regulators not subjected to differential pressure, may be constructed of either the materials given in Annex G or materials complying with the requirements given in Table 5, without taking into account the restrictions for pressures and nominal sizes, or of different materials provided they comply with the requirements of this document.

4.2.1.4 Material inspection documents of pressure bearing parts and inner metallic partition walls

Pressure bearing parts and inner metallic partition walls:

— bodies used in the apparatus[8)] category II, III and IV according to the European legislation on pressure equipment, shall be accompanied by a material inspection certificate type 3.2 in accordance with EN 10204:2004. For these bodies when the material manufacturer has an appropriate quality-assurance system, certified by a competent body established within the EC and having undergone a specific assessment for materials, an inspection certificate type 3.1 in accordance with EN 10204 is accepted;

8) Apparatus means gas pressure regulator or safety shut off device as applicable.

— bodies used in the apparatus category I according to the European legislation on pressure equipment, shall be accompanied by a material test report at least type 2.2 in accordance with EN 10204:2004.

Pressure bearing parts and inner metallic partition walls of other components used for regulators with:

— PS ≤ 25 bar can be accompanied by a material test report at least type 2.2 in accordance with EN 10204:2004;

— PS > 25 bar shall be accompanied by a material inspection certificate at least type 3.1 in accordance with EN 10204:2004.

4.2.1.5 Material inspection documents of fasteners and connectors

This subclause specifies the different types of material inspection documents supplied to the purchaser, in accordance with the requirements of the order, for the delivery of components used for the apparatus.

Fasteners (bolts, screws, studs, nuts) and connectors (compression fittings) used in the pressure bearing parts of the apparatus shall bear the marking in accordance with the relevant document and they shall be accompanied by a material test report type 2.2 in accordance with EN 10204.

Table 5 — Materials

Material group	Properties	Restrictions		
	Amin [a] %	PS_{max} bar	(PSxDN [b])$_{max}$ bar x mm	DN_{max}[e] mm
Pressure bearing parts and inner metallic partition walls				
Rolled and forged steel [c]	16	100	-	-
Cast steel [c]	15	100	-	-
Spheroidal graphite cast iron [d]	7	20	1500	1000
	15	50	5000	300
Malleable cast iron	6	20	1000	100
Copper-zinc wrought alloys	15	100	-	25
Copper-tin and copper-zinc cast alloys	5	20	1000	100
	15	100	-	25
Aluminium wrought alloys	4	20	-	50
	7	50	-	50
		100	-	25
Aluminium cast alloys	1,5	10	250	150
	4	20	1600	1000
Integral process and sensing lines				
Copper	-	25	-	-
Steel	-	100	-	-
Connectors				
Steel	8	-	-	-
Fasteners				
Steel for bolts, screws, studs	9	50	-	-
	12	100	-	-

NOTE For castings, the specified mechanical characteristics are those measured on machined test piece prepared from separately cast test samples in accordance with the relevant document for the selected materials.

[a] A = percentage elongation after fracture (according to the applicable document relevant to the chosen material).

[b] Body inlet nominal size has to be considered; for the bodies of any pilot and auxiliary device this term shall refer to their inlet connections.

[c] Bending rupture energy measured in accordance with EN ISO 148-1:2016 shall be not less than 27 J as average of three test pieces with minimum individual of 20 J at minimum operating temperature. For minimum operating temperature of −20°C, bending rupture energy at −46°C of minimum 14J is accepted instead of a bending rupture energy of 27 J at −20°C.

[d] Bending rupture energy measured in accordance with EN ISO 148-1:2016 shall be not less than 12 J, as an average of three test pieces with minimum individual of 9 J, as a minimum operating temperature of −20 °C (class 2) for PS > 25 bar.

[e] DN max refers to both inlet and outlet connections including technical solutions with enlarged outlet

4.2.1.6 Manufacturing requirements

4.2.1.6.1 Welding requirements

Fabrication welds in all pressure bearing parts shall be made using qualified welding procedures in accordance with applicable EN ISO 15607:2003, EN ISO 15609-1:2004, EN ISO 15610:2003, EN ISO 15611:2003, EN ISO 15612:2018, EN ISO 15613:2004, EN ISO 15614-1:2017 and EN ISO 15614-2:2005/AC:2009 and by qualified welders or welding operators according to applicable EN ISO 9606-2:2004, EN ISO 9606-3:1999, EN ISO 9606-4:1999, EN ISO 9606-1:2017 and EN ISO 14732:2013. Welders and welding process shall be qualified in compliance with applicable requirements of the European legislation on pressure equipment.

In addition, for fabrication welds to make bodies, blind flanges, bonnets and actuator casings:

— only full penetration welds shall be used;

— weld fabrication and heat-treatment shall comply with EN 13445-4:2014/A1:2016.

These additional requirements are not applicable to seal welding.

4.2.1.6.2 Material traceability

For all pressure bearing parts of all pressure regulators and inner metallic partition walls of pressure regulators classified as safety accessory, the manufacturer shall identify the material throughout the production from receipt up to the final routine tests by markings or labelling.

4.2.1.7 Non-destructive testing (NDT)

4.2.1.7.1 Non-destructive testing for steel bodies

Raw materials for steel bodies shall be non-destructively tested in accordance with Tables 6 and 7.

In the case of random inspection, if a casting, forging does not conform to the acceptance criteria, a further inspection sample of twice the original sample size from the production batch shall be examined. If one of these castings, forgings fails, the examination shall be extended to all castings, forgings in the production batch.

Any casting, forging that does not conform to the acceptance criteria shall be repaired according to an applicable procedure and then re-examined.

4.2.1.7.2 Non-destructive testing of fabrication welds

Fabrication welds on pressure bearing parts shall be non-destructively tested in accordance with Tables 6 and 7.

In the case of random inspection, if a weld does not conform to the acceptance criteria, a further inspection sample of twice the original sample size from the production batch shall be examined. If one of these welds fails, the examination shall be extended to all welds in the production batch.

Any weld that does not conform to the acceptance criteria shall be repaired according to an applicable procedure and then re-examined.

4.2.1.7.3 Qualification of personnel for non-destructive testing

The NDTs shall be carried out by personnel qualified in accordance with EN ISO 9712:2012 or Recommendation SNT-TC1A:2016, and can be approved by a recognized Third Party Organization.

Table 6 — Non-destructive testing

<table>
<tr><td colspan="2" rowspan="3"></td><th colspan="5">Type of non-destructive testing</th></tr>
<tr><td colspan="2">Volumetric</td><td colspan="3">Surface</td></tr>
<tr><td>Radiographic</td><td>Ultrasonic</td><td>Visual</td><td>Magnetic particle</td><td>Liquid penetrant</td></tr>
<tr><td rowspan="3">Sections to be examined and/or extent of coverage</td><td>Steel castings</td><td colspan="2">EN 12516-1:2014+A1:2018, C.2.1.2</td><td>Accessible surfaces</td><td colspan="2" rowspan="2">EN 12516-1:2014+A1:2018, C.2.1.3</td></tr>
<tr><td>Forgings, bars, plates and tubular products</td><td colspan="2">EN 12516-1:2014+A1:2018, C.2.2 and C.2.3</td><td>Not applicable</td></tr>
<tr><td>Fabrication welds</td><td colspan="2">According to E and F in Table 7</td><td>Accessible surfaces</td><td colspan="2">According to B in Table 7</td></tr>
<tr><td colspan="2">NDT procedures and acceptance criteria for castings, forgings and their fusion weld repairs</td><td>EN 12516-1: 2014+A1:2018, Annex D</td><td>EN 12516-1: 2014+A1:2018, Annex G</td><td>MSS SP 55[a] and EN ISO 17637: 2016 [b]</td><td rowspan="2">EN 12516-1: 2014+A1:2018, Annex E</td><td rowspan="2">EN 12516-1: 2014+A1:2018, Annex F</td></tr>
<tr><td colspan="2">NDT procedures and acceptance criteria for fabrication welds, including their repairs</td><td>EN 12516-1: 2014+A1:2018, C.2.4 and Annex D</td><td>EN 12516-1: 2014+A1:2018, C.2.4 and Annex G</td><td>EN ISO 17637: 2016[b]</td></tr>
<tr><td>General requirements</td><td colspan="6">• Examinations shall be performed on the material after any heat treatment required by the material or welding either before or after the finish machining at the option of the manufacturer.
• Accessible surfaces in case of surface examination include exterior and interior surfaces but no threads, drilled or threaded holes etc.</td></tr>
<tr><td colspan="7">[a] This document is applicable only to steel castings.
[b] This document is applicable only to fusion weld repairs.</td></tr>
</table>

Table 7 — Minimum inspection sample

	p_{max}	DN				
		< 100	≥ 100 < 150	≥ 150 < 200	≥ 200 < 250	≥ 250
Castings	100	A + B	A + C	A + C	A + D	
	$50 \leq p_{max} < 100$		A + B			
	< 50	A				
Forgings, bars, plates and tubular products	100	/		C	C	D
	$50 \leq p_{max} < 100$			/		
Full penetration fabrication welds	> 16	A + F				
	$5 < p_{max} \leq 16$	A + E				
Partial penetration fabrication welds	> 16	A + B				

A is the visual examination of 100 % of the production batch.

B is the magnetic particle or liquid penetrant examination of 100 % of the production batch.

C is the volumetric examination (radiographic and ultrasonic) of 10 % of the production batch, selected on random basis.

D is the volumetric examination (radiographic and ultrasonic) of 20 % of the production batch, selected on random basis.

E is the volumetric examination (radiographic and ultrasonic) of 10 % of the circumferential, corner and nozzle seams of the production batch, selected on random basis, and 100 % of the longitudinal seams of the production batch.

F is the volumetric examination (radiographic and ultrasonic) of 20 % of the circumferential, corner and nozzle seams of the production batch, selected on random basis, and 100 % of the longitudinal seams of the production batch.

NOTE A production batch consists of castings or forgings from the same melt and the same heat treatment or welds made by the same process and/or welder or welding operator. An inspection sample is a percentage of the production batch.

4.2.2 Requirements for elastomeric materials (vulcanized rubber materials)

Elastomeric materials shall comply with

— the requirements shown in the Annex J; or

— the requirements of EN 549; or

— the characteristics established by the manufacturer and validated via a risk assessment Note: field experience of minimum 5 years may be admitted for validation.

The following supplementary requirements shall be considered:

— for diaphragms in communication to environmental conditions, the resistance to ozone;

— for seat rings and other elastomeric components subjected to erosion by flowing gas, the abrasion resistance and tear strength related to the design of the relevant components.

The characteristics of elastomeric materials shall be proved by a declaration of compliance with the order type 2.1 in accordance with EN 10204.

For spare parts made of elastomeric material the installation, operation and maintenance manual of the regulator shall specify appropriate packing and storage requirements in order to minimize the deterioration of the elastomeric material (against UV radiations and ozone cracking).

4.2.3 Requirements for non-metallic materials different from those in 4.2.2

Non-metallic materials used for functional parts in contact with the gas shall be chemically resistant to the fuel gases listed in Clause 1 and to the additive substances normally used for odorization and conditioning of gases. Furthermore, these non-metallic materials shall be resistant to the permissible impurities in the gas.

The resistance to liquids of such non-metallic materials shall meet the requirements in Table 8.

The change in mass in accordance with ISO 1817 after immersion for 7 days ± 2h at (23 ± 2) °C in test liquid B and after drying shall comply with the requirements in Table 8.

Table 8 — Requirements for non-metallic materials different than those in 4.2.2

Property	Reference standard	Requirements
Maximum change in mass after 7 days ± 2h at (23 ± 2) °C	EN ISO 175	±5 %
Maximum change in mass after drying		+5 % /-2 %

4.3 Strength of housings and other parts

4.3.1 Body

The limit pressure p_l (determined or calculated in accordance with 7.7.3), maximum allowable pressure PS and maximum inlet pressure p_{umax} shall be as follows:

$$p_l \geq S_b \times PS \geq S_b \times p_{umax}$$

NOTE For S_b value see Table 9.

4.3.2 Flanges

The ratings of flanges in accordance with EN 1092-1:2018, EN 1092-2:1997, EN 1092-3:2003, EN 1092-4:2002, ISO 7005-2:1988, EN 1759-1:2004, EN 1759-3:2003 and EN 1759-4:2003, shall not be less than maximum allowable pressure PS.

4.3.3 Other pressure bearing parts

The other pressure bearing parts are classified in the following three groups:

I) parts that are subjected to inlet pressure under normal operating conditions and that are designed to withstand a maximum allowable pressure equal to PS;

II) parts that are subjected to inlet pressure as a result of failure conditions:

  a) are designed to withstand a maximum allowable pressure equal to PS (e.g. casing of actuators as per scheme of Figure 1a), or

b) are designed to withstand a specific maximum allowable pressure of PSD which is lower than PS and have additional protective measures (e.g. casing of actuators as per scheme of Figure 1b), or

III) parts of all types of regulators (IS or DS) that can never be subjected to inlet pressure even in the case of failure conditions and that are designed to withstand a maximum allowable pressure PS or a specific maximum allowable pressure PSD which is lower than PS (e.g. casing of actuator as per scheme of Figure 1b).

Pressure bearing parts group I)

For this group the limit pressure p_l, the maximum allowable pressure PS and the maximum inlet pressure p_{umax} shall comply with the following requirements:

$$p_I \geq S \times PS \geq S \times p_{umax}$$

Pressure bearing parts group II)

a) For this sub-group the limit pressure p_l, the maximum allowable pressure PS and the maximum inlet pressure p_{umax}, shall comply with the following requirements:

$$p_I \geq S \times PS \geq S \times p_{umax}$$

b) For this sub-group pressure bearing parts may be protected against exceeding their allowable pressure:

— by a safety accessory integrated to regulator as per 4.1.2.1; or by

— a separated stand-alone safety accessory. In this case the relevant installation, operating and maintenance manual shall include appropriate instructions; or by

— an appropriate design (specific safety accessory e.g. a relief valve, vent tapping, bleeding through sensing / process lines and/or limiting of the flowing gas by appropriate clearances between movable and fixed parts). In this case, it is necessary to consider also the working conditions with the downstream isolation valve of the installation in the closed position.

In this case, the limit pressure p_l of the concerned pressure bearing parts, the specific maximum allowable pressure PSD and the maximum pressure p_{max} reached in the event of a failure, shall comply with the following requirements:

$$p_l \geq S \times PSD \geq S \times p_{max}$$

The set point of safety accessory shall be adjusted in such a way to limit the pressure to the relevant specific maximum allowable pressure PSD. Appropriate instructions on this subject shall be included in the operating and maintenance manual.

Pressure bearing parts group III)

Where the parts are designed to withstand PS, the limit pressure p_l, the maximum allowable pressure PS and the maximum inlet pressure p_{umax} shall comply with the following requirements:

$$p_l \geq S \times PS \geq S \times p_{umax}$$

Where the parts are designed to withstand PSD, the limit pressure p_l, the specific maximum allowable pressure PSD and the maximum pressure p_{max} reached in the event of a failure, shall comply with the following requirements:

$$p_l \geq S \times PSD \geq S \times p_{max}$$

In above last case with specific maximum allowable pressure PSD, the markings shall include also the maximum component operating pressure p_{max} and the specific maximum allowable pressure PSD as detailed in Clause 10.

4.3.4 Integral strength pressure regulators[9)]

Regulators classified as integral strength regulators shall include only pressure bearing parts designed to withstand the maximum allowable pressure PS.

For these types of regulators, the marking shall include the symbol "IS".

4.3.5 Differential strength pressure regulators[10)]

Regulators classified as differential strength regulators include some pressure bearing parts designed to withstand a specific maximum allowable pressure PSD where PSD < PS.

For these types of regulators, the marking shall include the symbol "DS".

4.3.6 Inner metallic partition walls

Where a chamber in the regulator is separated into individual pressure bearing chambers by a metallic partition wall, the partition wall shall be designed taking into account the maximum differential pressure. The following requirement shall be complied with:

$$p_l \geq S \times \Delta pmax$$

4.3.7 Minimum values of safety factor for pressure bearing parts

The values listed in Table 9 shall be used to limit the stresses in the walls of pressure bearing parts and inner metallic partition walls at the maximum allowable pressure.

4.3.8 Welded joint coefficient

For welded joints both in pressure bearing parts and inner metallic partition walls, the joint coefficient shall not exceed the following values:

— for welded joints subject to 100 % NDT: 1;

— for welded joints subject to random NDT: 0,85;

— for welded joints not subjected to NDT other than visual inspection: 0,7.

9) For these regulators the maximum inlet pressure is p_{umax}.

10) See previous note.

Table 9 — Minimum values of safety factor

Group of materials	Minimum value of safety factor	
	S	For parts of the body stressed by forces from pipelines only S_b
Rolled and forged steel	1,7	2,13
Cast steel	2,0	2,5
Spheroidal graphite cast iron and malleable cast iron	2,5	3,13
Copper-zinc wrought alloys and aluminium wrought alloys	2,0	2,5
Copper-tin cast alloys and copper-zinc cast alloys	2,5	3,13
Aluminium cast alloys Amin 4 %	2,5	3,13
Aluminium cast alloys Amin 1,5 %	3,2	4,0

4.3.9 Design requirements for strength of elastomeric parts

Diaphragms used as pressure containing parts in chambers subjected, or that can be subjected to a maximum differential pressure Δp_{max} shall withstand a test pressure (in bar) of at least:

— 0,3 bar if Δpmax < 0,15 bar;

— 2 Δpmax if 0,15 bar ≤ Δpmax < 5 bar;

— 1,5 Δpmax but at least 10 bar if Δpmax ≥ 5 bar.

Above design requirements shall be validated by test according to 7.7.3.4.

5 Functional and characteristic requirements

5.1 General

5.1.1 Mounting position

Regulators within the scope of this document shall function in any mounting position specified by the manufacturer, ± 5°.

5.2 Shell strength, external tightness and internal sealing

5.2.1 Shell strength

Pressure bearing parts subjected to the test described in 7.7.4 shall show no visible leakage.

5.2.2 External tightness

The pressure bearing parts and all connecting joints shall be leak-proof when tested in accordance with 7.7.7.

5.2.3 Internal sealing

The control member in its closed position and inner metallic partition walls which are subjected to inlet pressure shall seal in accordance with the requirements of 7.7.9.3 or 7.7.9.4.3.

5.3 Control classifications

5.3.1 Accuracy under stable conditions

5.3.1.1 Accuracy classes

Regulators shall conform to accuracy requirements relevant to the declared accuracy class(es) chosen from Table 10.

Table 10 — Accuracy classes

Accuracy class	Permissible positive and negative regulation change
AC 1	± 1 % [a]
AC 2,5	± 2,5 % [a]
AC 5	± 5 % [a]
AC 10	±10 %
AC 20	±20 %
AC 30	±30 %

[a] But not lower than ± 1 mbar.

The same type of regulator may have different accuracy classes depending on the set range Wd and/or the inlet pressure range b_{pu}.

5.3.1.2 Hysteresis

The hysteresis is included in the accuracy class and shall be declared by the manufacturer if requested in the order specification.

5.3.2 Lock-up behaviour

5.3.2.1 Lock-up pressure classes

Regulators shall conform to lock-up pressure requirements relevant to the declared class(es) chosen from Table 11.

Table 11 — Lock-up pressure classes

Lock-up pressure class	Permissible positive regulation change within the lock-up pressure zone
SG 2,5	2,5 % [a]
SG 5	5 % [a]
SG 10	10 %
SG 20	20 %
SG 30	30 %
SG 50	50 %

[a] But not lower than 1 mbar.

The same type of regulator may have different lock-up pressure classes depending on the specified set range W_d and/or the inlet pressure range b_{pu}.

At the lowest limit temperature the permissible deviation for the declared lock-up pressure classes may move to a less stringent class as detailed in 7.7.9.4.5.

5.3.2.2 Classes of lock-up pressure zone

Regulators shall conform to lock-up pressure zone requirements relevant to the declared class(es) chosen from Table 12.

Table 12 — Lock-up pressure zone classes

Class of lock-up pressure zone	Limit value of the lock-up pressure zone as a percentage of $Q_{min,pu}$ to $Q_{max,pu}$
SZ 2,5	2,5 %
SZ 5	5 %
SZ 10	10 %
SZ 20	20 %

Within the lock-up pressure zone the regulator need not comply with 5.3.3.

The same type of regulator may have different classes of lock-up pressure zone depending on the set range Wd and/or the inlet range b_{pu}.

5.3.3 Stable conditions

For the permissible positive and negative regulation change specified in 5.3.1.1 the amplitude of any oscillations occurring in steady-state shall not exceed 20 % of the accuracy class or 1 mbar whichever is the higher value.

5.4 Final visual inspection

5.4.1 Requirements for final visual inspection after type tests

In the type test specifically after the tests 7.7.4 up to and including 7.7.9.4.5 and test in 7.7.9.4.6 when applicable, excluding the test in 7.7.9.3, the regulator shall show no undue wear, binding, corrosion, damage or other defects which may affect its long term performance.

5.4.2 Requirements for final visual inspection after routine tests and production surveillance

After routine tests and production surveillance there shall be no visible evidence of damages and the markings shall comply with the applicable instructions.

5.5 Fail close conditions

For fail close regulators the control member shall tend to close or close in the following cases:

— failure of any main diaphragm;

— failure of continuous supply of energy from gas system to move the control member.

5.6 Fail open conditions

For fail open regulators the control member shall tend to open or open in at least one of the following cases:

— failure of any main diaphragm;

— failure of continuous supply of energy from gas system to move the control member.

5.7 Closing force for monitor at full open position

At the activation of the monitor, the closing force shall ensure the reaching of the controlling position of control member by a sufficient safety factor under all operating conditions. In the case of closing springs, appropriate measures against the breakage of springs shall be considered as those detailed in 4.1.7.

The closing force, when the monitor is activated at its fully open position, shall comply with the following requirement:

$$F_S \geq 5 \times R \pm f \times S \pm f \times W + f \times D$$

where

R	is the friction force (non-static friction) in N;
S	is the unbalanced load from static pressure in N;
W	is the weight of the moving parts in N;
D	is the dynamic force on the closing member from the flowing gas through the regulator in N;
f = 1,1	where the force opposes the closing of the control member;
f = 0,9	where the force assists the closing of the control member.

The addition (+) is applied when the force opposes the closing of the control member and the subtraction (-) when the force assists the closing of the control member.

The dynamic force (D) is considered zero if it assists the closing of the control member.

When there is any torque developed in moving parts by the flowing gas it shall be considered when calculating F_S.

The value of closing force shall be verified at the most critical operating conditions in the most critical mounting position.

This requirement is not applicable to:

— direct acting regulators (e.g. Figure 1);

— pilot controlled regulators using a diaphragm as control member (e.g. Figure 3).

5.8 Antistatic characteristics

Any external actuated part shall be electrically connected/bonded to the body in such way to meet the requirements detailed in 7.7.8.

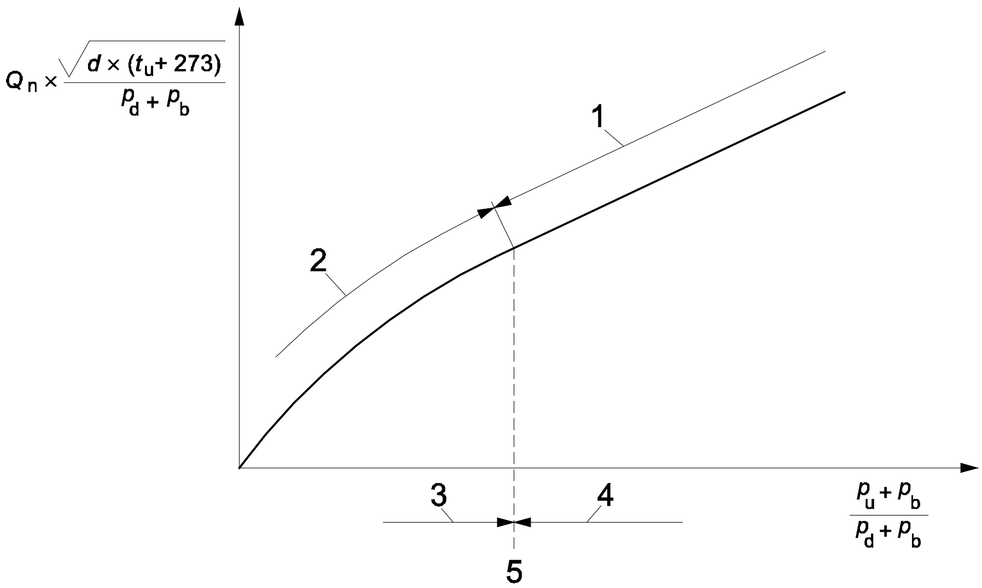
6 Gas pressure regulator sizing

6.1 Flow behaviour

The flow behaviour of a regulator is said to be critical if, at constant inlet temperature, the volumetric flow rate varies proportionally only with the absolute inlet pressure.

The flow behaviour of a regulator is said to be sub-critical if, at constant inlet temperature, the volumetric flow rate varies with both the absolute inlet and outlet pressures.

The boundaries of the critical and sub-critical flow behaviour (see Formula (9) in 7.7.9.2.2) are shown in the system of Cartesian coordinates of Figure 8 and coincide with the two different sections of the plotted curve. For the definition of the symbols see 6.2.



Key

1 linear section

2 nonlinear section

3 sub-critical behaviour

4 critical behaviour

5 border point between sub-critical and critical behaviour

Figure 8 — Flow behaviour of a regulator with the control member in a fixed position

6.2 Sizing equations for the calculation of volumetric flow rates of a gas pressure regulator with its control member in its mechanically fully open position

6.2.1 Normal calculations

Volumetric flow rates should be calculated using the sizing equations of EN 60534-2-1.

6.2.2 Practical calculations

Normally, in the regulators field it is common to use the following formulae[11]:

a) sub-critical flow behaviour

$$Q_n = \frac{13,58}{\sqrt{d \times (t_u + 273,15)}} \times C_g \times \frac{p_u + p_b}{2} \times \sin \left[K_1 \times \sqrt{\frac{P_u - P_d}{P_u + P_b}} \right]_{\text{deg}} \tag{3}$$

b) critical flow behaviour (see Formula (9) in 7.7.9.2.2)

$$Q_n = \frac{13,58}{\sqrt{d \times (t_u + 273,15)}} \times C_g \times \frac{p_u + p_b}{2} \tag{4}$$

where

K_1 is the body shape factor;

d is the relative density of the gas (air = 1, non-dimensional value);

t_u is the gas temperature at the inlet of the regulator in °C.

6.2.3 Simplified calculations

The following formulae may be used with an adequate accuracy for use in practice to make a simplified calculation of the flow rates. In these formulae the relative density d and the temperature t_u of the gas for which the flow is calculated, are used

a) flow at sub-critical pressure ratio $(p_u - p_d) \leq 0,5 \times (p_u + p_b)$

$$Q_n = \frac{13,58}{\sqrt{d \times (t_u + 273,15)}} \times K_G \times \sqrt{(p_d + p_b) \times (p_u - p_d)} \tag{5}$$

b) flow at critical pressure ratio $(p_u - p_d) > 0,5 \times (p_u + p_b)$:

$$Q_n = \frac{13,58}{\sqrt{d \times (t_u + 273,15)}} \times K_G \times \frac{p_u + p_b}{2} \tag{6}$$

11) For original source of the formulae of this sub-clause see bibliography [11]. For a 2nd source of the same formulae, see also EN 60534-2-2.

The manufacturer shall detail in the relevant document supplementary information on the appropriated use of the flow coefficient K_G for high pressure-recovery body[12)] focused to meet the expected accuracy in the volumetric flow rate calculation.

6.3 Calculation of the maximum accuracy flow rate

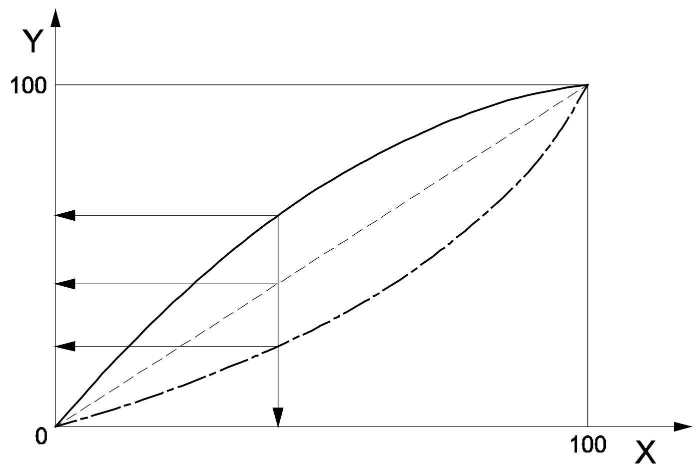
The maximum accuracy flow rate should be calculated from the formulae given in 6.2 by using the applicable percentage of the flow coefficient at fully open position. This percentage, which is equal to or less than 100, depends on the accuracy class AC and shall always be specified by the manufacturer (see Figure 6).

6.4 Inherent flow characteristics

The relationship between flow coefficient and the position of the control member is usually represented diagrammatically (see Figure 9). Flow coefficients are usually expressed as a percentage of the flow coefficient at fully open position and the position of the control member as a percentage of the maximum travel (limit imposed by a mechanical stop). Figure 9 gives examples of the inherent flow characteristics of three different types of regulator.

6.5 Calculation of volumetric flow rates for partially open gas pressure regulators

Volumetric flow rates for regulator positions between closed and fully open shall be calculated using the formulae given in 6.2, but by using the percentage of the flow coefficient at fully open position associated with a given percentage of the valve travel as detailed in 6.4.



Key

X travel in %

Y C_g, K_G in %

Figure 9 — Three examples of inherent flow characteristics

6.6 Flow coefficient

For all flow coefficients the tolerance between the value declared by the manufacturer and the actual value verified during the type test shall be within ± 10 %.

12) See bibliography [17].

7 Testing

7.1 General

Clause 7 provides guidance on the procedure that may be used when a certification of compliance with the requirements of this document is required.

The subclauses in Clause 7 may be applied also to the conformity assessment to the European legislation on pressure equipment.

7.2 Tests

Table 13 gives an overview of the different types of tests and correlates them to the requirements and test methods detailed in Clauses 4, 5 and 7.

The requirements in this chapter shall be followed when compliance evaluation with this document is requested.

Where compliance evaluation to this document is finalized with positive result, the regulator can bear as marking the number of this document.

Table 13 — Summary of tests and requirements

Test schedule			**Requirement**	**Test method**	
T	M	S	Clause	Title	Clause
Constructional tests					
A	A	A	4.1	Dimensional check and visual inspection	7.7.1
A	A	A	4.2	Materials check	7.7.2
A			4.3	Verification of the strength of pressure bearing parts and inner metallic partition walls	7.7.3
A			4.1.8	Verification of the strength of parts transmitting actuating forces	7.7.3.3
A	A	A	5.2.1	Shell and inner metallic partition walls strength test	7.7.4
A	A	A	5.2.2	External tightness test	7.7.7
A			5.5	Method to prove the compliance with requirements detailed in subclauses 5.5 or 5.6	7.7.9.5
A			5.6		
A			5.7	Verification of closing force for monitor in fully open position under normal operating conditions	7.7.6
A		A	5.8	Test method and acceptance criteria to verify the antistatic characteristics	7.7.8

Test schedule			**Requirement**	**Test method**	
T	M	S	Clause	Title	Clause
Functional tests					
A			6.6	Determination of the flow coefficients	7.7.9.2
	A [a]	A	5.2.3	Check of internal sealing and lock-up pressure	7.7.9.3
A			5.3.1.1 and 5.3.3	Determination of a performance curve and verification of the hysteresis band	7.7.9.4.2
A			5.2.3	Determination of the lock-up pressure and verification of the internal sealing	7.7.9.4.3
A			5.3	Performance classification of pressure regulators	7.7.9.4.4
A			5.3.2.1	Operational check at the limit temperatures of −10 °C or −20 °C and 60 °C	7.7.9.4.5
optional			-	Methods for measuring the sound pressure level	7.7.9.4.6
A			5.4.1	Final visual inspection after type test	7.7.10.1
	A	A	5.4.2	Final visual inspection after routine tests and production surveillance	7.7.10.2

A = Applicable

S = Production surveillance

M = Routine tests

T = Type test

[a] Simplified test method for accuracy class is not required in the routine tests; procedures of 7.7.9.3 can be used to check the set point.

7.3 Type test

Those tests (see Table 13) are carried out to establish the performance classification of the regulator or the series of regulators. These tests include verification of the documentation listed in 9.1.1.

When changes are made to the design of a regulator or a series of regulators in such a manner as to affect the above tests, the manufacturer shall inform the parties involved, if any, in the compliance evaluation to this document.

7.4 Selection of test samples

The number and types of a series of regulators to be subjected to a type test shall be selected according to the following requirements:

— one regulator for each type of auxiliary device and/or pilot;

— two sizes from a series of up to six sizes and three sizes from series greater than six in number;

— one regulator for each accuracy class AC, if applicable.

If the series of regulators includes sizes of regulators with more than one valve seat diameter, the test sample shall have the largest valve seat installed.

The check in accordance with 7.7.9.4.5 shall only be carried out on one test sample.

7.5 Routine tests

Those tests (see Table 13) carried out on each regulator[13)] by the manufacturer during the production process. The tests verify that materials, dimensions, external conditions and performance remain in compliance with the results of the type test.

7.6 Production surveillance

Those tests and verifications (see Table 13) are carried out in order to confirm continuing compliance with this document.

The tests and verifications include additionally:

— verification of the routine tests records;

— verification of drawings and material certificates.

7.7 Test and verification methods

7.7.1 Dimensional check and visual inspection

The actions to assess:

— the dimensional compliance of pressure bearing parts with the applicable drawings;

— the compliance of the regulator construction with the related assembly drawing and the construction requirements of this document.

7.7.2 Materials check

The actions to assess the compliance of the materials used or prescribed with the requirements in 4.2.

The verification of the materials used shall be carried out by the review of the material certificates.

The verification of the materials prescribed shall be carried out by the review of the part list.

7.7.3 Verification of the strength of pressure bearing parts, inner metallic partition walls and other parts[14)]

7.7.3.1 Strength calculation method for metallic parts

Verification is made by proving the compliance of the actual safety factors with those specified in 4.3.7 and the compliance of minimum allowable thicknesses shown in drawings with values specified in the strength calculations.

Strength calculation shall be carried out according to EN 12516-2:2014 and EN 12516-4:2014 +A1:2018.

7.7.3.2 Verification of experimental design method for metallic parts

When the strength calculation described in 7.7.3.1 is not fully reliable (e.g. due to the specific shape of the concerned pressure bearing part) the design may by validated by following experimental design method.

13) See, when applied, the exception in 7.7.4.

14) Strength calculation method and experimental design method shall be used according to the European legislation on Pressure equipment.

Verification is made by proving the compliance of the actual safety factors with those specified in 4.3.7 taking into account the minimum allowable thicknesses shown in drawings and the minimum proof strength (yielding) for selected material.

Actual safety factors are obtained through following methods:

— hydrostatic pressure test applied until the first sign of yielding or failure becomes apparent in any component and verification that the limit pressure p_l at which the first sign of yielding or failure becomes apparent is:

$$p_l \geq DP \times S_b \times \frac{s_{ry}}{s_{min}} \times \frac{|R_{p0,2}|_r}{|R_{p0,2}|_{min}}$$ for the body only;

$$p_l \geq DP \times S \times \frac{s_{ry}}{s_{min}} \times \frac{|R_{p0,2}|_r}{|R_{p0,2}|_{min}}$$ for other components;

— hydrostatic pressure test and verification that permanent deformations[15] do not exceed 0,2 % of l0 or 0,1 mm, whichever is greater, up to the following test pressures:

$$0,9 \times PS \times S_b \times \frac{s_{rw}}{s_w} \times \frac{|R_{p0,2}|_r}{|R_{p0,2}|_{min}}$$ for the body only;

$$0,9 \times PS \times S \times \frac{s_{rw}}{s_w} \times \frac{|R_{p0,2}|_r}{|R_{p0,2}|_{min}}$$ for other components;

where

$|R_{p0,2}|_{min}$ is the minimum proof stress (yielding) for selected material according to relevant document in N/mm²;

$|R_{p0,2}|_r$ is the measured proof stress (yielding) according to relevant document for the material of the test sample in N/mm²;

s_w is the minimum design wall thickness for the weakest point in mm;

s_{rw} is the measured wall thickness of test sample at the weakest point in mm.

Ratio s_{rw} / s_w can never be ≤ 1 (see EN 12516-2:2014).

The weakest point can be located by technical evaluation or by measurements (strain gauge, etc.).

15) The percentage of the permanent deformation is calculated as:

$$100 \times \frac{l - l_0}{l_0}$$

where

l_0 is the distance between any two points on a pressure bearing part before applying the test pressure;

l is the distance between the same points after releasing the test pressure.

The test is carried out in such a manner that deformations of the test sample in all directions are possible. There shall be no additional stresses due to bending, torque or tension.

Forces from fastening systems shall be similar to those experienced under normal installation conditions.

Bodies and pressure bearing parts manufactured from different materials may be pressure tested separately.

Special high strength screws, bolts and nuts and gaskets (between individual pressure bearing parts) may be used for hydrostatic testing.

For pressure bearing parts of other components (excluding the body) with specific maximum allowable pressure PSD, in the above formula the pressure PS shall be replaced by PSD.

For pressure bearing parts other than above subjected to differential pressure Δp_{max} in the above formulae the pressure PS shall be replaced by Δp_{max}.

The verification of strength by the finite elements method (FEM/FEA) can be an alternative method to the aforesaid experimental design method; Guideline ASME V&V 10-2006 [22] can be a reference for verification and validation of static computational models, calculated by FEM/FEA.

7.7.3.3 Verification of the strength of parts transmitting actuating forces

Verification is made by proving the compliance of the actual safety factors with those specified in 4.1.8 and the compliance of dimensions shown on drawings with values specified in the strength calculations. Alternatively, verification may be made by an actual test.

7.7.3.4 Verification of strength of diaphragm used as pressure containing parts

Design requirements of 4.3.9 shall be validated by test; during test, the diaphragm shall be fastened as it is in normal operating conditions and shall not be supported for its strength by other supplementary components.

The test is carried out at ambient temperature with air or gas at the test pressure above specified for at least 15 min. Necessary safety measures shall be taken.

After the test no leakage (see 7.7.7.1 for criteria), or failure, or visual damages shall be detected.

The diaphragm used in this test shall not be the same as used in test according to 7.7.7.2.

7.7.4 Shell and inner metallic partition walls strength test

Pressure bearing parts, including those that become pressure bearing parts in case of a diaphragm or differential pressure seal failure and inner metallic partition walls shall be pressure tested. The test is carried out with water at ambient temperature at a pressure according to the values in Table 14 for 3 min. The criteria of 5.2.1 shall be met.

The test is carried out in such a manner that deformations of the test sample in all directions are possible. There shall be no additional stresses due to bending, torque or tension.

Forces from fastening systems shall be similar to those experienced under normal installation conditions at least during the type test.

The test may be carried out without trim (i.e. the internal parts that are in flowing contact with gas).

The test may also be carried out with gases, if the necessary safety measures are taken.

Chambers separated by diaphragms are pressurized on both sides of the diaphragm at equal pressure.

Table 14 — Pressure values for the shell strength test

Chambers with the maximum allowable pressure PS	Chambers with specific maximum allowable pressure PSD
Test pressure	
1,5PS but at least PS + 2 bar	1,5PSD but at least PSD + 2 bar

The statistical strength test is applicable to pressure bearing parts where (PS x V) and, when applicable (PSD x V) is ≤ 50. The envelope volume is the volume under pressure excluding the space occupied by internal parts. The pressure is expressed in [bar], the volume in [l].

The statistical approach shall consider a production batch of at least 10 pieces from the same melt.

The starting test sample of a batch of metallic pressure bearing parts shall be at least 10 % of the whole batch. In the case of a piece of this test sample does not conform with the acceptance criteria, a further test sample of twice the starting sample shall be tested. If another metallic pressure bearing part fails, the test shall be extended to all pressure bearing parts of the batch.

7.7.5 Alternative shell and inner metallic partition walls strength test

Hydrostatic pressure tests as detailed in 7.7.4 may be replaced by other tests (e.g. pneumatic test) whose reliability shall be demonstrated. For tests other than the hydrostatic pressure test, additional safety measures, when appropriate, such as non-destructive tests or other methods of equivalent validity, shall be applied before those tests are carried out.

7.7.6 Verification of closing force for monitor in fully open position under normal operating conditions

The data specified by the manufacturer for all relevant loads are checked by testing the monitor at ambient temperature. The test shall be carried out at the most unfavourable operating conditions, to be specified by the manufacturer.

For this purpose the friction (R) is determined as the arithmetic mean of 3 tests. The friction to be considered is that measured with motion (not static friction).

The loads (S) and (W) are calculated or determined by any other method.

The dynamic force (D) shall be considered only if in the fully open position it opposes the closing of the control member. It may be either measured at the most unfavourable operating conditions or calculated. Informative Annex H details one method of calculation.

NOTE For meaning of the symbols, refer to 5.7

7.7.7 External tightness test

7.7.7.1 External tightness test of metallic housing

The assembled regulator and its auxiliary devices are pneumatically tested to assess compliance with the requirements of 5.2.2. The test is carried out at ambient temperature with air or gas at the test pressure specified in Table 15. This test shall be carried out for at least:

— 15 min in the type test;

— 1 min in the routine tests and in the production surveillance.

The result of the test is satisfactory if one of the following conditions is met:

— bubble tight for a time of 5 s. This test may be carried out by covering the regulator with a foaming liquid, by immersing the regulator in a tank of water or by other equivalent methods;

— external leakage not higher than the values listed in Table 16.

The test pressures in Table 15 do not apply to any chambers bounded on at least one side by a diaphragm even if they are subjected to gas pressure under normal operating conditions.

The test is carried out in such a manner that deformations of the regulator in all directions are possible. There shall be no additional stresses due to bending, torque or tension.

Forces from fastening systems shall be similar to those experienced under normal installation conditions at least during the type test.

Recognized alternative detection methods may be used for checking leakage (e.g. electronic device). For such methods the equivalence to the above requirements shall be demonstrated.

Table 15 — Pressure values in the external tightness test

Chambers subjected, or that can be subjected to gas pressures		**Chambers safeguarded in accordance with 4.3.3 with specific maximum allowable pressure PSD**
$> p_d$	$\leq p_d$ [a]	
Test pressures		
1,1 PS	1,2 p_{ds} max but at least 0,5 PS whichever is the greater	1,1 PSD

[a] Only if PS ≤ 20 bar. For PS > 20 bar the test pressure shall be 1,1 PS.

Table 16 — Maximum external and internal leakage rates

Nominal size DN	**Air leakage rate in cm³/h** [a]	
	external	**internal** [b]
25	40	15
40 to 80	60	25
100 to 150	100	40
200 to 250	150	60
300 to 350	200	100
400	400	300

[a] At normal conditions.

[b] Leakage class in accordance with EN 1349 if specified in the order specification.

7.7.7.2 External tightness test of chambers bounded on at least one side by a diaphragm

Such chambers shall be pneumatically tested at a test pressure (in bar) equal to at least:

— 0,2 bar if Δpmax < 0,15 bar;

— 1,33 Δpmax if 0,15 bar ≤ Δpmax < 5 bar;

— 1,1 Δpmax but at least 6,65 bar if Δpmax ≥ 5 bar.

Test method and acceptance criteria shall be in accordance with 7.7.7.1.

7.7.8 Test method and acceptance criteria to verify the antistatic characteristics

The electrical resistance between the external actuated part and the body shall be measured using a DC power source not exceeding 12 V. The resistance shall be measured on dry regulators before pressure testing and shall not exceed 10 Ω.

7.7.9 Functional tests

7.7.9.1 General conditions

If the regulator has built-in safety device(s) it shall be tested with the safety device(s) in its (their) normal operating position.

The tests may be carried out either with air or with gas. Where necessary, measured volumetric flow rates shall be converted into values that are related to air at normal conditions. Due to the need to obtain a homogeneous set of test results that will permit different types of regulators to be compared with each other, or to assess in the laboratory the requested performance of a regulator in the field, or make the assessments specified in 7.7.9.4, the measured values shall be converted into volumetric flow rates related to an inlet reference temperature of 15 °C. Pressure gauges shall have an accuracy of at least AC/4 across the scale range according to the applicable document, and pressure gauge used in range from 25 % to 75 % of full range. Tests shall be carried out at ambient temperature. Regulators shall be tested in the mounting position specified by the manufacturer.

The external sensing/process lines shall be located on the downstream pipework according to the recommendations of the manufacturer.

7.7.9.2 Determination of the flow coefficients

7.7.9.2.1 Normal method

If the volumetric flow rates are calculated using the sizing equations of EN 60534-2-1, the tests shall be carried out in accordance with EN 60534-2-3.

7.7.9.2.2 Practical method for C_g flow coefficient and K_1 body shape factor

If in the flow calculation the formulae given in 6.2 are being used then the following formulae shall be used to calculate flow coefficient C_g and the body shape factor K_1.

To determine C_g of a regulator with the control member in the mechanically fully open position it is necessary to plot a diagram as shown in Figure 9 of 6.1. The C_g shall be determined for at least three different operating conditions in the critical flow behaviour with:

$$C_g = \frac{2 \times Q_n \times \sqrt{d \times (t_u + 273{,}15)}}{13{,}58\ (p_u + p_b)} \qquad (7)$$

This formula derives from the Formula (4)

The C_g flow coefficient shall be assumed to be equal to the arithmetic mean of the three values.

The shape factor K_1 (see 6.2.2) shall be determined for at least two different operating conditions in the sub-critical flow behaviour with:

$$K_1 = \frac{\arcsin\left[\frac{Q_n \sqrt{d \times (t_u + 273,15)}}{13,58 \times C_g} \times \frac{2}{(p_u + p_b)}\right]_{\deg}}{\sqrt{\frac{p_u - p_d}{p_u + p_b}}} \qquad (8)$$

This formula derives from Formula (3)

The two different sub-critical operating conditions shall be chosen within following two values (1,15 ÷ 1,25) and (1,40 ÷ 1,50) of the ratio $\left(p_u + p_b\right) / \left(p_d + p_b\right)$.

The shape factor K_1 shall be assumed to be equal to the arithmetic mean of the two values.

For C_g and K_1 shape values a tolerance of ± 10 % is permitted.

The behaviour shall be assumed to be critical when:

$$\frac{p_u + p_b}{p_d + p_b} \geq \frac{K_1^{\,2}}{K_1^{\,2} - 8100} \qquad (9)$$

i.e. under the operating conditions at which the sin = 1 for the 1st time versus the increasing of the ratio

$$\frac{p_u + p_b}{p_d + p_b}$$

In the Formulae (7) and (8) Q is the volumetric flow rate at normal conditions of the test fluid as measured by the flow meter 9 in Figure 14. The measured values shall be converted into values related to the normal conditions specified in 3.3.2.1. The calculation of Q shall be carried out using the following formula:

$$Q_n = 269,58 \times \frac{p_M + p_b}{t_M + 273,15} \times Q_M \qquad (10)$$

Where in above formulae:

C_g is the flow coefficient;

d is the relative density of the test fluid (air = 1, non-dimensional value);

t_u is the temperature of the test fluid in °C at the inlet of the regulator;

p_M is the fluid pressure at the flow meter;

pd is the pressure at the outlet of the regulator in bar abs;

pu is the pressure at the inlet of the regulator in bar abs;

Qn is the volumetric flow rate in m^3/h at normal conditions;

Q_M is the volumetric flow rate measured at the flow meter at operating conditions;

t_M is the fluid temperature at the flow meter in °C;

K_1 is the body shape factor.

The tests shall be carried out where technical possible and economically justified on a test rig in accordance with 7.7.9.4.6. Where this is not the case, alternative test and calculation methods e.g. that detailed in A.3 may be used for the determination of flow coefficient C_g.

7.7.9.2.3 Test method for K_G flow coefficient

For the determination of the flow coefficient the regulator with the control member in the mechanically fully open position shall install in a test rig according to 7.7.9.4.6.

The volumetric flow rate Q is measured at an absolute inlet pressure p_u = 2 bar and absolute outlet pressure p_d = 1 bar.

The flow coefficient is related to conditions specified in 3.3.2.4 and calculated by:

$$K_G = 2 \times Q_n \times \frac{\sqrt{d \times (t_u + 273,15)}}{13,58 \times (p_u + p_b)} \tag{11}$$

This formula derives from Formula (6).

For larger regulators or insufficient capacity of the test facility the value of the volumetric flow rate Q shall be measured at sub-critical flow behaviour $(p_u - p_d) \leq 0,5 \times (p_u + p_b)$ for three different Δp between inlet pressure pu and outlet pressures pd.

For every measured value the associated flow coefficient is calculated as follows:

$$K_G = \frac{Q_n}{\sqrt{(p_d + p_b) \times (p_u - p_d)}} \times \frac{\sqrt{d \times (t_u + 273,15)}}{13,58} \tag{12}$$

This formula derives from Formula (5).

The volumetric flow rate Q_n is calculated by the Formula (10).

The flow coefficient of the regulator is the arithmetic average value from the three calculated values.

The manufacturer shall consider further measures on the suitability of the above test methods for high pressure-recovery bodies[16)] focused to meet the expected accuracy in the volumetric flow calculation.

16) See bibliography [17].

Where in above formulae:

K_G	is the flow coefficient
d	is the relative density of the test fluid (air = 1, non-dimensional value)
t_u	is the temperature of the test fluid in °C at the inlet of the regulator
pd	is the pressure at the outlet of the regulator in bar abs
pu	is the pressure at the inlet of the regulator in bar abs
Qn	is the volumetric flow rate in m^3/h at normal conditions

7.7.9.3 Check of internal sealing and lock-up pressure class

These tests shall be carried out with volumetric flow rates greater than $Q_{n,min,pu}$ at the extreme values of the inlet pressure range b_{pu} for the setting of the controlled pressure or for the extreme values of specific set range W_{ds} or for the extreme values of set range W_d according to the order specification.

Initial conditions to be set as follows:

— inlet pressure to be equal to p_{umin} and the volumetric flow rate to be zero;

— increase the volumetric flow rate to the level specified above;

— adjust the controlled pressure to the required set point.

The test for each setting shall comprise the following steps (see Figure 10):

a) reduce the volumetric flow rate until complete lock-up takes place within a period not less than the response time of the regulator;

b) record the lock-up pressure:

    — after 5 s;

    — after 30 s

    from the closure of the regulator;

    NOTE 1 These values are not appropriate for pilot controlled regulators.

c) increase the volumetric flow rate close to the above value and determine the corresponding outlet pressure p_d;

d) increase the inlet pressure until p_{umax} is reached and determine the corresponding outlet pressure p_d;

e) repeat the above steps from a) to c) without any further adjustment of the setting;

f) reduce the volumetric flow rate until complete lock-up takes place within a period not less than the response time of the regulator;

g) record the lock-up pressure:

— after 5 s;

— after 30 s

from the closure of the regulator;

NOTE 2 These values are not appropriate for pilot controlled regulators.

Provided the values of lock-up pressure at 5 s and 30 s are comparable, taking account of the accuracy of the measuring system, it shall be assumed that the regulator has passed the internal leakage test.

The values of lock-up pressure, the outlet pressures resulting from the two increases in the volumetric flow rate and the setting shall be within the applicable range.

If the manufacturer is unable to provide the required test volumetric flow rate, an alternative test procedure may be used to cover these checks.

In these verifications a test rig in accordance with 7.7.9.4.6 is not mandatory.

If a detection method is available to verify compliance with the required internal leakage rates given in Table 16, an alternative procedure may be followed to check the internal sealing and to measure the lock-up pressure at p_{umin} and p_{umax}.

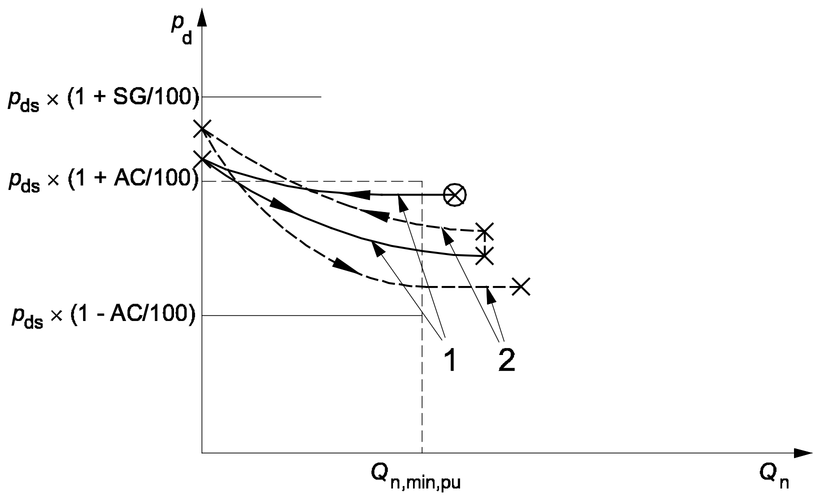
In this case the determined leakage rates shall comply with:

— the requirements of Table 16, or

— the leakage class in accordance with EN 1349:2009 if specified in the order specification (see Annex F).

After the completion of above verifications it shall be verified that the regulator meets the internal sealing performance also for momentary inlet pressure surge up to 1,1 PS.

NOTE 3 Above procedures can be used to check the set point.



Key

⊗ Setting 1 $p$umin

× measured value 2 $p$umax

Figure 10 — Graphical representation of the tests detailed in 7.7.9.3

7.7.9.4 Functional tests under stable conditions

7.7.9.4.1 General conditions

These tests shall be carried out at ambient temperature. The purpose is to verify the values stated by the manufacturer for the:

— accuracy class;

— maximum hysteresis band, if specified in the order specification;

— lock-up pressure class;

— class of lock-up pressure zone;

— maximum accuracy flow rate and minimum flow rate.

The tests shall be carried out where technically possible and economically justified on a test rig in accordance with 7.7.9.4.6.

Where this is not the case, alternative test and calculation methods e.g. those explained in Annex A or the modelling tests on test specimens to a smaller scale as described in EN 60534-2-3, may be used for the determination of $Q_{nmax,pumin}$, $Q_{nmax,pumax}$, AC, SG and hysteresis band if specified in the order specification under the following pre-conditions:

a) the maximum possible size and at least the minimum size of a series of regulators shall be tested using a test rig in accordance with 7.7.9.4.6;

b) to prove that the alternative method chosen is reliable by comparing the results with those from a test at full operating conditions in a particular regulator size;

c) to use the alternative method for larger sizes of regulators of the same series.

However, if the regulator or even the smallest regulator of a series cannot be tested using a test rig in accordance with 7.7.9.4.6, the test method as detailed in Annex A may be used without other pre-conditions.

The compliance with performance requirements shall be checked against only three families of performance curves for three different values of outlet pressure chosen within the set range W_d in accordance with the following criteria:

— p_{dmin}

— p_{dmax}

— $P_{dint} = P_{dmin} + \frac{P_{dmax} - P_{dmin}}{3}$

For each family of performance curves three values of inlet pressure shall be chosen within the inlet pressure range b_{pu} in accordance with the following criteria:

— p_{umin}

— p_{umax}

— $P_{uav} = \frac{P_{umin} + P_{umax}}{2}$ (rounded to the nearest whole number)

The regulator shall be kept pressurized throughout the whole process with no interruption of this condition until the determination of the families of performance curves is completed.

7.7.9.4.2 Determination of a performance curve and verification of the hysteresis band

With the understanding that the "actual set point" cannot be determined at the outset of this process, the setting of the regulator shall be adjusted at:

— an inlet pressure equal to p_{uav};

— the volumetric flow rate recommended by the manufacturer.

Changes to the setting prior to the completion of the whole process for the determination of a single performance curve, or families of performance curves, are not permitted. The flow rate regulating valve 8 (Figure 14) shall be used to vary the volumetric flow rates. The operating time of the valve shall not be less than the response time of the regulator as specified by the manufacturer. Volumetric flow rates measured by the flow meter 9 (Figure 14) shall be recalculated to refer to:

— normal conditions (see 3.3.2.1);

— test fluid at the reference temperature of 15 °C at the inlet of the regulator under test.

To this end the following formula shall be used:

$$Q_n = 16{,}75 \frac{P_M + P_b}{t_M + 273} Q_M \sqrt{d\,(t_u + 273)} \qquad (13)$$

where

Q_n is the volumetric flow rate in m³/h of the test fluid with relative density d and inlet temperature t_u for p_n and T_n see 3.3.2.1;

d is the relative density of the test fluid (air = 1 non dimensional value);

p_M is the fluid pressure at the flow meter;

Q_M is the volumetric flow rate measured at the flow meter at operating conditions;

t_M is the fluid temperature at the flow meter in °C;

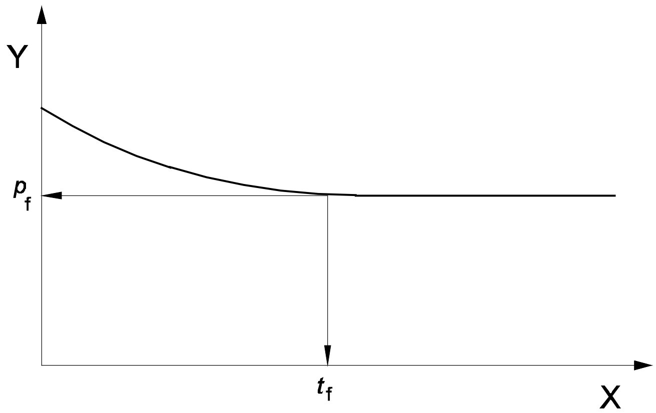
t_u is the fluid temperature in °C at the inlet of regulator under test.

At least 11 different measurements conveniently distributed over the full range of values between Q_{nmin} and Q_{nmax} (5 with volumetric flow rates increasing, 4 with volumetric flow rates decreasing, an additional measurement at zero volumetric flow rate and one at the start setting) shall be taken for each pair of p_u and p_{ds} values.

Figure 4 is an example of a chart showing the relevant details such as the start setting, the measured results and the performance curve for the controlled variable related to a single pair of p_u and p_{ds} values.

7.7.9.4.3 Determination of the lock-up pressure and verification of the internal sealing

The lock-up pressure shall be determined in connection with tests carried out to determine the performance curve of the controlled variable. The time required to reduce the volumetric flow rate to zero shall not be less than the lock-up time of the regulator. This condition is deemed to be satisfied when the lock-up pressure is found to be independent of the time needed to reduce the volumetric flow rate to zero (see Figure 11).



Key

X time to reduce the volumetric flow rate to zero

Y pressure with control member at closing position

Figure 11 — Graphical representation of tests detailed in 7.7.9.4.3

The lock-up pressure p_f shall be measured twice, after 1 min and after 2 min from the regulator closure. When the inlet pressure is greater than 16 bar the second measurement shall be taken after 5 min.

Any lock-up pressure value that can be affected by temperature variation in the fluid contained in the volume between the regulator under test and the flow rate regulating valve, shall be recalculated and related to the initial temperature by using the following formula:

$$P_f = \frac{t + 273}{t_i + 273} (P_{fi} + P_b) - P_b \qquad (14)$$

where

p_{fi} is the lock-up pressure related to the second measurement;

t is the test fluid temperature in °C related to the first measurement;

t_i is the test fluid temperature in °C related to the second measurement.

The regulator shall be deemed leak-tight if the last two lock-up pressures, corrected for the initial temperature, are comparable (taking account of the accuracy of the measuring system) or comply with the internal leakage rate requirements given in:

— Table 16; or

— the leakage class in accordance with EN 1349:2009 if specified in the order specification (see Annexe F).

The lock-up pressures of the regulator shall be within the applicable range. For lock-up pressure measurements the outlet pipework of the test rig shall have a minimum length as specified in Figure 14.

The internal sealing of regulator shall also be verified at:

— outlet pressure of zero;

— After the completion of above verifications it shall be verified that the regulator meets the internal sealing performance also for momentary inlet pressure surge up to 1,1 PS.

7.7.9.4.4 Performance classification of pressure regulators

7.7.9.4.4.1 Determination of the accuracy class, the lock-up pressure class, the class of lock-up pressure zone, the maximum accuracy flow rate and the minimum flow rate related to a specified inlet pressures range (a family of performance curves)

The determination is based on optimal enveloping of each family of performance curves with the vertical and horizontal limit lines as shown in Figure 6. An example of an optimal enveloping procedure is shown in Figure 12 and is described as follows:

— plot the performance curves of a family in a diagram with volumetric flow rates on the decimal scale of the abscissa and outlet pressure on the logarithmic scale of the ordinate;

— locate on this diagram, in an optimized manner, three horizontal lines spaced as shown in Figure 12; the optimization of the location of these lines is reached when the greatest possible number of performance requirements are met;

— identify the actual set point where the dashed horizontal line intersects the ordinate;

— ensure that $Q_{nmax,puav}$, $Q_{nmax,pumin}$, $Q_{nmax,pumax}$, $Q_{nmin,pumax}$, $Q_{nmin,puav}$, $Q_{nmin,pumin}$, AC and p_f are within the established limits.

Other equivalent optimal enveloping methods may be used.

If the performance data listed by the manufacturer are not met, the test report shall detail the actual performance data taken from the type tests.

7.7.9.4.4.2 Determination of the accuracy class, the lock-up pressure class, the class of lock-up pressure zone, the maximum accuracy flow rate and the minimum flow rate related to a specified inlet pressure range and set range (more than one family of performance curves)

The determination is based on the output data as in the previous subclause deduced from the three families of performance curves specified in 7.7.9.4..4.1.

The regulator is classified for a specified inlet pressure range (b_{pu}) and set range (W_d) in accordance with following procedure:

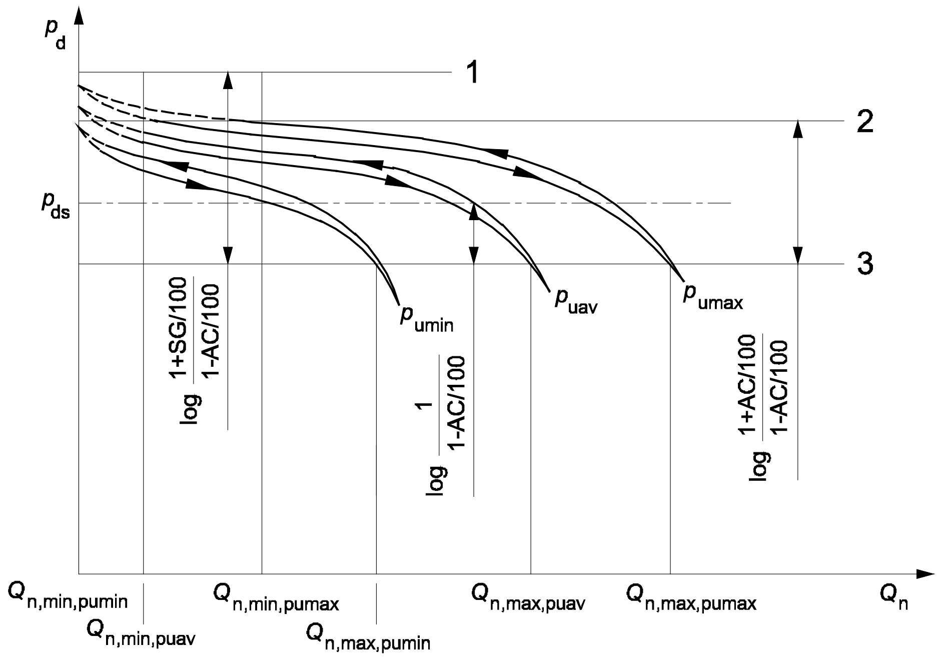
— accuracy class (AC);

— lock up pressure class (SG); and

— lock up pressure zone (SZ)

shall be the less performance data verified for above three families of performance curves while:

— the maximum accuracy flow rate is the lowest maximum accuracy flow rate of the three above families of performance curves and the minimum flow rate is largest minimum flow rate of the three above families of performance curves.



Key

1 max limit for p_f

2 max limit for p_d with Q outside the lock-up zone

3 min limit for p_d

Figure 12 — Graphical representation of tests detailed in 7.7.9.4.4

7.7.9.4.5 Operational check at the limit temperatures of –10 °C or –20 °C and 60 °C

The regulator shall be installed in a suitable thermostatically controlled enclosure.

The operational check shall include in the listing order a test at lowest limit temperature and subsequently a test at highest limit temperature.

To start the check the test medium shall be brought to the relevant temperature.

The check shall verify the internal sealing and determine the lock-up pressure in accordance with 7.7.9.4.3 under the following conditions:

— max inlet pressure/min outlet pressure;

— at the two relevant limit temperatures.

— with flow related to the lock-up zone SZ

The lock-up pressure at the −10 °C and at the −20 °C limit temperatures shall be:

$$p_f \leq p_{ds} \times \left(1 + \frac{2\ \mathrm{SG}}{100}\right)$$

except when at ambient temperature:

— lock-up pressure SG = 30. In this case the SG = 30 may be multiplied by 1,5;

— lock-up pressure SG = 50.

EXAMPLES At ambient temperature SG 5 may change to SG 10 both at −20 °C and at −10 °C. At ambient temperature SG 30 may change to SG 45 both at −20 °C and at −10 °C.

The lock-up pressure at upper limit temperature shall be:

$$p_f \leq p_{ds} \times \left(1 + \frac{SG}{100}\right)$$

where

p_{ds} and SG are those determined at ambient temperature.

Further the check shall include the verification of opening start.

At lowest limit temperatures a check to determine the control member movement shall also be carried out at the following conditions:

— minimum value of set point (p_{dsmin});

— minimum operating differential pressure Δp_{min}.

After above checks, the external tightness test in accordance with 7.7.7 is repeated at the lower limit temperatures.

7.7.9.4.6 Test rig requirements

The requirements detailed in this subclause are mandatory only for type testing.

The tests shall be carried out on one test rig built as specified in Figure 14 or in accordance with EN 60534-2-3 as appropriate. The nominal diameter of the pipework connecting the full bore valves and the flow rate regulating valves with the regulator shall not be smaller than the nominal diameter of the regulator and so chosen as to ensure that in all operating conditions during the tests the velocity of the fluid where the impulse is taken does not exceed:

— 50 m/s for pressure ≥ 0,5 bar;

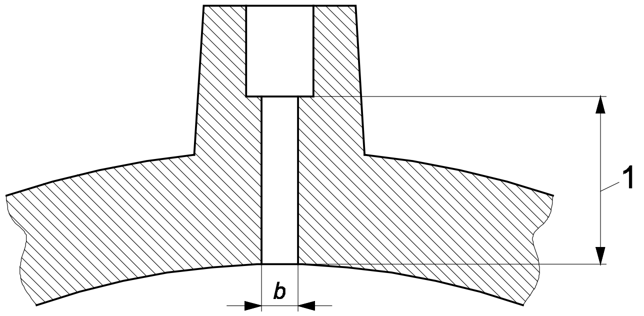
— 25 m/s for pressures < 0,5 bar.

The connections between the regulator and the test rig pipework shall be made using concentric reducers according to ISO 3419 or equivalent. The pressure tapping diameter *b* shown in Figure 13 shall be at least 3 mm and shall be no larger than 12 mm or one-tenth of the nominal pipe diameter, whichever is the lesser. The tapping shall be circular and its edge shall be clean and sharp or slightly rounded and free from burrs or other irregularities. Any suitable method of making a physical connection is acceptable provided the above recommendations are followed. However, fittings shall not protrude inside the pipework.

In the event of unstable conditions due to volumetric flow rate variations consequent to the operation of the flow regulating valve 8 (see Figure 14), it is permissible to increase the length of the pipework connecting the flow regulating valve 8 (see Figure 14) to the regulator, or to provide for an additional volume by installing a parallel line or reservoir.

The lock-up pressure tests shall always be carried out on a test rig in which the downstream pipework has the minimum specified length; for these tests an additional downstream volume is not permitted. The flow meter shall be installed in accordance with the instructions of the manufacturer.

NOTE For alternative test methods under the conditions of 7.7.9.4.1 see also Annex A.

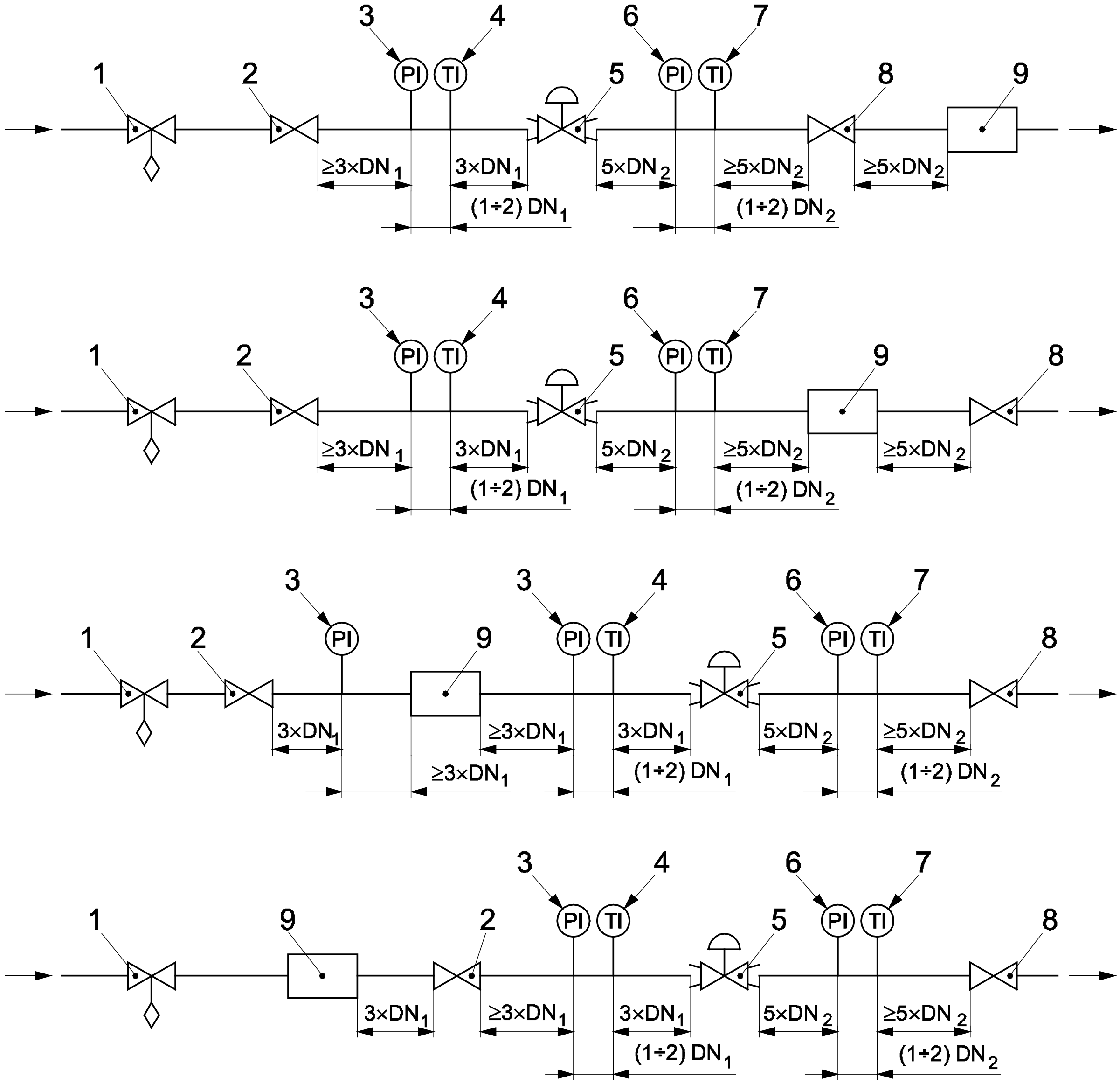


Key

b pressure tapping diameter

1 minimum 2,5 b, recommended 5 b

Figure 13 — Recommended pressure tapping



Key

DN_1 = nominal diameter of the upstream pipework connected to the regulator under test

DN_2 = nominal diameter of the downstream pipework connected to the regulator under test

1 shut-off device to prevent overpressure, if necessary

2 inlet full bore valve

3 inlet pressure indicator

4 inlet temperature indicator

5 regulator under test

6 outlet pressure indicator

7 outlet temperature indicator

8 flow rate regulating valve

9 flow meter

Figure 14 — Test rig requirements

7.7.9.5 Method to prove the compliance with requirements detailed in subclauses 5.5 or 5.6

The reaction of regulators detailed in subclauses 5.5 and 5.6 shall either be proved by appropriate failure analysis or in case of doubt by the relevant test(s).

The failure analysis shall consider:

— only the failures listed in 5.5 or 5.6; and

— only one of the failure at same time and its consequences, if any.

Regulators whose reaction to all the specified failures in 5.5, comply with the requirements detailed in the same subclause, are classified as “fail close” type.

Regulators whose reaction to any specified failures in 5.6, comply with the requirements detailed in the same subclause, are classified as “fail open” type.

Failure analysis can identify a differentiation in the reaction of “fail open” regulators to the failures listed in Clause 5.6, e.g. it is necessary to consider that damages on other diaphragms can bring the regulator to tend to open or to open or to tend to close or close (see e.g. Figure 3).

Details shall be specified in the installation, operation and maintenance manual.

7.7.10 Final visual inspections

7.7.10.1 Final visual inspection after type test

Upon completion of the tests in 7.7.4 up to and including 7.7.9.4.5 and the test 7.7.9.4.6 when applicable, excluding the test in 7.7.9.3, the test samples shall be dismantled and inspected to verify the compliance with the requirements detailed in 5.4.1.

7.7.10.2 Final visual inspection after routine tests and production surveillance

Upon completion of the routine tests the regulator shall be externally inspected to verify the compliance with the requirements detailed in 5.4.2.

8 Field surveillance

Regulators require suitable field surveillance to guard against unnoticed deterioration of key components such as the seat-ring, sensing element, O-ring seals etc. The frequency of such checks shall be dependent on the operating duty.

The notice concerning the pressure residual risks not covered by design shall be included in the operating instructions (installation, operation and maintenance manual).

9 Documentation

9.1 Documentation related to type test

9.1.1 Documentation required prior to type test

The following documentation shall be available at the time of carrying out the type test:

a) photographs and/or leaflets;

b) scheme and related functional description;

c) technical data for the series of regulators and a list of performance data to be confirmed;

d) assembly drawing of the regulator;

e) overall dimensional drawing;

f) nameplate drawing;

g) strength calculation or test report for all pressure bearing parts;

h) parts list with material description for all components;

i) manufacturing drawings of all pressure bearing parts and critical internal components;

j) Operating instructions (installation, operation and maintenance manual).

9.1.2 Test report

On completion of the type test a report according to EN ISO/IEC 17025 should be provided detailing the results of the tests carried out. If alternative methods under the provisions of 7.7.9.4.1 are used, they shall be described in detail in an appropriate section of the test report.

9.2 Documentation related to the routine tests

Documentation relevant to routine tests may include when applicable:

— Inspection certificate; and/or

— Non destructing testing (NDT) certificate; and/or

— material certificate in accordance with EN 10204 for pressure bearing parts and for bolts, screws and studs.

Above documentation may be provided to the customer upon agreement.

9.3 Documentation related to production surveillance in accordance with 7.6

9.3.1 Documentation for production surveillance

For each series of regulators the following documentation shall be available:

— type test report;

— records of inspections satisfactorily passed during the manufacturing process.

9.3.2 Production surveillance report

The production surveillance report shall detail the results of all tests and verifications listed in 7.6.

9.4 Operating instructions

Installation, operation and maintenance manual (operating instructions) shall be provided with regulator and released in the language of the country of destination or in the languages accepted by the user, giving appropriate notices/instructions on:

— specific provisions for visually indication whether the control member of the stand-by monitor is in the closed or fully open position under normal operating conditions if the monitor is not equipped with an appropriate device (see 4.1.1);

— specific provisions as specified in 4.3.3 for the protection of pressure bearing parts in differential strength regulators and for the specific markings IS and, where applicable, DS;

— details for fail open regulators as specified in 7.7.9.5;

— Specific provision as specified in Clause 8;

— information on safe use of the connections;

— safety requirements concerning commissioning and de-commissioning procedures;

— safety requirements on filling/discharge of gas of/from the regulator;

— a statement of whether maintenance is possible and the relevant instructions;

— data on the nameplate except serial number, year of manufacturing and specific set range;

— hazards arising from misuse and particular features of the design when appropriate;

— provisions, if any, for transport and handling;

— how to trace the right spare parts;

— packing provisions and storage requirements for spare parts (both for metallic and elastomeric parts);

— a statement on installation according to the provisions of EN 12186:2014 or EN 12279:2000/A1:2005;

— a statement that the regulator does not require any protection against exceeding its allowable pressure when for the upstream pressure regulating station the maximum downstream incidental pressure (MIPd) is less than or equal to 1,1 x PS;

shall be included with each regulator or shipment of regulators.

10 Marking

10.1 General requirements

The marking data shall be indicated using the symbols of this document.

The flow direction shall be marked clearly and permanently on the body by an arrow.

If a nameplate is used it shall be permanently legible and attached at a clearly visible place.

The technical details listed below shall be repeated in the inspection certificate (see Annex B).

10.2 Basic requirements

Each regulator shall carry markings containing the following data:

— CE mark, where applicable;

— manufacturer’s name and/or logo and/or registered trade-mark;

— regulator model;

- serial number;
- year of manufacture;
- maximum allowable pressure PS;
- temperature class 1 or temperature class 2 (TS);
- fluid type;
- nominal size DN.

10.3 Other additional requirements

The following further information shall be included in the marking:

- EN 334 (when the regulator complies with the this document);
- end connection type (flanged, threaded, etc.);
- specific set range Wds;
- type of regulator (IS or DS);
- failure mode type (fail close regulator or fail open regulator);
- valve seat diameter (only where different sizes are provided) or valve trim (for this term see EN 60534-1) or the flow coefficient if the previous data are not representative of the regulator flow rate;
- maximum component operating pressure pmax and the specific maximum allowable pressure PSD of safeguarded chambers (for differential strength regulators only);
- leakage class in accordance with EN 1349, when specified in the order specification;
- where necessary, warning drawing attention to dangerous misuses;
- additional marking in accordance with order specification.

10.4 Marking of integrated safety devices

The integrated safety devices shall be marked:

- according to EN 14382 for SSD;
- according to this document for monitor.

10.5 Markings for the various connections

Each connection shall be marked in terms of:

- function, e.g. breather line, sensing line, exhaust line, venting line;
- minimum nominal diameter for the pipework concerned.

11 Packaging of finished product

Before packaging the product shall be subjected to the following:

— removal of any internal debris and complete drying of the regulators;

— protection of all flanges and nozzles against impact and oxidation;

— protection of inner surface against oxidation from the atmosphere and against any introduction of foreign matter.

Packaging of finished product shall be suitable to avoid damages from shocks and impact from environment conditions capable to modify the original features.

Annex A
(informative)

Alternative methods for the determination of the accuracy class, the lock-up pressure class, the maximum accuracy flow rate, the flow coefficients and the verification of the hysteresis band

A.1 General

The following alternative test methods may be used to establish the performance classification of a regulator or a series of regulators. The detailed procedure shall be agreed with the manufacturer.

A.2 Test methods

A.2.1 Direct acting gas pressure regulator

In this type of regulator it is necessary to vary the pressure on one side of the pressure detecting element in order to move the control member from the open position to the closed position.

The test method comprises the following steps:

— set the regulator at the minimum value of the set range Wd following the manufacturer's instructions;

— increase the pressure in the casing of the actuator from an external source until the control member reaches its closed position and verify the internal sealing at the minimum and maximum inlet pressures (internally impulsed regulators may have to be modified);

— vent the pressure from the body;

— slowly reduce the pressure in the casing of the actuator until the control member reaches the required open position (i.e. the one relevant to the expected maximum accuracy flow rate) and measure the pressure corresponding to each 10 % increase in the valve travel;

— slowly increase the pressure in the casing of the actuator until the control member reaches the lock-up position and measure the pressure corresponding to each 10 % decrease in the valve travel;

— establish the closed position by the verification of internal sealing;

— calculate for each position of the control member the volumetric flow rate Q using the method detailed in 6.5.

With balanced moving parts (i.e. no variation in the thrust on the moving parts against changes in inlet pressure p_u) all measured values of the pressure, except that for the closed position, shall be within the expected accuracy class AC.

The measured value of the lock-up pressure pf shall be within the expected lock-up pressure class SG. The hysteresis can be verified by measuring the maximum difference in pressure for the same position of the control member.

The calculated value of flow rate giving maximum accuracy shall be greater than or equal to that specified by the manufacturer (see Figure A.1).

With unbalanced moving parts the same method shall be used, with account taken of the unbalanced thrust (see Figure A.2).

A.2.2 Pilot controlled gas pressure regulators

With this type of regulator it is necessary to vary the motorization pressure in the motorization chamber in order to move the control member from the closed position to an open position and vice versa. The thrust created by the motorization pressure is normally balanced by the load of a spring. The motorization pressure is supplied by the pilot. The pilot controls the supply of the motorization fluid according to the value of the difference between the value of the controlled variable and the set point in such a way as to keep the outlet pressure as close as possible to its set point.

Therefore, in both a regulator and pilot with moving parts balanced (i.e. no variation in the thrust on the moving parts with changes in inlet pressure) it is possible to classify the performance of the system i.e. the regulator with its pilot, by measuring the variation in outlet pressure against the position of the control member from the closed position to a specific valve travel. The test method shall be established in detail according to the specific design of the regulator.

In the following test method reference shall be made to the functional diagram given in Figure A.3.

Figure A.4 shows the relationship between the valve travel, motorization pressure p_m and the flow through the process line Q_f and the outlet pressure of the system p_d including the regulator and its pilot.

The test method comprises the following steps:

a) set the pilot at the minimum value of the set range W_d following the manufacturer's instructions;

b) feed the pilot from an external source using the applicable auxiliary device at minimum inlet pressure p_umin and exhaust the fluid from the chamber where both process and sensing lines are connected;

c) keep the regulator in the closed position using upstream inlet pressure. The inlet and outlet end connections may be sealed by using blind flanges;

d) verify internal sealing of the regulator with Q_f = 0 at minimum and maximum inlet pressure p_u;

e) regulate the inlet pressure at p_umin;

f) increase the flow Q_f until the first internal flow occurs in the regulator and measure the outlet pressure p_d in the chamber where both process and sensing lines are connected (at this stage the inlet and outlet pressures in the regulator body are balanced, because there is zero flow through the regulator);

g) increase the flow Q_f to open the regulator until 100 % of the valve travel relevant to the maximum accuracy flow rate $Q_\mathrm{nmax,pumin}$ has occurred and measure the outlet pressure p_d corresponding to each 10 % increase in the valve travel;

h) decrease the flow Q_f to bring the regulator to the closed position and measure the outlet pressure p_d corresponding to each 10 % decrease in the valve travel. The closed position is verified by an internal sealing test;

i) regulate the inlet pressure at p_{umax};

j) repeat the tests explained above from f) to h);

k) calculate, for each position of the control member, the volumetric flow rate Q using the method detailed in 6.5.

With balanced moving parts (i.e. no variation in the thrust on the moving parts with changes in the inlet pressure p_u) all measured values of:

— outlet pressure p_d shall be within the expected accuracy class AC. The hysteresis can be verified by measuring the maximum difference in outlet pressures p_d for the same position of the control member;

— lock-up pressure p_f shall be within the lock-up pressure class SG and the calculated value of the maximum accuracy flow rate shall be greater than or equal to that specified by the manufacturer (see Figure A.4).

With unbalanced moving parts the same method shall be used, with account taken of the unbalanced thrust (see Figure A.5).

A.3 Determination of flow coefficients for larger capacity regulators

For larger capacity regulators if the available volumetric flow rates do not permit the use of the method detailed in 7.7.9.2, the following procedure may be followed:

— firstly, determine the flow coefficient for a partially open position that is compatible with the available volumetric flow rate by using Formula (7) of 7.7.9.2.2;

— determine the shape factor K1 applicable to the same partially open position by using Formula (8) of 7.7.9.2.2;

— determine the function shown in Figure A.6 at sub-critical conditions calculating $C_{g,x}$ by using the following formula:

$$C_{g,x} = \frac{Q_n \times \sqrt{d \times (t_u + 273{,}15)}}{13{,}58 \times \frac{p_u + p_b}{2} \times \sin\left[K_1 \times \sqrt{\frac{p_u - p_d}{p_u + p_b}}\right]_{deg}} \quad \text{(A.1)}$$

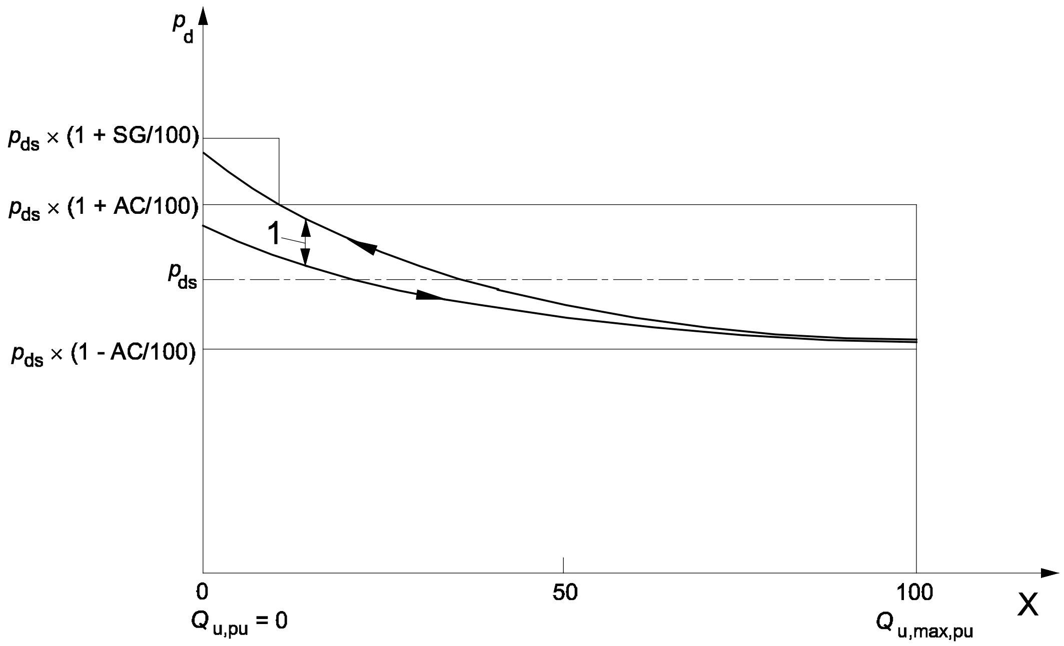
— These calculations shall be made for three different opening positions of the control member;

— extrapolate the value of C_g taken from the graph given in Figure A.6 by starting from the point in the x coordinate for 100 % control member travel.

Where there is sufficient flow the previous extrapolation can be avoided by carrying out the test detailed in the third indent with the control member at full open position.

To convert the measured flow rate to the volumetric flow rate Q to normal conditions see 7.7.9.2.2.

For C_g and K_1 values limit deviations of ± 10 % are permitted.

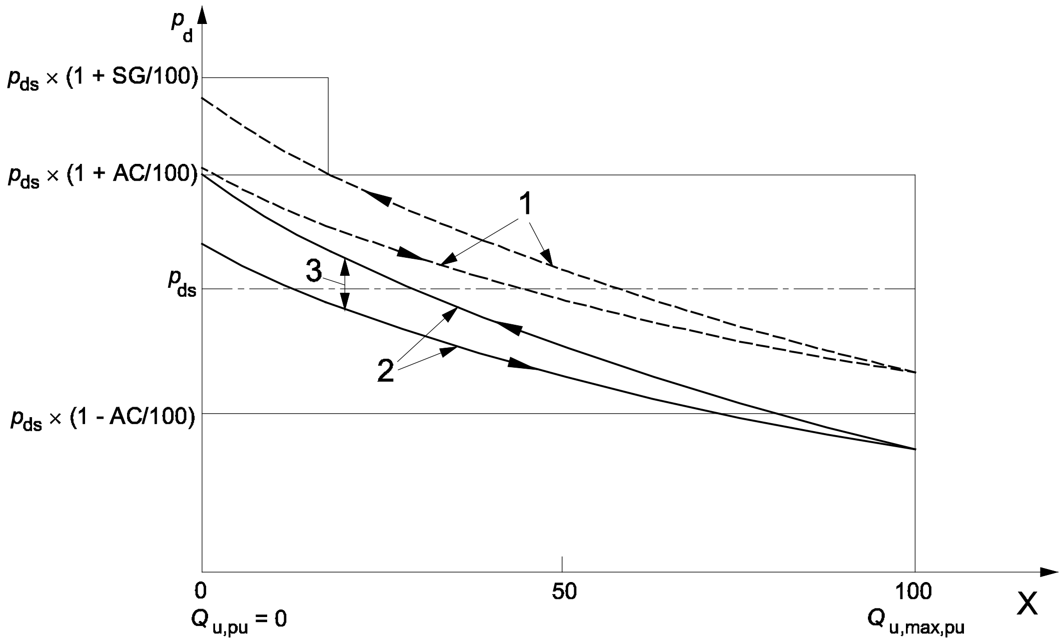


Key

1 hysteresis band

X travel in %

Figure A.1 — Graph of the outlet pressure plotted against different positions of the control member in a balanced direct acting regulator



Key

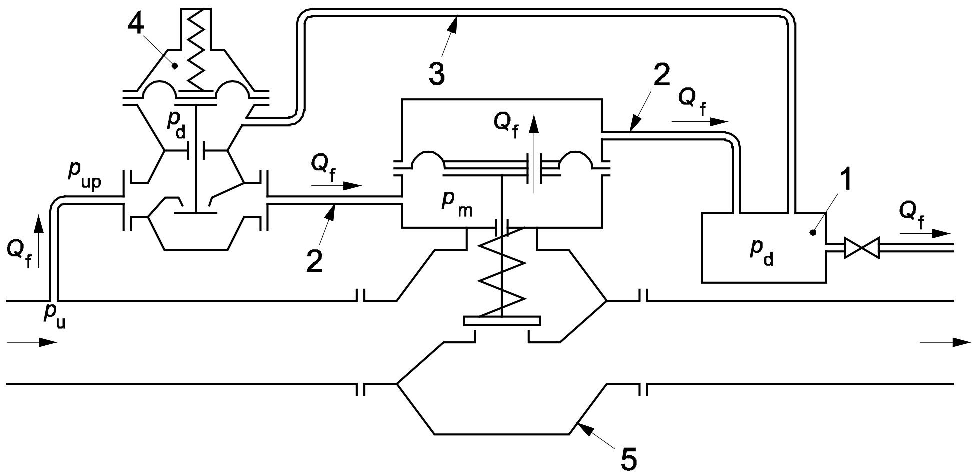
1 corrected measured values to take account of unbalanced thrust

2 measured values

3 hysteresis band

X travel in %

Figure A.2 — Graph of the outlet pressure plotted against different positions of the control member in an unbalanced direct acting regulator



Key

1 chamber for test purposes

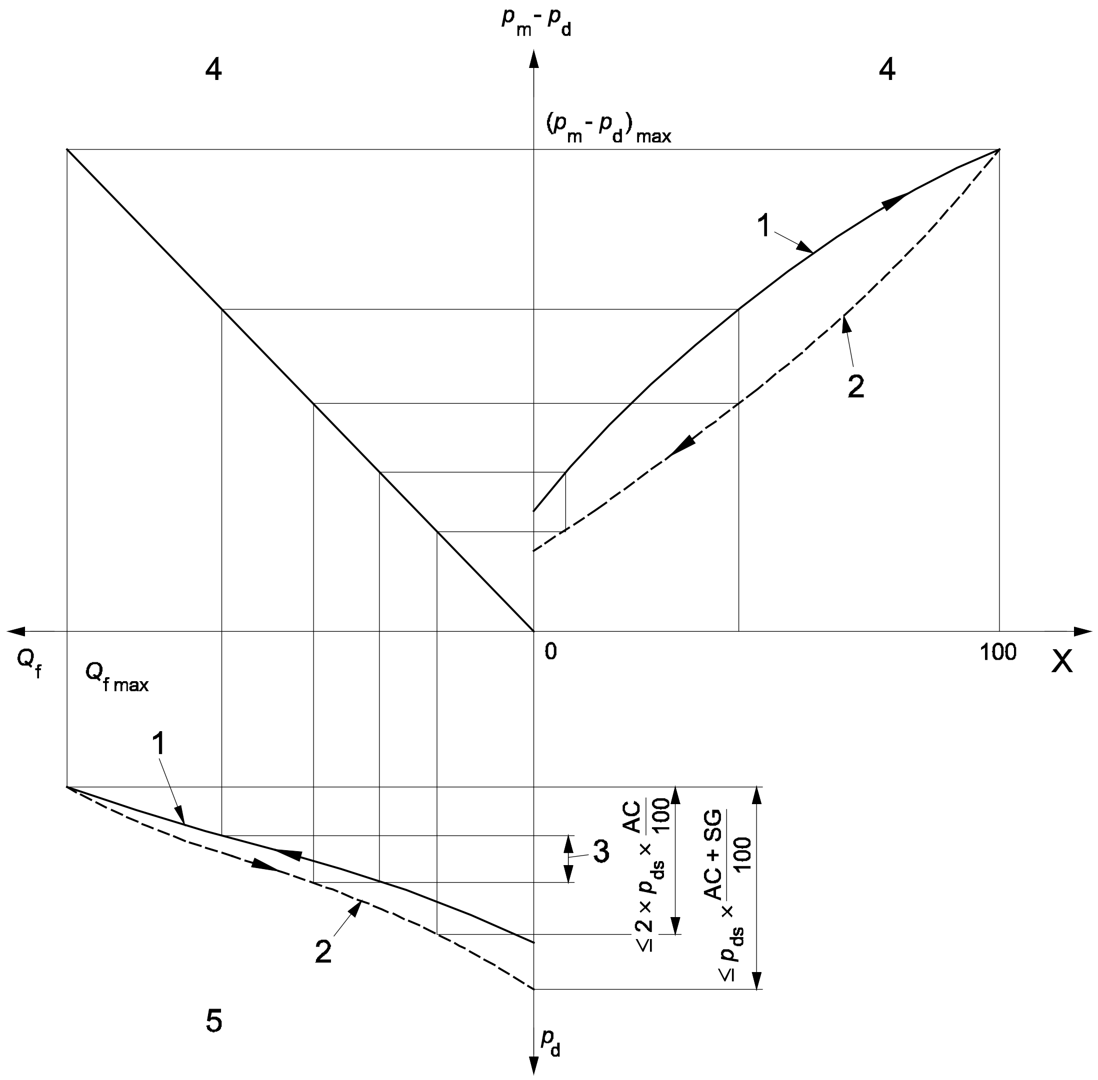
2 process line

3 sensing line

4 pilot

5 regulator

Figure A.3 — Functional diagram of a pilot controlled regulator



Key

X regulator travel in %

1 opening

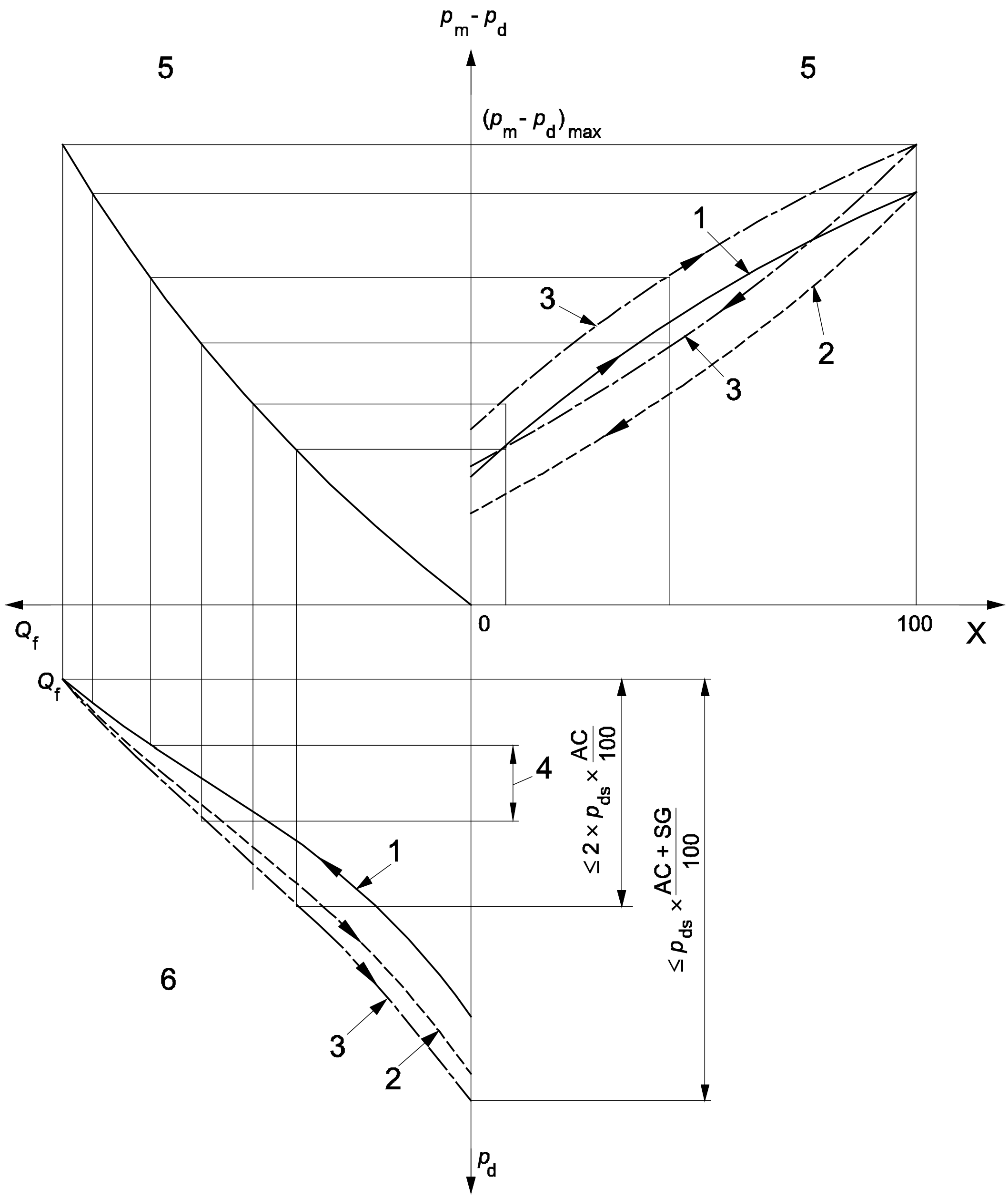
2 closing

3 hysteresis band

4 regulator

5 pilot

Figure A.4 — Graphs relating to the tests detailed in A.2 for a balanced pilot controlled regulator



Key

X regulator travel in %

1 opening

2 closing

3 corrected measured values to take account of unbalanced thrust

4 hysteresis band

5 regulator

6 pilot

Figure A.5 — Graphs relating to the tests detailed in A.2 for an unbalanced pilot controlled regulator

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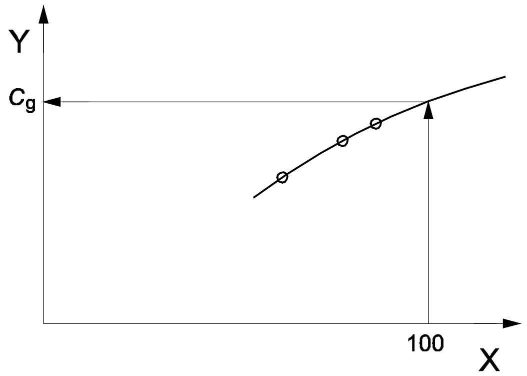


Key

X travel in %

Y C_{gx}

O measured values

Figure A.6 — Graph of C_g values plotted against different positions of the control member

Annex B
(informative)

Inspection certificate

The following gives an example of the format which may be used where an inspection certificate and declaration of compliance to this document is provided.

<table>
<tr><td>MANUFACTURER'S TRADE MARK/NAME</td><td colspan="4">Inspection certificate type 3.1 [a] according to EN 10204
Declaration of compliance according to EN ISO/IEC 17050-1</td><td>N° ________
Date ________</td></tr>
<tr><td>TYPE :
No.</td><td colspan="5">AUXILIARY DEVICES/SAFETY DEVICES
1: ... No... 2 : ... No. ... 3 : ... No....</td></tr>
<tr><td>END CONNECTIONS :</td><td colspan="2">DN
assembly drg.</td><td colspan="2">PN
overall dim. drg.</td><td>FACE-TO-FACE</td></tr>
<tr><td></td><td colspan="2">PRESSURE BEARING PARTS</td><td colspan="2">MATERIALS</td><td rowspan="3"></td></tr>
<tr><td>REGULATOR</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>AUXILIARY DEVICES</td><td colspan="2">1 ......
2 ......
3 ......</td><td colspan="2"></td></tr>
<tr><td colspan="6">FUNCTIONAL CHARACTERISTICS</td></tr>
<tr><td>REGULATOR</td><td colspan="2">Maximum allowable pressure PS ________ bar

Inlet pressure range bpu __ to __ bar
Specific set range Wds __ to __ bar
Temperature class ________
Pilot feeding pressure [b] pup ________ bar
Motorization pressure [b] pm ________ bar
Valve seat diameter [b] ________ mm
Max operating press. of chamber
safeguarded in diff. strength reg.[b] pmax ______ bar
Specific max. allowable press. of</td><td>SAFETY DEVICE [b]</td><td colspan="2">Functional characteristics of built-in safety devices according to the relevant document</td></tr>
</table>

	chamber in diff. strength regulatorb) Creep relief devices:b) – opening pressure	PSD _______ bar pdo _______ bar		

Settings: regulator _____bar auxiliary devices _____bar safety device max. ____bar min. ____bar

CLASS OF: maximum inlet pressure p_{umax} ______ accuracy AC ______

lock-up pressure SG _______ lock-up pressure zone SZ leakage class in accordance with EN 1349 [c] _______

TESTS	Strength test Body and inner metallic partition walls: 1,5 PS (min PS + 2) _______bar Casing of actuator _____bar Auxiliary devices ______bar External tightness test Body 1,1 PS _______bar Casing of actuator _____bar Auxiliary devices ______bar Setting, lock-up pressure at p_{umax}/p_{umin} ______/______bar Internal sealing at 1,1 x PS ________bar setting of : ______ at _____ bar ______at ______ bar ______at ______ bar Opening pressure of creep relief device _________ bar

The above-described product(s) is(are) in compliance with EN 334.

SIGNATURE OF THE PERSON RESPONSIBLE FOR THE TESTS	SIGNATURE OF THE PERSON AUTHORIZED BY THE MANUFACTURER	SIGNATURE OF THE INSPECTOR OR PERSON AUTHORIZED BY THE CUSTOMER [a] (for witnessing the acceptance test only)

a) Type 3.2 when the certificate is signed by the person authorized by the customer.

b) For pilot operated regulators only

c) When leakage class is specified in the order specification.

Annex C
(informative)

Acceptance test

Acceptance tests and verifications are carried out on the finished regulators by the manufacturer in the presence of the purchaser's inspector before shipping, if specified in the order specification.

The tests are:

— dimensional check and visual inspection in accordance with 7.7.1;

— material check in accordance with 7.7.2;

— external tightness test in accordance with 7.7.7;

— check of internal sealing, setting and lock-up pressure class in accordance with 7.7.9.3.

Unless otherwise specified, the number of regulators selected for an acceptance test shall be as follows:

— 2 regulators for batches of 2 to 4 pieces;

— 3 regulators for batches of 5 to 8 pieces;

— 4 regulators for batches of 9 to 20 pieces;

— 5 regulators for batches of 21 to 30 pieces;

— 6 regulators for batches of 31 to 60 pieces;

— 10 % [17] or batches > 60 pieces.

Additional tests, if required, may be specified in the order specification.

[17] Rounded up to a whole number.

Annex D
(informative)

Compliance evaluation [18)]

D.1 General

For regulators certified as in compliance with this document, the manufacturer shall carry out the compliance evaluation in accordance with D.4.

The evaluation of compliance with this document includes the conformity assessment to European legislation on pressure equipment according to requirement of clauses in Annex ZA.

D.2 Introduction

The compliance certification scheme shall meet the requirements of this document and establish:

— if the production surveillance in accordance with 7.6 may be carried out by the body, if any, that has certified the quality management system of the manufacturer;

— a guideline to be followed when any non-conformities are discovered during the production surveillance as detailed in 7.6.

It is also recommended to establish the certificate of compliance in accordance with Clause 5.10 of EN ISO/IEC 17025:2005.

D.3 Procedure

The evaluation of compliance shall include:

— the type test in accordance with 7.3; the tests samples shall be selected as detailed in 7.4;

— a production surveillance as detailed in 7.6 every five years; the test samples shall include two regulators for each certified series and they shall be selected at random from the production population present at the time of the production surveillance visit to the manufacturer's premises.

The production surveillance may be carried out by the body, if any, that has certified the quality management system of manufacturer, if it is provided for in the certification scheme for regulators.

Any other verification related to the quality management system of the manufacturer shall be carried out by the body, if any, that has certified the quality management system.

D.4 Manufacturer's compliance evaluation

For each series of regulators the manufacturer shall carry out:

— the tests as detailed in Clause 7;

— a permanent internal control of production using a quality management system certified by a third party.

18) For the purpose of these recommendations, the definitions contained in EN 45020 are applied

Furthermore, the manufacturer shall retain and file:

— the material certificates for all pressure bearing parts;

— the NDT reports and the inspection certificate;

for a period of at least 10 years from the delivery of the regulator.

A copy of these certificates shall be made available to the purchaser if requested in the order specification.

D.5 Issue of the certificate of compliance

If the series of regulators complies with this document a “certificate of compliance” may be issued.

Annex E
(normative)

Creep (venting) relief device

E.1 General

A creep relief device can be built in into a spring operated regulator to vent gas to the atmosphere when the controlled pressure is higher than lock-up pressure of regulators with a limited capacity.

The creep relief device is built into the regulator when requested in order specification.

E.2 Terms and definitions

E.2.1
opening pressure
$\boldsymbol{p}_{\mathbf{do}}$
pressure at which the first internal leak occurs

E.2.2
closing pressure
$\boldsymbol{p}_{\mathbf{df}}$
falling pressure at which the relief valve is pressure tight after re-seating

E.3 Requirements

E.3.1 Construction

The creep relief device is normally integrated in the actuator. The connection for exhaust line shall be at least DN 10.

The design in accordance with this annex meets the requirements in 4.1.2.

E.3.2 Functional requirements

The set point shall be higher than lock-up pressure of the regulator.

The opening pressure and the closing pressure shall meet following requirements: both p_{do} and p_{df} shall be greater than or equal to p_{f}.

E.4 Testing

Separate external pressure sources are connected to the inlet and outlet of the regulator and the inlet is pressurized to the maximum value.

The pressure applied to the outlet is increased at a rate of change not greater than 1,5 % of the selected set pressure (of regulator) per second until the first internal leak of creep relief valve is reached. Under these conditions the first appearance of leakage is considered as the opening pressure.

The outlet pressure is lowered until the creep relief valve is closed and the internal sealing and p_{df} are verified.

E.5 Type test

The above mentioned requirements shall be verified.

E.6 Routine tests

The opening and closing pressure shall be verified.

E.7 Documentation

When the regulator is equipped with a creep relief device this device shall be mentioned in the test report.

E.8 Marking

The marking of the regulator shall include also p_{do}.

Annex F
(informative)

Order specification

F.1 General

This annex gives guidelines on the form that an order specification should take.

The ordering of gas pressure regulators, particularly for larger sizes, depends on the site conditions, other regulators already in the grid, inter-changeability and other factors. Therefore, in addition to the minimum specifications in tenders, offers and orders other specifications as detailed in G.2 may also be required.

F.2 Minimum specifications

F.2.1 Details of construction

— direct acting/pilot controlled;

— fail close/fail open;

— integral strength/differential strength;

— built-in safety devices;

— built-in creep relief device;

— built-in vent limiter,

— built-in monitor;

— additional features;

— type of end connections.

F.2.2 Dimensions

— regulator size (see 3.1.7);

— nominal pressure PN;

— face-to-face dimension.

F.2.3 Performance

— inlet pressure range b_{pu};

— allowable pressure PS;

— set range or set point $W_d/W_{ds}/p_{ds}$ (for regulator and monitor);

— set range or set point W_{dso}/W_{dsu}/p_{dso} /p_{dsu} (for safety device);

— opening pressure p_{do} (for creep relief device);

— maximum accuracy flow rate and minimum flow rate (at stable conditions and specified inlet pressures) $Q_{nmax,pumin}$/$Q_{nmin,pumax}$;

— temperature class 1 or temperature class 2.

F.3 Optional specifications

— lifting facilities;

— sealing of adjusting devices;

— external visual device for the position of control member of monitor,

— minimum values of flow coefficients and factors;

— accuracy class AC (for regulator);

— accuracy group AG (for safety device);

— maximum hysteresis band;

— lock-up class/lock-up pressure zone SG/SZ;

— minimum operating differential pressure Δp_{min};

— leakage class in accordance with EN 1349 (reference to Clause 7.7.9.3);

— additional marking;

— sound pressure level LpA;

— likely spectral distribution in octave bands;

— the calculation method for sound emission and likely spectral distribution in octave bands of the noise level with centre frequencies of 500 Hz through to 8 000 Hz;

— maximum flow from creep relief device;

— acceptance test in accordance with Annex C;

— copy(ies) of various certificates;

— full tests using a test rig in accordance with 7.7.9.4.6 instead of any alternative methods;

— alternative test methods in accordance with Annex A instead of those detailed in 7.7.9.4.5;

— inspection certificate;

— NDT certificate;

— material certificate type in accordance with EN 10204 for pressure bearing parts;

- material certificate type in accordance with EN 10204 for bolts, screws and studs;
- languages for manual accepted by the user.

Annex G
(informative)

Materials

G.1 Steel materials for pressure bearing parts and inner metallic partition walls

The steel materials listed in Table G.1 with the restrictions listed in the last 5 columns of the same table, are suitable for the design of pressure bearing parts and inner metallic partition walls of regulators complying with this European Standard.

Table G.1 — Steel materials for pressure bearing parts and inner metallic partition walls

Materials				Restrictions				
				Regulator				
Group	Type	Relevant document		Operating temperature		PS_{max}	$[PS \times DN^{b}]_{max}$	DN_{max} [b]
				-10 °C to 60 °C [a]	-20 °C to 60 °C	bar	bar x mm	mm
Pressure bearing parts and inner metallic partition walls								
Rolled and forged steel	S235JR / 1.0037 with thickness ≤ 40 mm, S275JR / 1.0044 with thickness ≥ 1,5 mm, S355JR/ 1.0045 with thickness ≥ 1,5 mm	EN	EN 10025-1:2004 EN 10025-2:2004/AC: 2005 EN 10025-3:2004 EN 10025-4:2004 EN 10025-5:2004	x		100	-	-

Materials			Restrictions				
			Regulator				
Group	Type	Relevant document	Operating temperature		PS_{max}	[PS xDN [b]]$_{max}$	DN_{max} [b]
			-10 °C to 60 °C [a]	-20 °C to 60 °C	bar	bar x mm	mm
Pressure bearing parts and inner metallic partition walls							
	S235J2G3 / 1.0116 and S235J2G4 / 1.0117 both with 1 mm < nominal thickness ≤ 150 mm, S275J2G3 / 1.0144 and S275J2G4 / 1.0145 and S355J2G3 / 1.0570 all with 2,5 mm < nominal thickness ≤ 150 mm	EN 10025-6:2004+A1:2009		x			
	S275JO / 1.0143 and S355JO / 1.0553 both with 1,5 mm < nominal thickness ≤ 250 mm and supplementary requirements KV 27 J av. Of three and 20 J min at –20 °C						

Materials			Restrictions				
			Regulator				
Group	Type	Relevant document	Operating temperature		PS_{max}	[PS xDN [b]]$_{max}$	DN_{max} [b]
			-10 °C to 60 °C [a]	-20 °C to 60 °C	bar	bar x mm	mm
Pressure bearing parts and inner metallic partition walls							
	P235GH / 1.0345, P265GH / 1.0425, P295GH/ 1.0481, P355GH / 1.0473 all with product thickness ≤ 150 mm	EN 10028-2:2017 [c]	x				
	P275NH / 1.0487, P355NH / 1.0565 with thickness ≤ 150 mm, P355NL1 / 1.0566 with 5 mm ≤ product thickness ≤ 150 mm	EN 10028-3:2017 [c]		x			
	All types	EN 10028-4:2017, EN 10028-5:2017 [c]		x			
	All grades from P355 to P 500 with product thickness ≤ 150 mm	EN 10028-6:2017 [c]		x			

Materials				**Restrictions**				
				Regulator				
Group	**Type**	**Relevant document**		**Operating temperature**		**PS_{max}**	**[PS xDN [b]]$_{max}$**	**DN_{max} [b]**
				-10 °C to 60 °C [a]	**-20 °C to 60 °C**	**bar**	**bar x mm**	**mm**
Pressure bearing parts and inner metallic partition walls								
	All austenitic steel designation, other steel designation with Amin ≥ 16 % and impact properties at temperatures < –20 °C		EN 10028-7:2016 [c]		x			

Materials				Restrictions				
				Regulator				
Group	Type	Relevant document		Operating temperature		PS_{max}	[PS xDN [b]]$_{max}$	DN_{max} [b]
				-10 °C to 60 °C [a]	-20 °C to 60 °C	bar	bar x mm	mm
Pressure bearing parts and inner metallic partition walls								
Rolled and forged steel	25 CrMo4 / 1.7218 and 25CrMoS4 / 1.7213 both with 100 mm < d ≤ 160 mm or 60 mm < t ≤ 100 mm, 36CrNiMo4 / 1.6511 and 39NiCrMo3/1.6510 with supplementary requirements Amin = 16 %. All types shall be quenched and tempered (+QT) and with supplementary requirements for cast analysis C ≤ 0,25 % or, when 0,25 % < C ≤ 0,40, Ni ≥ 1 %	EN	EN 10083-1:2006	x		100	-	-

Materials				Restrictions				
				Regulator				
Group	Type	Relevant document		Operating temperature		PS_{max}	[PS xDN [b]]$_{max}$	DN_{max} [b]
				-10 °C to 60 °C [a]	-20 °C to 60 °C	bar	bar x mm	mm
Pressure bearing parts and inner metallic partition walls								
	36CrNiMo4 / 1.6511 and 39NiCrMo3/1.6510 quenched and tempered (+QT) with supplementary requirements Amin = 16 % and KV 27 J av. Of three and 20 J min. at –20 °C				x			
	Steel designations quenched and tempered (+QT) with Amin ≥ 16 % and with supplementary requirements for cast analysis C ≤ 0,25 %.		EN 10083-2:2006	x				

Materials				**Restrictions**				
Group	**Type**	**Relevant document**		**Regulator**				
				Operating temperature		**PS_{max}**	**$[PS \times DN^{b}]_{max}$**	**DN_{max} [b]**
				-10 °C to 60 °C [a]	**-20 °C to 60 °C**	**bar**	**bar x mm**	**mm**
Pressure bearing parts and inner metallic partition walls								
	All austenitic steel designations, other steel designations with longitudinal Amin ≥ 16 % and supplementary requirements KV 27 J av. Of three and 20 J min. at −20 °C		EN 10088-3:2014		x			
	DD11 / 1.0332, DD12 /1.0398, DD13 / 1.0335		EN 10111:2008	x				
	All steel designations used for skin-pass		EN 10130:2006	x				
	S275J2H, S355J2H		EN 10210-1:2006		x			
	P195TR2 / 1.0108, P235TR2 / 1.0255, P265TR2 / 1.0259		EN 10216-1:2013 [c]	x				

Materials				**Restrictions**				
				Regulator				
Group	**Type**	**Relevant document**		**Operating temperature**		**PS$_{max}$**	**[PS xDN [b]]$_{max}$**	**DN$_{max}$ [b]**
				-10 °C to 60 °C [a]	**-20 °C to 60 °C**	**bar**	**bar x mm**	**mm**
Pressure bearing parts and inner metallic partition walls								
	P195TR2 / 1.0108, P235TR2 / 1.0255, P265TR2 / 1.0259 with supplementary requirements KV 27 J av. Of three and 20 J min. at –20 °C				x			
	All steel designations with Amin ≥ 16 % and supplementary requirements KV 27 J av. Of three and 20 J min at –20 °C	EN	EN 10222-2:1999/AC:2000 [c]		x	100	-	-

Materials			Restrictions				
			Regulator				
Group	Type	Relevant document	Operating temperature		PS_{max}	[PS xDN [b]]$_{max}$	DN_{max} [b]
			-10 °C to 60 °C [a]	-20 °C to 60 °C	bar	bar x mm	mm
Pressure bearing parts and inner metallic partition walls							
Rolled and forged steel	All steel designations	EN 10222-3:2017 [c]		x			
	All steel designations	EN 10222-4:2017[c]		x			
	All steel designations martensitic type	EN 10222-5:2017[c]	x				
	All steel designations austenitic type, other steel types with Amin ≥ 16 % and supplementary requirements KV 27 J av. Of three and 20 J min. at –20 °C			x			
	All steel designations with longitudinal Amin ≥ 16 % and with supplementary requirements for cast analysis C ≤ 0,25 %	EN 10250-2:1999	x				
	S235J2G3 / 1.0116, S355J2G3 / 1.0570 with tR ≤ 500 mm			x			

Materials			Restrictions				
			Regulator				
Group	Type	Relevant document	Operating temperature		PS_{max}	[PS xDN [b]]$_{max}$	DN_{max} [b]
			-10 °C to 60 °C [a]	-20 °C to 60 °C	bar	bar x mm	mm
Pressure bearing parts and inner metallic partition walls							
	All steel designations with Amin ≥ 16 %	EN 10250-4:1999	x				
	All austenitic grades			x			
	All steel designations of austenitic steels, other steel designations with Amin ≥ 16 % and supplementary requirements KV 27 J av. Of three and 20 J min at −20 °C	EN 10272:2016 [c]		x			
	E235 / 1.0308, E275 / 1.0225, E315 / 1.0236, E355 / 1.0580	EN 10297-1:2003	x				
	E275K2 / 1.0456, E355K2 / 1.0920, E420J2 / 1.0599, E460K2 / 1.8891			x			

Materials				Restrictions				
				Regulator				
Group	Type	Relevant document		Operating temperature		PS_{max}	[PS xDN [b]]$_{max}$	DN_{max} [b]
				-10 °C to 60 °C [a]	-20 °C to 60 °C	bar	bar x mm	mm
Pressure bearing parts and inner metallic partition walls								
Rolled and forged steel	A 105M with supplementary requirement for chemical composition: C ≤ 0,25 %, A 105N (normalized) with hardness between 137HB to 187HB (supplementary requirements S1 and S2.4)	ASTM	ASTM A 105/A105M:2014	x		100	-	-
	A 106 grade A, A 106 grade B with supplementary requirement for chemical composition: C ≤ 0,25 % or hardness ≤ 187 HB		ASTM A 106/A 106M:2014	x				

Materials			Restrictions				
			Regulator				
Group	Type	Relevant document	Operating temperature		PS_{max}	[PS xDN [b]]$_{max}$	DN_{max} [b]
			-10 °C to 60 °C [a]	-20 °C to 60 °C	bar	bar x mm	mm
Pressure bearing parts and inner metallic partition walls							
	A 106 grade B with supplementary requirements KV 27 J av. Of three and 20 J min. at –20 °C			x			
	Types F5a/F6a class 2 with supplementary requirements KV 27 J av. Of three and 20 J min. at –20°C, types F304 and F316	ASTM A 182/A 182M:2015		x			
	A 234M grade WP1 with supplementary requirement for chemical composition: C ≤ 0,25 % and all remaining grades except the grades WPB and WPC	ASTM A 234/A 234M:2014	x				

Materials			Restrictions				
			Regulator				
Group	Type	Relevant document	Operating temperature		PS_{max}	[PS xDN [b]]$_{max}$	DN_{max} [b]
			-10 °C to 60 °C [a]	-20 °C to 60 °C	bar	bar x mm	mm
Pressure bearing parts and inner metallic partition walls							
	All austenitic types, all other grades with Amin ≥ 16 % and supplementary requirement KV 27 J av. Of three and 20 J min. at –20 °C	ASTM A 240:2015		x			
	A 266 grade 4 with supplementary requirement for chemical composition: C ≤ 0,25 %	ASTM A 266A/ 266M:2013	x				
	A 276 all austenitic grades	ASTM A 276:2015		x			

Materials				Restrictions				
				Regulator				
Group	Type	Relevant document		Operating temperature		PS_{max}	[PS xDN [b]]$_{max}$	DN_{max} [b]
				-10 °C to 60 °C [a]	-20 °C to 60 °C	bar	bar x mm	mm
Pressure bearing parts and inner metallic partition walls								
	A 311 grade 1018 with diameter, thickness, or distance between parallel faces up to 30 mm incl. and with supplementary requirement s KV 27 J av. Of three and 20 J min. at −20 °C	ASTM	ASTM A 311/A 311M:2004 (2015)		x	100	-	-
	A 333M all grades		ASTM A 333/A 333M:2013		x			
	A 350M LF2 class 1, LF3, LF5 classes 1 and 2, LF6 class 1 and 2, LF9, LF787 classes 2 and 3		ASTM A 350/A 350M:2015		x			
	A 420M all grades		ASTM A 420/A 420M:2014		x			
	A 516 all grades with KV 27 J av. Of three and 20 J min. at −20°C (supplementary requirement S5)		ASTM A 516/A 516M:2010		x			

Materials			Restrictions				
			Regulator				
Group	Type	Relevant document	Operating temperature		PS_{max}	[PS xDN [b]]$_{max}$	DN_{max} [b]
			-10 °C to 60 °C [a]	-20 °C to 60 °C	bar	bar x mm	mm
Pressure bearing parts and inner metallic partition walls							
Rolled and forged steel	A 564 H1075 with supplementary requirements Amin ≥ 16 % and KV 27 J av. Of three and 20 J min. at −20°C, A 564 T630 H1150 and H1150M with supplementary requirements KV 27 J av. Of three and 20 J min. at −20°C	ASTM A 564/ 564M:2013		x			
	A 694 all grades with supplementary requirement for chemical composition: C ≤ 0,25 %	ASTM A 694/ A694M:2014	x				
	A 694 Gr F60 with supplementary requirement KV 27 J av. Of three and 20 J min at −20 °C			x			

Materials			Restrictions				
			Regulator				
Group	Type	Relevant document	Operating temperature		PS_{max}	[PS xDN [b]]$_{max}$	DN_{max} [b]
			-10 °C to 60 °C [a]	-20 °C to 60 °C	bar	bar x mm	mm
Pressure bearing parts and inner metallic partition walls							
	A 707M all grades from L2 to L8 and all classes	ASTM A 707/A 707M:2014		x			
Cast steel	All cast steel designations	EN 10213-3:2007+A1:2016		x	100	-	-
	All cast steel designations	EN 10293:2015	x				
	A 216M grades WCA and WCC, A 216M grade WCB with supplementary requirement for chemical composition C ≤ 0,25 % or hardness ≤ 187HB	ASTM A 216/A 216M:2014	x				

Materials			Restrictions				
			Regulator				
Group	Type	Relevant document	Operating temperature		PS_{max}	[PS xDN [b]]$_{max}$	DN_{max} [b]
			-10 °C to 60 °C [a]	-20 °C to 60 °C	bar	bar x mm	mm
Pressure bearing parts and inner metallic partition walls							
	A 216M WCB with supplementary requirement KV 27 J av. And 20 J min at –20°C			x			
	A 217 all grades	ASTM A 217/A 217M:2014	x				
	A 217 grade CA15 with supplementary requirements KV 27 J av. Of three and 20 J min at –20 °C			x			
	All austenitic types, all other grades with supplementary requirements A ≥ 16 % and KV 27 J av. Of three and 20 J min at –20 °C	ASTM A 351/A 351M:2014		x			
	A 352M all grades	ASTM A 352/A 352M:2006 (2012)		x			
	A 426 all grades	ASTM A 426:2013	x				

Materials			Restrictions				
			Regulator				
Group	Type	Relevant document	Operating temperature		PS_{max}	[PS xDN [b]]$_{max}$	DN_{max} [b]
			-10 °C to 60 °C [a]	-20 °C to 60 °C	bar	bar x mm	mm
Pressure bearing parts and inner metallic partition walls							
	A 426 grade CPCA15 with KV 27 J av. Of three and 20 J min at –20 °C (supplementary requirement S 11)			x			
	A 451 all grades	ASTM A 451:2014		x			
	17–4ph H1100 with supplementary requirements Amin ≥ 15 % and KV 27 J av. Of three and 20 J min at −20° C	AMS5355:2015 (Aerospace Material Specification)		x			
The following remarks shall be applied to all sheets of this table							
a These material can be used for operating temperature from −20 °C to 60 °C when PS ≤ 25 bar. b Body inlet nominal size has to be considered; for the bodies of any pilot and auxiliary device this term shall refer to their inlet connections. c Harmonized supporting standard to PED at the time of writing.							

G.2 Metallic materials different from steel materials for pressure bearing parts and inner metallic partition walls

The metallic materials listed in Table G.2 with the restrictions listed in the last 5 columns of the same table, are suitable for the design of pressure bearing parts and inner metallic partition walls of regulators complying with this European Standard.

Table G.2 — Metallic materials different from steel materials for pressure bearing parts and inner metallic partition walls

Materials			Restrictions				
			Regulator				
Group	Type	Relevant document	Operating temperature		PS_{max}	[PS xDN [b]]$_{max}$	DN_{max} [b]
			-10 °C to 60 °C [a]	-20 °C to 60 °C	bar	bar x mm	mm
Pressure bearing parts and inner metallic partition walls							
Spheroidal graphite cast iron	EN-GJS400–18 / EN-JS1020, EN-GJS400–18-LT / EN-JS1025, EN-GJS400–15 / EN-JS1030, EN-GJS 400-18U-LT / EN-JS1049	EN 1563:2018		x	20	1 500	1 000
	A 395M	ASTM A 395/A 395M:1999 (2014)		x			
	A 536 Grades 60–40–18 and 65–45–12	ASTM A 536:1984 (2014)		x			
	A 874M	ASTM A 874/A 874M:1998 (2014)		x			
	400–15/S, 400–18/S, 500–7/S	ISO 1083:2018		x			
	EN-GJS400–18-LT / EN-JS1025, EN-GJS-400–18U-LT / EN-JS1049 with wall thickness ≤ 60 mm	EN 1563:2018		x	50	5 000	300
	EN-GJS400–15 / EN-JS1030, EN-GJS-400–18U-RT / EN-JS1059 with wall thickness ≤ 60 mm		x				
	EN-GJS400–18 / EN-JS1020		x				
	400–18LT/S	ISO 1083:2018		x			
	400–15/S, 400–18/S		x				
	A 395M	ASTM A395/A 395M:1999 (2014)	x				

Materials			Restrictions				
			Regulator				
Group	Type	Relevant document	Operating temperature		PS_{max}	[PS xDN [b]]$_{max}$	DN_{max} [b]
			-10 °C to 60 °C [a]	-20 °C to 60 °C	bar	bar x mm	mm
Pressure bearing parts and inner metallic partition walls							
	A 536 Grade 60–40–18	ASTM A 536:1984 (2014)	x				
Malleable cast iron	Grades 60–40–18, 65–45–12 and 80–55–06	ASTM A 536:1984(2014		x	20	1 000	100
Copper-zinc wrought alloys	All material designations with A ≥ 15 %	EN 1652:1997/AC:2003		x	100	-	25
	All material designations with A ≥ 15 %	EN 12164:2016		x			
	All material designations with A ≥ 15 %	EN 12165:2016		x			
	ASTM B 283 — UNS No C 37700 and 64200	ASTM B 283:2014		x			
	P-Cu Zn 37 all denominations with A ≥ 15 %	UNI 4892:1962 (withdrawn without replacement)		x			
	P-Cu Zn 33 all denominations with A ≥ 15 %	UNI 4894:1962 (withdrawn without replacement)		x			
	P-Cu Zn 40 Pb 2 all denominations with A ≥ 15 %	UNI 5705:1965 (withdrawn without replacement)		x			
Copper-tin and copper-zinc cast alloys	All material designations with A ≥ 15 %	EN 1652:1997/AC:2003		x	20	1 000	100
	Cu Sn5Zn5Pb5-B (CB491K) and CuSn5Zn5Pb5-C (CC491K)	EN 1982:2017 [c]		x			
	All material designations with A ≥ 5 %	EN 12844:1988		x			
	ASTM B 584 all UNS nos with elongation ≥ 15 %	ASTM B 584:2014		x	100	-	25

Materials			Restrictions				
			Regulator				
Group	Type	Relevant document	Operating temperature		PS_{max}	[PS xDN [b]]$_{max}$	DN_{max} [b]
			-10 °C to 60 °C [a]	-20 °C to 60 °C	bar	bar x mm	mm
Pressure bearing parts and inner metallic partition walls							
Aluminium wrought alloys	All metallurgic state and thickness for which Amin ≥ 4 %	EN 485-2:2016+A1:2018		x	20	-	50
	All metallurgic state and dimensions for which Amin ≥ 4 %	EN 586-2:1994		x			
		EN 754-2:2016		x			
	All metallurgic state and thickness for which Amin ≥ 4 %	EN 755-2:2016		x			
Aluminium wrought alloys	Al 99,5	UNI 9001-2:1988 (withdrawn without replacement)		x	20	-	50
	Al Cu 5.5 Pb 0,4 Bi 0,4	UNI 9002-5:1988 (withdrawn without replacement)		x			
	Al Si 1 Mg 0,9 Mn 0,7 (6082) in T6 conditions	UNI 9006-4:1987 (withdrawn without replacement)		x			
	Al Mg 1 Si 0,6 Cu 0,28 Cr 0,20 (6061) in T6 conditions	UNI 9006-2:1988 (withdrawn without replacement)		x			
	All metallurgic state and thickness for which Amin ≥ 7 %	EN 485-2:2016+A1:2018		x	50	-	50
	All metallurgic state and dimensions for which Amin ≥ 7 %	EN 586-2:1994		x			
		EN 754-2:2016		x			

Materials			Restrictions				
			Regulator				
Group	Type	Relevant document	Operating temperature		PS_{max}	[PS xDN [b]]$_{max}$	DN_{max} [b]
			-10 °C to 60 °C [a]	-20 °C to 60 °C	bar	bar x mm	mm
Pressure bearing parts and inner metallic partition walls							
	All metallurgic state and thickness for which Amin ≥ 7 %	EN 755-2:2016		x			
	EN AW-6082	EN 573-3:2013 and EN 755-2:2016		x			
	Al Mg 0,5 Si 0,4 Fe 0,2 (6060) in T6 conditions	UNI 9006-1:1988 (withdrawn without replacement)		x			
	Al Mg 1 Si 0,6 Cu 0,28 Cr 0,20 (6061) in T6 conditions with thicknesses / diameters range for which A ≥ 7 %	UNI 9006-2:1988 (withdrawn without replacement)		x			
	Al Si 1 Mg 0,9 Mn 0,7 (6082) in T6 conditions with thicknesses / diameters range for which A ≥ 7 %	UNI 9006-4:1987 (withdrawn without replacement)		x			
	All metallurgic state and thickness for which Amin ≥ 7 %	EN 485-2:2016+A1:2018		x	100	-	25
	All metallurgic state and dimensions for which Amin ≥ 7 %	EN 586-2:1994		x			
		EN 754-2:2016		x			
Aluminium wrought alloys	All metallurgic state and dimensions for which Amin ≥ 7 %	EN 755-2:2016		x			
	Al Mg 0,5 Si 0,4 Fe 0,2 (6060) in T6 conditions	UNI 9006-1:1988 (withdrawn without replacement)		x			

Materials			Restrictions				
			Regulator				
Group	Type	Relevant document	Operating temperature		PS_{max}	[PS xDN [b]]$_{max}$	DN_{max} [b]
			-10 °C to 60 °C [a]	-20 °C to 60 °C	bar	bar x mm	mm
Pressure bearing parts and inner metallic partition walls							
	Al Mg 1 Si 0,6 Cu 0,28 Cr 0,20 (6061) in T6 conditions with thicknesses / diameters range for which A ≥ 7 %	UNI 9006-2:1988 (withdrawn without replacement)		x			
	Al Si 1 Mg 0,9 Mn 0,7 (6082) in T6 conditions with thicknesses / diameters range for which A ≥ 7 %	UNI 9006-4:1987 (withdrawn without replacement)		x			
Aluminium cast Alloys	All alloy designations with elongation ≥ 1,5 %	EN 1706:2010		x	10	250	150
	All alloy designations with elongation ≥ 1,5 %	ASTM B85:2014		x			
	All alloy designations with elongation ≥ 4 %	EN 1706:2010		x	20	1600	1000
	All alloy designations with elongation ≥ 4 %	ASTM B85:2014		x			

The following remarks shall be applied to all sheets of this table

a These material can be used for operating temperature from −20 °C to 60 °C when PS ≤ 25 bar.

b Body inlet nominal size has to be considered; for the bodies of any pilot and auxiliary device this term shall refer to their inlet connections.

c Harmonized supporting standard to PED at the time of writing.

G.3 Materials for auxiliary devices, integral process and sensing lines, threaded sealing plug, connectors and fasteners

The materials listed in the previous Tables G.1, G.2 and/or in the following Table G.3 with relevant restrictions are suitable for the design of auxiliary devices and threaded sealing plug. The materials listed in the following Table G.3 with relevant restrictions are suitable for the design of integral process and sensing lines connectors and fasteners of regulators complying with this document.

Table G.3 — Materials for auxiliary devices, integral process and sensing lines, connectors and fasteners

Materials			Restrictions				
Component	Type	Relevant document	Regulator				
			Operating temperature		PS_{max}	[PS xDN [b]]$_{max}$	DN_{max} [b]
			-10 °C to 60 °C	-20 °C to 60 °C	bar	bar x mm	mm
Auxiliary devices and threaded sealing plug							
Various	11SMn30 / 1.0715, 11SMn37 / 1.0736, 11SMnPb30 / 1.0718, 11SMnPb37 / 1.0737, 35S20 / 1.0726, 35SPb20 / 1.0756, 36SMn14 / 1.0764, 36SMnPb14 / 1.0765, 38SMn28 / 1.0760, 38SMnPb28 / 10761, 44SMn28 / 1.0762, 44SMnPb28 / 1.0763, 46SPb20 / 1.0757 all with thickness within the extreme limits specified by the document and supplementary requirement Amin ≥ 16 %	EN 10277–3:2008 [a]		x	100	-	25
Integral process and sensing lines							
Pipes	Cu 999	EN 1057:2006+A1:2010		x	25	-	-
	X6CrNiMoTi17–12–2 / 1.4571	EN 10088–1:2014		x	100	-	-
	E235 / 1.0308	EN 10305-1: 2016		x			
	X6 Cr Ni Ti 1810 / 1.4541	EN 12216-5: 2013		x			
	All grades	API specification 5L:2012+ERRATA 2015		x			
	All grades	ASTM A 106:2014		x			

Materials			Restrictions				
			Regulator				
Component	Type	Relevant document	Operating temperature		PS_{max}	[PS xDN [b]]$_{max}$	DN_{max} [b]
			-10 °C to 60 °C	-20 °C to 60 °C	bar	bar x mm	mm
	TP 304, TP 304L, TP 316, TP 316L	ASTM A 213/A 213M:2015		x			
	TP 304, TP 304L, TP 316, TP 316L	ASTM A 269:2014		x			
	TP 304	ASTM A 312/A 312M:2015		x			
	Grade 6	ASTM A 333/A 333M:2013		x			
	Screwed and socket steel tube	EN10255:2004 + A1:2007		x			
	P235 TR2/ 1.0255	EN 10216-2:2013		x			
Connectors							
Compression fittings	All steel designations with Amin ≥ 8 % and thickness within the relevant limits specified by the document	EN 10277-3:2003 [a]		x	100	-	-
	All steel designations	EN 10088-3:2014		x			
	All steel designations	ISO 8434 -1:2007 ISO 8434 -2:2007 ISO 8434 -3:2005 ISO 8434 -6:2009		x			

Materials			Restrictions				
Component	Type	Relevant document	Regulator				
			Operating temperature		PS_{max}	[PS xDN [b]]$_{max}$	DN_{max} [b]
			-10 °C to 60 °C	-20 °C to 60 °C	bar	bar x mm	mm
	All grades	ASTM A 420/A 420M:2016		x			
Fasteners							
Bolts, screws, studs, and nuts	Class 10.9 for bolts, screws and studs	EN ISO 898-1:2013		x	50	-	-
	Class 10 for nuts	EN ISO 898-2:2012		x			
	All alloy groups and types with Amin ≥ 9 % for bolts, screws and studs	ASTM F 593:2017		x			
	All austenitic designations	EN 10088-3:2014		x	100	-	-
	Class 4.6, 5.6, 8.8 for bolts, screws and studs	EN ISO 898-1:2013		x			
	Grade A1, A2, A3 and A4 for bolts, screws and studs	EN ISO 3506-1:2009		x			
	Classes.4, 5 and 8 for nuts	EN ISO 898-2:2012		x			
	Grade A1, A2, A3 and A4 for nuts	ISO 3506-2:2009		x			
Bolts, screws, studs, and nuts	C15 E as per EN 10084 and grade A1, A2, A3 and A4 as per EN ISO 3506-2 for eye-nuts as per DIN 582	EN 10084:2008 or EN ISO 3506-2:2009		x	100	-	-
	All grades	ASTM A 193/A 193M:2016		x			
	All grades for nuts	ASTM A 194/A 194M2017		x			
	All classes and grades	ASTM A 320/A 320M:2017		x			

Materials			Restrictions				
Component	**Type**	**Relevant document**	**Regulator**				
			Operating temperature		**PS_{max}**	**[PS xDN [b]]$_{max}$**	**DN_{max} [b]**
			-10 °C to 60 °C	**-20 °C to 60 °C**	**bar**	**bar x mm**	**mm**
	All alloy groups and types with Amin ≥ 12 % for bolts, screws and studs	ASTM F 593:2017		x			
	All alloy groups	ASTM F 594:2015		x			
	Grade 8 for bolts etc.	SAE J429:2014		x			
	Grade 8 for nuts	SAE J995:2017		x			

The following remarks shall be applied to all sheets of this table.

a Supporting standard for new approach directives.

b Body inlet nominal size has to be considered; for the bodies of any pilot and auxiliary device this term shall refer to their inlet connections.

G.4 Update to year 2017 on Metallic Material Standards used in the previous editions of this standard

Table G.4 — Update on Metallic Material Standards

Material Standard in Table G.1, G.2 and G.3 used in the previous editions of this standard	Status	Updated Material Standard used in this edition
EN 10025	Replaced by	EN 10025-1:2004 EN 10025-2:2004 EN 10025-2:2004/AC:2005 EN 10025-3:2004 EN 10025-4:2004 EN 10025-5:2004 EN 10025-6:2004+A1:2009
EN 10216-1	Replaced by	EN 10216-1:2013
EN 10213-3	Replaced by	EN 10213:2007+A1:2016
ISO 8434	Replaced by	ISO 8434-1:2007
BS 1387	Replaced by	EN 10255:2004+A1:2007
BS 1490	Replaced by	EN 1559-1:2011 EN 1559-5:2017 EN 1676:2010 EN 1706:2010
BS 1474	Replaced by	EN 573-3:2013 EN 755-2:2013 EN 755-3:2008 EN 755-4:2008 EN 755-6:2008 EN 755-7:2016 EN 755-8:2016 EN 755-9:2016 EN 12020-2:2016
DIN 1630	Replaced by	EN 10216-2:2013 (for material St 37.4/1.0255)
DIN 2391-2	Replaced by	EN 10305-1:2016
DIN 17458	Replaced by	EN 10216-5:2013
UNI 3158	Replaced by	EN 10293:2015
UNI 4892	Withdrawn without replacement	Following standards can be used like reference: EN 1652:1997/AC:2003
UNI 4894	Withdrawn without replacement	Following standard can be used like reference: EN 1652:1997/AC:2003

Material Standard in Table G.1, G.2 and G.3 used in the previous editions of this standard	**Status**	**Updated Material Standard used in this edition**
UNI 5705-65	Withdrawn without replacement	Following standards can be used like reference: EN 12164:2016, EN 12165:2016, EN 12167:2016, EN 12168:2016, EN 12420:2014
UNI 9001-2	Withdrawn without replacement	Following standards can be used like reference: EN 485-2:2016+A1:2018, EN 573-3:2013
UNI 9002-5	Withdrawn without replacement	Following standards can be used like reference: EN 754-2:2016, EN 755-2:2016, EN 573-3:2013
UNI 9006-1	Withdrawn without replacement	Following standards can be used like reference: EN 755-2:2016, EN 573-3:2013
UNI 9006-2	Withdrawn without replacement	Following standards can be used like reference: EN 755-2:2016, EN 573-3:2013
UNI 9006-4	Withdrawn without replacement	Following standards can be used like reference: EN 755-2:2016, EN 573-3:2013

Annex H
(informative)

Dynamic force calculation method

H.1 General

The dynamic force is given by the following formulae:

$$D = C_r \times A \times \rho_{ul} \times c_{ul}^2 \quad \text{(H.1)}$$

where:

- C_r is the dynamic factor determined as explained in H.2;
- A is the area in m² of control member exposed to the dynamic impact of flowing fluid calculated in appropriated way according to the specific design of the control member itself
- ρ_{ul} is the density in kg/m³ at inlet end connection of the fluid under volumetric flow rate $Q_{ul.}$ The volumetric flow rate $Q_{ul.}$is traced as explained hereinafter;
- c_{ul} is the velocity in m/s of fluid at the inlet end connection under volumetric flow rate Q_{ul} .

For monitors with variable mounting positions the most unfavourable case shall be considered.

In the Formula (13) the values of ρ_{ul} and of Q_{ul} are referred to the most critical operating conditions traced as follows.

$$\left(Q_{ul}^2 \times \rho_{ul}\right)_{max}$$

where

- Q_{ul} is the volumetric flow rate in m³/h at the inlet end connection at operating conditions (not at normal conditions),
- ρ_{ul} is the density in kg/m³ of the fluid at inlet end connection under volumetric flow rate Q_{ul}.

Both the values of Q_{ul} and that of ρ_{ul} shall be chosen from those declared by the manufacturer.

H.2 Test method for the determination of the dynamic factor *C*r

H.2.1 General

The following test method refers to Figure H.1:

a. assemble the monitor with all internal movable parts at their normal position for full open position and install it on a test rig in accordance with 7.7.9.4.6. The external movable parts are not necessary;

b. with the maximum possible test pressure, measure the force (T_{it}) on the stem for three different values of volumetric flow rate Q_{uti};

c. calculate the single dynamic factors for the three values of flow with:

$$C_{\text{ri}} = \frac{T_{\text{it}}}{A \times c_{\text{uti}}^2 \times \rho_{\text{uti}}}$$

where

T_{it} is the measured force on stem in N;

C_{uti} is the velocity in m/s of fluid at the inlet end connection under volumetric flow rate Q_{uti}

ρ_{uti} is the density in kg/m^3 of the fluid at inlet end connection under volumetric flow rate Q_{uti}

Q_{uti} is the value volumetric flow rate in m^3/h (not at normal conditions) chosen to carry out the test

d. calculate the dynamic factor of the monitor as arithmetic mean of above three single values with:

$$C_{\text{r}} = \frac{C_{\text{r1}} + C_{\text{r2}} + C_{\text{r3}}}{3}$$

H.2.2 Test method for the determination of the dynamic factor Cr for a series of monitor

Carry out the tests as in H.2.1 on a test sample of at least three sizes in the series; the sample shall include the smallest, the largest and the average sizes;

a. calculate the Reynolds number for each size of the test sample with:

$$\text{Re} = \frac{L_i \times c_{\text{uti}} \times \rho_{\text{uti}}}{\eta_{\text{t}}}$$

where

L_i is the max dimension of the control member perpendicular to the flowing fluid in m;

η_{t} is the viscosity of the test fluid in kg × s/m^2;

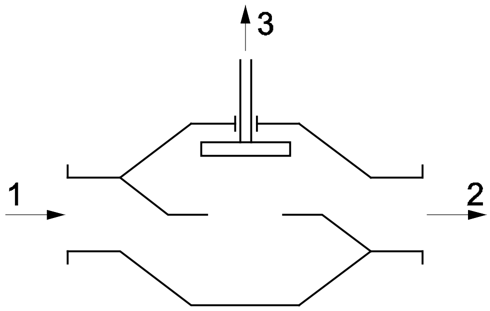
b. trace the curve Cr = f(Re) if the value of *C*r is found to vary with size;

c. calculate the Reynolds number at Q_{ul} for each size of regulator not included in the test sample with:

$$\text{Re} = \frac{L_i \times c_{\text{ul}} \times \rho_{\text{ul}}}{\eta_t}$$

d. extrapolate the value of C_{r} from the curve c for each size not included in the test sample using the relevant Reynolds number as calculated in H.2.2.c;

in case the curve *C*r = f(Re) does not vary with the size, the value of C_{r} is the same for all sizes.



Key

1 Inlet

2 Outlet

3 Load T_{it} (opposed to the closing of control member)

Figure H.1 — Model for dynamic force test method

Annex I
(normative)

Vent limiter

I.1 General

In the pressure regulating stations, according to the provisions available in some national legislation/regulation/practice, the piping of the temporary vented fuel gas to a safe area is not mandatory, under specified conditions, when the vented flow rate is not higher than specified values.

The function of the vent limiters is to limit to the established values the flow rate of fuel gas vented to the environment around the regulator from the chamber at atmospheric side of the pressure detecting element in case of its failures.

Vent limiter may be considered as a part of a regulator.

In the installation, operating and maintenance manual of the regulator the use of these vent limiters and the relevant functional performances shall be specified.

All functional requirements of the regulator shall be fulfilled when using a vent limiter.

The compliance evaluation to this EN of the regulator equipped with these devices also includes the use of such devices.

The vent limiter is built into the regulator when requested in order specification.

I.2 Scope

This annex specifies functional, testing and marking requirements of vent limiters incorporated in the regulators.

Other requirements (materials, strength, etc.) are those detailed in this EN.

I.3 Terms, symbols and definitions

I.3.1
vent limiter
unit with an automatic valve reacting on gas flow and/or pressure

I.3.2
vented flow rate
Q_v
flow rate vented to atmosphere via the vent limiter with any value of expected pressure inside the chamber at atmosphere side (in normal operating conditions) of the pressure detecting element

Note 1 to entry: The vented flow rate is expressed as air flow rate in l/h under normal conditions.

I.3.3
vented flow rate limit
Q_{vl}
maximum flow rate limited by the vent limiter with any value of expected pressure inside the chamber at atmosphere side (in normal operating conditions) of the pressure detecting element

Note 1 to entry: The maximum vented flow rate is expressed as air flow rate in litre/h under normal conditions.

I.4 Requirements

I.4.1 General requirements

The vent limiter shall be delivered as a unit with all components for the installation on the regulator.

It shall close automatically above the maximum vented flow rate specified in the installation, operating and maintenance manual.

The mounting position and the design of the vent limiter shall be such to avoid as far as possible ingress of dirt from outside and ingress of dropping water.

If the connection of the breather valve to the housing is with threaded type, there shall be a possibility to use standard tools for fastening.

I.4.2 Materials

The selection of materials shall comply with the requirements detailed in 4.2. Orifices limiting the vented flow shall be made of corrosion resistant material.

I.4.3 Strength

According to the strength classification chosen by the manufacturer, the requirements of the subclause 4.3.3 shall be fulfilled.

I.4.4 Functional requirements

The vent limiter shall be designed for the same operating temperature range of the regulator. All its functional requirements shall be fulfilled under this operating temperature range.

According to the installation conditions, different types of vent limiters can be designed with the following vented flow rate limits Q_{vl}:

— $Q_{vl} \leq 30$ l/h of air at normal conditions;

— $Q_{vl} \leq 70$ l/h of air at normal conditions;

— $Q_{vl} \leq 150$ l/h of air at normal conditions;

— $Q_{vl} \leq 319$ l/h of air at normal conditions.

These flow rates are the maximum rates under the following operating conditions:

— specified operating temperature range;

— all pressures up to maximum allowable pressure PS or specific maximum allowable pressure PSD;

— all mounting positions specified in the installation, operating and maintenance manual.

The vent limiter shall open automatically after the re-establishing of the pressure value at normal operating conditions and shall be ready to operate again.

I.5 Testing and acceptance criteria

I.5.1 General

The type test of the regulators that can be equipped with only one type of vent limiters shall be carried out with the regulators incorporating such vent limiter.

The type test of the regulators that can be equipped with different types of vent limiters shall be carried out with the regulators incorporating the vent limiter with smallest vented flow rate limit.

The verification of the vented flow rate limit Q_{vl} can be carried out on the vent limiter disassembled from the regulator according to the test method detailed in the following subclause.

I.5.2 Type test method

The vent limiter shall be installed in a suitable thermostatically controlled enclosure with:

— its inlet connection connected to pressure carrying pipe; and

— its outlet to a pipe at atmospheric pressure.

The installation shall further include a suitable low flow meter with maximum error of indication (5 %). The vent limiter shall be installed in the most critical position specified by the manufacturer.

The tests are carried out at the two temperature limits relevant to the temperature class of regulator.

The tests may be carried out either with air or with other gas.

Before starting the test, it shall be verified that the body of vent limiter is at the established temperature limit.

For each temperature limit the inlet pressure is slowly increased from atmospheric pressure until to reach first the maximum vented flow rate and subsequently the zero flow; than the pressure is slowly decreased to reach again first the maximum vented flow rate and subsequently a limited flow. The vented flow rate is continuously recorded as function of the inlet pressure.

The measured values of flow rate shall be converted into volumetric flow rate of air at normal conditions.

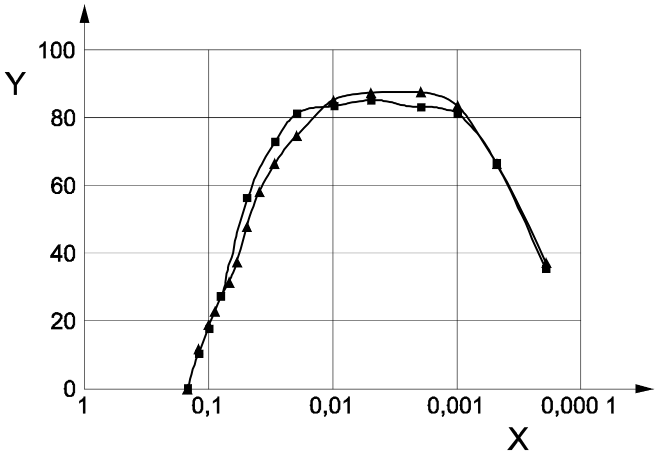
Following acceptance criteria shall be met:

— The maximum flow rate recorded during the increasing of the inlet pressure for both temperature limits shall not exceed the specified vented flow rate limit Q_{vl} and

— The maximum flow rate recorded during the decreasing of the inlet pressure for both temperature limits shall differ ≤ |10 %| from that found for the increasing of inlet pressure and

— The maximum recorded pressure shall be ≤ maximum allowable pressure PS or specific maximum allowable pressure PSD specified in the installation, operating and maintenance manual of the regulator.

The Figure I.1 shows an example of the performance curve of a vent limiter.



Key

X Inlet pressure/maximum allowable pressure

Y Q_v/Q_{vl}

—▲— Increasing inlet pressure

—■— Decreasing inlet pressure

Figure I.1 — Example of performance of a vent limiter

I.6 Documentation

When the regulator is or can be equipped with vent limiters, this shall be mentioned in the type test report detailing the smallest vented flow rate limit.

All technical data included in the name plate of vent limiter shall be repeated in the installation, operating and maintenance manual.

In the installation, operating and maintenance manual there shall be a special notification that, in case of painting works on the regulator, the breather hole of the vent limiter shall be protected against ingress of paint.

I.7 Specific marking on vent limiter

Each vent limiter shall carry at least following marking:

— manufacturer name and/or logo;

— operating temperature range;

— serial No.;

— maximum allowable pressure;

— vented flow rate limit Q_{vl}.

NOTE If the vent limiter is supplied as an integral part of the regulator, the marking can be limited to the vented flow rate limit Q_{vl}.

Annex J
(normative)

Elastomeric material

Table J.1 — Minimum characteristics of vulcanized rubbers used in manufacturing of rubber components

<table>
<tr><th rowspan="3">Characteristics of basic rubber materials</th><th colspan="4">Types of rubber components</th></tr>
<tr><th colspan="2">Diaphragms under normal operating conditions</th><th rowspan="2">Seat rings and other elastomeric components subjected to erosion by flowing gas</th><th rowspan="2">Other seals</th></tr>
<tr><th>Exposed to gas</th><th>With at least one side in communication to environmental conditions</th></tr>
<tr><td>Resistance to ageing</td><td colspan="2" rowspan="3">Test method and acceptance criteria as per Table J.2</td><td rowspan="3">Test method and acceptance criteria as per Table J.2</td><td rowspan="3">Test method and acceptance criteria as per Table J.2</td></tr>
<tr><td>Resistance to gas</td></tr>
<tr><td>Resistance to lubricants</td></tr>
<tr><td colspan="3">/</td><td>supplementary specific consideration shall be done on the abrasion resistance and on tear strength liaised to the design of the relevant component[a]</td><td>/</td></tr>
<tr><td colspan="5">[a] These components shall be specifically involved when considering the surveillance and maintenance provisions (see 4.2.2)</td></tr>
</table>

Table J.2 — Test method and acceptance criteria referred to the properties of elastomeric materials

Property	Test method		Unit	Range of hardness IRHD [a]				
	Reference standard	Test conditions		≥ 45 to 55	> 55 to 65	> 65 to 75	> 75 to 85	> 85
				Acceptance criteria				
accelerated ageing	ISO 188	change in hardness at 70 °C ± 1 °C for 168 ± 2h	%	±10	±10	±10	±10	±10
		change in tensile strength at 70 °C ± 1 °C for 168 ± 2h		±15	±15	±15	±15	±15
		change in elongation at break at 70 °C ± 1 °C for 168 ± 2h		from 10 to −25	from 10 to −25	from 10 to −25	from 10 to −25	from 10 to −25
resistance to gas	ISO 1817	change in volume after immersion in liquid B at (23 ± 2) °C after 72 +0/-2) h	%	≤ 40	≤ 40	≤ 30	≤ 30	≤ 25
		change in volume after immersion in liquid B at (40 ± 1) °C for 7 days ± 2 h and after drying		≥ −20	≥ −17	≥ −15	≥ −15	≥ −15
resistance to lubricant	ISO 1817	change in hardness after immersion in oil N. 3 (IRM 903) at (70 ± 1) °C for 7 days ± 2h	%	±10	±10	±10	±10	±10
		change in volume after immersion in oil N. 3 (IRM 903) as above		from 15 to −5	from 15 to −5	from 15 to −5	from 15 to −5	from 15 to −5

a For equivalence between the hardness IRHD and shore see in “Roger Brown, Physical Testing of Rubber, 4th Edition, Springer Science + Business Media, Inc. – Clause 4 “Hardness” – subclause 4.4 “Accuracy and comparison of hardness tests”.

Annex K
(informative)

Sound emission

K.1 Sound emission requirements

On request in the order specification, the sound pressure level L_{pA} of the regulator shall be given for the operating conditions for which it has been ordered if the expected L_{pA} of the regulator exceeds 70 dB.

The reference for the measurement of the sound pressure level is given in 7.7.9.4.6.

The operating conditions are directly related to:

— the inlet pressure;

— the outlet pressure;

— the volumetric flow rate;

— the type of gas.

On request in the order specification, the manufacturer shall also supply the following information for specified operating conditions:

— the likely spectral distribution of the noise level in octave bands with centre frequencies of 500 Hz through to 8 000 Hz;

— sound pressure level below 70 dB.

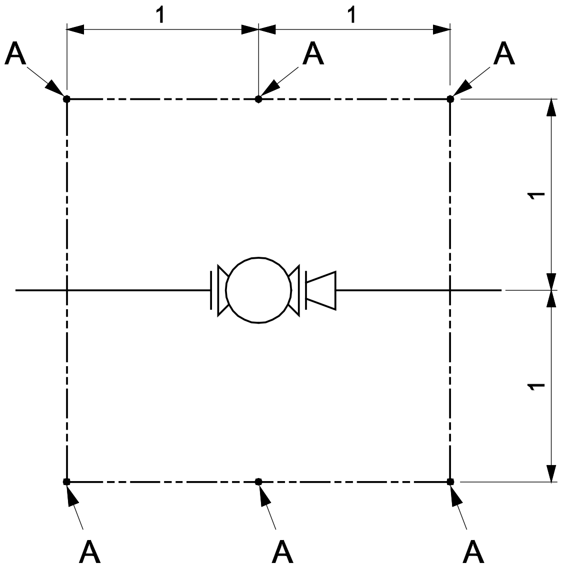
On request in the order specification the manufacturer shall supply the calculation method for sound emission and likely spectral distribution of the noise level in octave bands with centre frequencies of 500 Hz through to 8 000 Hz.

With reference to the wide variety of different operating conditions and data, it may be appropriate to determine the noise level by calculation. Calculations methods as detailed in documents EN 60534-8-3 may be used.

— Measured sound pressure level: the declared LpA shall be measured in accordance with K.2 and shall be related to the points of measurement indicated in Figure K.1 at the same height as the regulator.

— Calculated sound pressure level: the declared LpA shall be calculated using a method established by the manufacturer. Normally the calculation formulae are tailored for a specific series of regulators.

The accuracy of the sound pressure measurement or the calculated sound pressure level shall be given and shall not exceed ± 5 dB.



Key

A standard measurement points

1 distance equal to 1 m

Figure K.1 — Points of measurement for sound pressure level

K.2 Methods for measuring the sound pressure level

The fully assembled regulator with all its auxiliary devices shall be installed:

— at between 0,8 m and 1,2 m above floor level;

— in accordance with the requirements specified in 7.7.9.4.6 with regard to the velocities of the fluid in the test rig.

The floor shall be one of normal concrete or similar construction. Care shall be taken to ensure that any possible effects of sound emissions other than the noise generated by the regulator are excluded (for example noise generated by the flow rate regulating valve or the external environment). The points of measurement of sound emission shall be in accordance with Figure K1.

The sound pressure level measurement may be carried out on a test rig built in accordance with Figure 13 if the above requirements are met.

The results of the measurements shall be expressed in such a way as to conform with relevant regulations and the requirements of this document.

The test report shall include the following data:

— test procedure;

— thickness and nominal diameter of inlet and outlet pipes;

— indication of the point at which the measured sound level is the highest;

— the units of measurement used to express the results.

Annex L
(informative)

Environmental Provisions

Table L.1 — Environmental provisions - Inputs

Environmental Issue	Stages of the life cycle liaised to the manufacturing of the equipment				All stages
	Acquisition		Production		
	Raw materials and energy	Pre-manufactured materials and components	Production	Packaging	Transport-ation
Inputs					
Materials	The manufacturer should endeavour to acquire materials and components from suppliers who have a declared environmental policy as per one of the following document EN ISO 14021 or EN ISO 14024 or EN ISO 14025.		The manufacturer should endeavour to minimize wastage (quantity and quality) of material by selecting appropriately classified and sized materials related to the finished parts required for manufacture.	Any packaging and protection used during storage/transport of the finished product should be selected to have the minimum environmental impact, i.e. use of recyclable or bio-degradable materials, minimum use of energy. The manufacturer shall endeavour to acquire materials and components for packaging from suppliers who have a declared environmental policy as per one of the following document EN ISO 14021 or EN ISO 14024 or EN ISO 14025.	/
Water	Drinking water shall be replaced by industrial water when available		Consideration shall be given to re-use of the pressurizing liquid agent. When the liquid agent needs to be disposed of, it shall be properly treated to	/	/

Environmental Issue	Stages of the life cycle liaised to the manufacturing of the equipment				All stages
	Acquisition		Production		
	Raw materials and energy	Pre-manufactured materials and components	Production	Packaging	Transport-ation
			minimize any environmental impact		
Energy	The manufacturer should endeavour to acquire materials and components from suppliers who have a declared environmental policy as per one of the following document EN ISO 14021 or EN ISO 14024 or EN ISO 14025.		Management of any energy user (e.g. tool machines, furnaces for heat treatment or electrodes drain and re-backing, thermostatic chambers, etc.) should be optimized to minimize the energy consumption. Where heat treatment is performed the process shall be designed to minimize energy consumption, use of coolants, and ensure the environmentally friendly disposal of insulating material and other waste. The simplified tests minimize the energy consumption (Ref. 7.7.4)	/	To minimize the environmental impact efficient transport of finished product should be adopted.
Land	/	/	/	/	/

Table L2 - Environmental provisions - Outputs

<table>
<tr><th rowspan="3">Environmental Issue</th><th colspan="4">Stages of the life cycle liaised to the manufacturing of the equipment</th><th rowspan="2">All stages</th></tr>
<tr><th colspan="2">Acquisition</th><th colspan="2">Production</th></tr>
<tr><th>Raw materials and energy</th><th>Pre-manufactured materials and components</th><th>Production</th><th>Packaging</th><th>Transportation</th></tr>
<tr><th colspan="6">Outputs</th></tr>
<tr><td>Emissions to air</td><td>/</td><td>/</td><td>The environmental impact of welding and allied processes shall be assessed in accordance with EN 14717.
The requirements of EN 14717 shall be applied where appropriate to shot blasting and thermal spraying.
The environmental impact of the coating system selected, its application and the disposal of residues shall be minimized.
The environmental impact of the surface treatment at the end of life disposal of the regulator shall be taken into account when selecting the system.
The simplified tests minimize the emissions to air (Ref. 7.7.4)</td><td>/</td><td>To minimize the environmental impact of emissions to air, efficient transport of finished product should be adopted.</td></tr>
<tr><td>Discharges to water</td><td>/</td><td>/</td><td>/</td><td>/</td><td>/</td></tr>
<tr><td>Discharges to soil</td><td>/</td><td>/</td><td>/</td><td>/</td><td>/</td></tr>
</table>

Environmental Issue	Stages of the life cycle liaised to the manufacturing of the equipment				All stages
	Acquisition		Production		
	Raw materials and energy	Pre-manufactured materials and components	Production	Packaging	Transportation
Waste	/	/	Unavoidable waste/scrap material should be recycled like preferred option. Treatment, storage, transportation and final disposal of solid and liquid waste from production process should be in compliance with applicable National and local waste regulations NOTE: At the time of writing these activities are regulated by the European Directive 2008/98/EC		/
Noise, vibration, radiation, heat loses	/	/	The simplified tests minimize the noise emissions (Ref. 7.7.4) Noise levels from the production process should be evaluated and measures put into place to minimize the impact upon the external environment in compliance with applicable National and local noise regulations	/	To minimize noise emissions efficient transport of finished product should be adopted.
Other relevant aspects					
Risk to the environment from accidents or unintended use	/	/	/	/	/
Customer information	/	/	/	/	/

Annex M
(informative)

Glossary

Table M.1 — Glossary

Term		
English	**French**	**German**
— Accuracy	— Précision	— Regelgenauigkeit
— Accuracy class	— Classe de précision	— Genauigkeitsklasse
— Actual value	— Valeur réelle	— Istwert
— Actuator	— Actionneur	— Stellantrieb
— Atmospheric pressure	— Pression atmosphérique	— Luftdruck
— Auxiliary devices	— Accessoires auxiliaires	— Zusatzeinrichtungen
— Body	— Corps	— Stellgliedgehäuse
— Breather line	— Conduit d'évent	— Atmungsleitungen
— Casing of actuator	— Enveloppe actionneur	— Stellantriebsgehäuse
— Class	— Class	— Klasse
— Class of look-up pressure zone	— Classe de zone de pressure de fermeture	— Schließdruckzonengruppe
— Closing force	— Force de fermeture	— Schließkraft
— Component operating pressure	— Pression de service du composant	— Komponentenbetriebsdruck
— Control member	— Organe de régulation	— Stellglied
— Controlled variable	— Grandeur régulée	— Regelgröße
— Controller	— Organe de mesure	— Regeleinrichtung
— Diaphragm	— Membrane	— Membrane
— Differential pressure	— Pression différentielle	— Differenzdruck
— Direct acting gas pressure regulator	— Régulateur de pression à action directe	— direkt wirkendes Gas-Druckregelgerät
— Disturbance variable	— Grandeurs de perturbation	— Störgröße
— Exhaust line	— Conduit de mise à l'atmosphère	— Abblaseleitungen

Term		
English	**French**	**German**
— Fail close regulator	— Régulateur à fermeture sur défaut	— Fail-Close-Regelgerät
— Fail open regulator	— Régulateur à ouverture sur défaut	— Fail-Open-Regelgerät
— Failure	— Défaillance	— Versagen
— Family of performance curves	— Réseau de courbes caractéristiques	— Kennlinienfeld
— Flow coefficient C_g	— Coefficient de debit C_g	— Durchflusskoeffizient C_g
— Flow coefficient K_G	— Coefficient de debit K_G	— Durchflusskoeffizient K_G
— Gas pressure regulator	— Régulateur de pression de gaz	— Gas-Druckregelgerät
— Gas volume	— Volume de gaz	— Gasvolumen
— Hysteresis band	— Bande d'hystérésis	— Hysterese
— Inlet pressure	— Pression amont	— Eingangsdruck
— Inlet pressure range	— Plage de pression amont	— Eingangsdruckbereich
— Inner metallic partition wall	— Paroi métallique intérieure de séparation	— innere metallische Trennwand
— Limit pressure	— Pression limite	— Grenzdruck
— Look-up pressure	— Pression de fermeture	— Schließdruck
— Look-up pressure class	— Classe de pression de fermeture	— Schließdruckgruppe
— Look-up pressure zone	— Zone de pression de fermeture	— Schließdruckzone
— Lock-up time	— Temps de fermeture	— Schließzeit
— Main components	— Composants principaux	— Hauptkomponenten
— Main diaphragm	— Membrane principale	— Hauptmembran
— Maximum accuracy flow rate	— Débit maximal pour la classe de précision	— AC-Maximaldurchfluss
— Maximum allowable pressure	— Pression maximale admissible	— maximal zulässiger Druck
— Maximum component operating pressure	— Pression maximale de service d'un composant	— maximaler Komponentenbetriebsdruck

Term		
English	**French**	**German**
— Maximum outlet pressure	— Pression aval maximale	— maximaler Ausgangsdruck
— Maximum inlet pressure	— Pression amont maximale	— maximaler Eingangsdruck
— Maximum/minimum allowable temperature	— Température maximale/minimale admissible	— maximale/minimale zulässige Temperatur
— Maximum value	— Valeur maximale	— Maximalwert
— Minimum flow rate	— Débit minimum	— Minimaldurchfluss
— Minimum inlet pressure	— Pression amont minimale	— Minimaler Eingangsdruck
— Minimum operating differential pressure	— Pression différentielle de service minimale	— Mindestdruckgefälle
— Minimum value	— Valeur minimale	— Minimalwert
— Monitor	— Moniteur	— Monitor
— Motorization pressure	— Pression de motorisation	— Stelldruck
— Nominal pressure	— Pression nominale	— Nenndruck
— Normal conditions	— Conditions normales	— Normbedingungen
— Outlet pressure	— Pression aval	— Ausgangsdruck
— Operating temperature range	— Plage de température de service	— Betriebstemperaturbereich
— Performance curve	— Courbe caractéristique	— Kennlinie
— Pilot	— Pilote	— Regler
— Pilot controlled gas pressure regulator	— Régulateur à action pilotée	— Gas-Druckregler mit Hifsenergie
— Pilot feeding pressure	— Pression d'alimentation du pilote	— Eingangsdruck des Reglers
— Pressure	— Pression	— Druck
— Pressure bearing parts	— Parties sous pression	— Druckbelastete Teile
— Pressure containing parts	— Parties soumises à la pression	— Druckhaltende Teile
— Process and sensing lines	— Lignes et prises d'impulsion	— Mess- und Funktionsleitungen
— Reference inlet	— Température amont	— Referenz

Term		
English	**French**	**German**
temperature	de référence	Eingangstemperatur
— Regulation change	— Variation de régulation	— Regelabweichung
— Regulator size	— Taille du régulateur	— Nennweite des Regelgeräts
— Safety factor	— Facteur de sécurité	— Sicherheitsbeiwert
— Seat ring	— Garniture de siège	— Ventilsitz-Dichtring
— Set point	— Point de consigne	— Sollwert
— Set range	— Etendue de réglage	— Führungsbereich
— Series of regulators	— Gamme de régulateurs	— Baureihe von Regelgerä10
— Sound pressure level	— Niveau de pression acoustique	— Schalldruckpegel
— Specific maximum allowable pressure	— Pression maximale admissible spécifique	— spezifischer maximal zulässiger Druck
— Specific set range	— Etendue de réglage spécifique	— spezifischer Führungsbereich
— Stable conditions	— Conditions stables	— stabile Betriebsbedingungen
— Test pressure	— Pression d’essai	— Prüfdruck
— Valve seats	— Sièges de clapet	— Ventilsitz
— Volumetric flow rate	— Débit volumétrique	— Volumenstrom

Annex ZA
(informative)

Relationship between this European Standard and the essential requirements of Directive 2014/68/EU aimed to be covered

This European Standard has been prepared under a Commission's standardization request M/071 given to CEN by the European Commission and the European Free Trade Association to provide one voluntary means of conforming to essential requirements of the New Approach Directive 2014/68/EU (PED).

Once this standard is cited in the Official Journal of the European Communities under that Directive, compliance with the normative clauses of this standard given in Table ZA.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding essential requirements of that Directive and associated EFTA regulations.

Table ZA.1 — Correspondence between this European Standard and Annex I of the Directive 2014/68/EU

Essential Requirements of Directive 2014/68/EU (PED)	Clause(s)/subclause(s) of this EN	Remarks/Notes
2.2.1	4.3.1, 4.3.2, 4.3.3, 4.3.6, 4.3.7	Design for adequate strength
2.2.3	4.1.8, 4.3.1, 4.3.2, 4.3.3, 4.3.6, 4.3.7, 4.3.8, 7.7.3.1	Calculation method
2.2.4	7.7.3.2	Experimental design method
2.7	4.1.9	Wear – Replacement of parts
2.11.1	4.1.2, 4.1.7	Design and independence from integrated safety devices and/or monitor
	5.5, 5.7, 7.7.6	
	4.1.2.1, 4.1.2.2, 4.1.2.3	Fail-safe modes of fail close regulator Redundancy
2.11.2	7.7.9.3, 7.7.9.4.3	Pressure limiting devices
3.1.1	4.2.1.6.1	Preparation of component parts
3.1.2	4.2.1.6.1	Permanent joining
3.1.3	4.2.1.7.3	Non-destructive tests (qualification of personnel)
3.1.4	4.2.1.6.1	Heat treatment of fabrication welds
3.1.5	4.2.1.6.2	Traceability
3.2.1	5.4.2, 7.7.10.2	Final inspection
3.2.2	7.7.4, 7.7.5	Proof test

Essential Requirements of Directive 2014/68/EU (PED)	Clause(s)/subclause(s) of this EN	Remarks/Notes
3.3	10.2, 10.4	Marking and labelling
3.4	9.4	Operating instructions
4.1 (a), 4.1 (b), 4.2 (a), 4.2(b)	4.2.1.1, 4.2.1.2	Appropriate characteristics and chemical resistance of materials
4.3	4.2.1.4, 4.2.1.5	Compliance of materials with specifications
7.1.2	4.3.7	Permissible membrane stress (Allowable stresses)
7.2	4.3.8	Joint coefficients
7.3	7.7.9.3, 7.7.9.4.3	Short duration pressure surge
7.4	7.7.4	Hydrostatic pressure test
7.5	4.2.1.1, 4.2.1.2	Material characteristics

WARNING 1 — Presumption of conformity stays valid only as long as a reference to this European Standard is maintained in the list published in the Official Journal of the European Union. Users of this standard should consult frequently the latest list published in the Official Journal of the European Union.

WARNING 2 — Other Union legislation may be applicable to the product(s) falling within the scope of this standard.

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