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Gas pressure safety and control devices for use in gas transmission, distribution and installations for inlet pressures up to and including 10 MPa —

Part 1: General requirements

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Contents

Page

Foreword

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

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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 161, *Controls and protective devices for gas and/or oil*.

A list of all parts in the ISO 23555 series can be found on the ISO website.

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

Introduction

This document provides general requirements for controls and protective devices and is intended to be used in conjunction with ISO 23555-2 and ISO 23555-3 for specific types of controls and protective devices or for controls for specific applications.

This document can also be applied, so far as reasonable, to controls not mentioned in a specific standard and to controls designed on new principles, in which case additional requirements can be necessary.

When no specific International Standard for a control exists, the control can be tested according to this document and further tests which take into account the intended use.

Controls and safety devices used with gases need to withstand the type of gas which is specified. Other ISO Technical Committees, such as ISO/TC 28, *Petroleum products and lubricants*, and ISO/TC 193, *Natural gas*, deal with the testing and properties of fuel gases.

Note that due to the differing properties of gas depending on its source/region of origin, certain differences in regulations exist at present in different regions, some of which are presented in Annex E.

This document intends to provide a basic framework of requirements until these differences can be harmonized.

Gas pressure safety and control devices for use in gas transmission, distribution and installations for inlet pressures up to and including 10 MPa —

Part 1: General requirements

1 Scope

This document specifies generic safety, constructional, performance, testing and documentation requirements for high pressure controls for use in gas transmission, distribution and installations (hereafter referred to as controls).

This document is applicable to controls with operating pressures greater than 500 kPa (5 bar) and up to and including 10 MPa (100 bar) and nominal size up to DN 400 for use with fuel gases as natural gas, manufactured gas, biomethane or liquefied petroleum gas (LPG) in commercial, industrial installations, including fuel gas infrastructures.

The test methods given in this document are intended for product type test, routine tests and batch surveillance tests.

This document is not applicable to:

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

— controls designed with declared maximum capacity ≤200 m^3/h (normal conditions) and declared maximum inlet pressure ≤500 kPa (5 bar), to be incorporated into pressure control systems used in service lines (pipework from the main pipework in a gas infrastructure to the point of delivery of the gas);

— industrial process control valves, such as IEC 60534;

— controls used in aggressive/sour gas environments (gas environments containing water and H_2S are considered sour) or severely corrosive conditions;

— controls in service conditions with renewables (e.g. H_2NG with hydrogen more than 10 %) and/or waste gases (e.g. biogas, etc.), if additional information is not provided (e.g. contaminant, liquid, etc.).

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 amendments) applies.

ISO 148-1, *Metallic materials — Charpy pendulum impact test — Part 1: Test method*

ISO 175, *Plastics — Methods of test for the determination of the effects of immersion in liquid chemicals*

ISO 1817, *Rubber, vulcanized – Determination of the effect of liquids*

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

ISO 7005 (all parts),*Pipe flanges*

ISO 9606-1, *Qualification testing of welders — Fusion welding — Part 1: Steels*

ISO 9606-2, *Qualification test of welders — Fusion welding — Part 2: Aluminium and aluminium alloys*

ISO 9606-3, *Approval testing of welders — Fusion welding — Part 3: Copper and copper alloys*

ISO 9606-4, *Approval testing of welders — Fusion welding — Part 4: Nickel and nickel alloys*

ISO 9712, *Non-destructive testing — Qualification and certification of NDT personnel*

ISO 10474:2013, *Steel and steel products — Inspection documents*

ISO 14732, *Welding personnel — Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials*

ISO 15607, *Specification and qualification of welding procedures for metallic materials — General rules*

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

ISO 15610, *Specification and qualification of welding procedures for metallic materials — Qualification based on tested welding consumables*

ISO 15611, *Specification and qualification of welding procedures for metallic materials — Qualification based on previous welding experience*

ISO 15612, *Specification and qualification of welding procedures for metallic materials — Qualification by adoption of a standard welding procedure specification*

ISO 15613, *Specification and qualification of welding procedures for metallic materials — Qualification based on pre-production welding test*

ISO 15614-1, *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 15614-2, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 2: Arc welding of aluminium and its alloys*

ISO 17637, *Non-destructive testing of welds — Visual testing of fusion-welded joints*

ISO/IEC 17025:2017, *General requirements for the competence of testing and calibration laboratories*

IEC 60534-2-3, *Industrial-process control valves — Part 2-3: Flow capacity — Test procedures*

IEC 60534-4:2006, *Industrial-process control valves — Part 4: Inspection and routine testing*

EN 437, *Test gases — Test pressures — Appliance categories*

EN 549:2019, *Rubber materials for seals and diaphragms for gas appliances and gas equipment*

EN 12516-1:2014, *Industrial valves — Shell design strength — Part 1: Tabulation method for steel valves shells*

EN 13445-4, *Unfired pressure vessels — Part 4: Fabrication*

EN 16129:2013, *Pressure regulators, automatic change-over devices, having a maximum regulated pressure of 4 bar, with a maximum capacity of 150 kg/h, associated safety devices and adaptors for butane, propane, and their mixtures*

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

3 Terms, definitions, symbols and abbreviated terms

3.1 Terms and definitions

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

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

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

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

3.1.1 General terms

3.1.1.1
biomethane
methane-rich gas with the properties similar to natural gas derived from biogas produced by anaerobic digestion or gasification or from power to gas by upgrading

[SOURCE: ISO 20675:2018, 3.12]

3.1.1.2
failure
termination of the ability of a functional unit to provide a required function or operation

[SOURCE: IEC 60050-192:2015, 192-03-01]

3.1.1.3
finite element analysis
FEA
examination of a phenomenon with the *finite element method* (3.1.1.4)

Note 1 to entry: FEA as applied in engineering is a computational tool for performing engineering analysis. It includes the use of mesh generation techniques for dividing a complex problem into small elements, as well as the use of software program coded with FEM algorithm.

3.1.1.4
finite element method
FEM
numerical method for solving problems of engineering and mathematical physics

Note 1 to entry: FEM is best understood from its practical application, known as *finite element analysis* (3.1.1.3).

3.1.1.5
differential strength type
DS
control device which includes *pressure-containing parts* (3.1.2.7) with different *design pressure* (3.1.4.3)

3.1.1.6
gas infrastructure
pipeline systems including pipework and their associated stations or plants for the transmission and distribution of gas

Note 1 to entry: Natural gas infrastructure is a highly integrated system of transmission and distribution pipelines (including regulating, measuring and compression stations), and storage facilities.

[SOURCE: ISO 20675:2018, 3.26, modified — Note 1 to entry has been added.]

3.1.1.7
high pressure control
device which directly or indirectly controls the gas pressure/flow and/or provides a safety function

3.1.1.8
integral strength type
IS
control device which includes all *pressure-containing parts* (3.1.2.7) with the same *design pressure* (3.1.4.3)

3.1.1.9
manufactured gas
synthetic gas
gas which has been treated and may contain components that are not typical of natural gas

Note 1 to entry: Manufactured (synthetic) gases may contain substantial amounts of chemical species that are not typical of natural gases or common species found in atypical proportions as in the case of wet and sour gases.

Note 2 to entry: Manufactured gases fall into two distinct categories, as follows:

a) those that are intended as synthetic or substitute natural gases, and that closely match true natural gases in both composition and properties;

b) those that, whether or not intended to replace or enhance natural gas in service, do not closely match natural gases in composition.

Case b) includes gases such as town gas, (undiluted) coke oven gas, and LPG/air mixtures, none of which is compositionally similar to a true natural gas (even though, in the latter case, it may be operationally interchangeable with natural gas).

[SOURCE: ISO 14532:2014, 2.1.1.4]

3.1.1.10
natural gas
NG
complex gaseous mixture of hydrocarbons, primarily methane, but generally also including ethane, propane and higher hydrocarbons in much smaller amounts and some non-combustible gases, such as nitrogen and carbon dioxide

[SOURCE: ISO 14532:2014, 2.1.1.1]

3.1.1.11
non-destructive testing
NDT
wide group of analysis techniques used in science and technology industry to evaluate the properties of a material, component or system without causing damage

3.1.1.12
shell
pressure-containing envelope of the control

3.1.1.13
control nominal size
DN
alphanumeric designation of size for components of a pipework system, which is used for reference purposes, comprising the letters DN followed by a dimensionless whole number which is indirectly related to the physical size, in millimetres, of the bore or outside diameter of the end connections

Note 1 to entry: The number following the letters DN does not represent a measurable value and should not be used for calculation purposes except where specified in the relevant standard.

Note 2 to entry: In standards which use the DN designation system, any relationship between DN and component dimensions should be given, e.g. DN/OD or DN/ID.

[SOURCE: ISO 23550:2018, 3.17]

3.1.1.14
series of controls
controls with the same design concept, but differing only in size

3.1.2 Terms related to components

3.1.2.1
main component
part including *control member* (3.1.2.2), control *body* (3.1.2.3), actuator, casing of actuator, controller, pilot (only in pilot-controlled controls)

Note 1 to entry: The control can include additional devices such as a relief device and other *auxiliary devices* (3.1.2.12).

3.1.2.2
control member
movable part of the control which is positioned in the flow path to restrict or to shut down the flow through the control

Note 1 to entry: A control member can be a plug, ball, disk, vane, gate, *diaphragm* (3.1.2.6), etc.

3.1.2.3
body
main pressure-containing envelop which provides the fluid flow passageway and the pipe end connections

Note 1 to entry: The body is part of the shell.

3.1.2.4
valve seat
corresponding sealing surface within a control which make full contact only when the *control member* (3.1.2.2), is in the closed position

[SOURCE: IEC 60534-1:2005, 3.2.4.1]

3.1.2.5
seat ring
part assembled in a component of the control to provide a replaceable seat

3.1.2.6
diaphragm
flexible member used as main diaphragm and diaphragm used to separate one chamber subjected to pressure into two parts with different pressure (e.g. balancing diaphragm)

3.1.2.7
pressure-containing part
part whose failure to function results in a release of the retained fuel gas to the atmosphere

Note 1 to entry: These include bodies, *control member* (3.1.2.2), bonnets, the casing of the actuator, blind flanges and pipes for *process and sensing lines* (3.1.2.9) but exclude compression fittings, *diaphragms* (3.1.2.6), bolts and other fasteners.

3.1.2.8
inner metallic partition wall
metallic wall that separates a chamber into two individual pressure-containing chambers at different pressures under normal operating conditions

3.1.2.9
process and sensing line
line which connects sensing points to the control

Note 1 to entry: Sensing point is the point from which the monitored variable is fed to the control.

Note 2 to entry: Sensing and process lines can be integrated into the control or external to the control. Lines with no internal flow are called "sensing lines" and those with internal flow are called "process lines".

3.1.2.10
breather line
line connecting the atmosphere side of the pressure detector element to atmosphere

3.1.2.11
exhaust line
line connecting the control or its fixtures to atmosphere for the safe exhausting of gas in the event of failure of any part

3.1.2.12
auxiliary device
any device [e.g. throttle devices, creep devices, *vent limiter* (3.1.2.13), etc.] functionally connected to the *main components* (3.1.2.1) of the control

3.1.2.13
vent limiter
unit with an automatic valve reacting on gas flow and/or pressure

3.1.3 Terms related to components of functional performance

3.1.3.1
inlet pressure
p_u
gas pressure at the inlet of the control

Note 1 to entry: All pressures specified in this document are static gauge pressures unless otherwise stated.

Note 2 to entry: Pressure is expressed in Pa, unless otherwise stated. 1 Pa = 0,001 kPa = 10^{-6} MPa = 10^{-5} bar = 0,1 mbar.

Note 3 to entry: For pressure expressed in bar: 1 bar = 1 000 mbar = 10^5 N/m^2 = 10^5 Pa = 10^{-1} MPa.

3.1.3.2
outlet pressure
p_d
gas pressure at the outlet of the control

Note 1 to entry: All pressures specified in this document are static gauge pressures unless otherwise stated.

Note 2 to entry: Pressure is expressed in Pa, unless otherwise stated. 1 Pa = 0,001 kPa = 10^{-6} MPa = 10^{-5} bar = 0,1 mbar.

Note 3 to entry: For pressure expressed in bar: 1 bar = 1 000 mbar = 10^5 N/m^2 = 10^5 Pa = 10^{-1} MPa.

3.1.3.3
differential pressure
Δp
difference between two values of pressure at two different points

Note 1 to entry: All pressures specified in this document are static gauge pressures unless otherwise stated.

Note 2 to entry: Pressure is expressed in Pa, unless otherwise stated. 1 Pa = 0,001 kPa = 10^{-6} MPa = 10^{-5} bar = 0,1 mbar.

Note 3 to entry: For pressure expressed in bar: 1 bar = 1 000 mbar = 10^5 N/m^2 = 10^5 Pa = 10^{-1} MPa.

3.1.3.4
atmospheric pressure
p_b
local static atmospheric absolute pressure in Pa (bar)

Note 1 to entry: All pressures specified in this document are static gauge pressures unless otherwise stated.

Note 2 to entry: Pressure is expressed in Pa, unless otherwise stated. 1 Pa = 0,001 kPa = 10^{-6} MPa = 10^{-5} bar = 0,1 mbar.

Note 3 to entry: For pressure expressed in bar: 1 bar = 1 000 mbar = 10^5 N/m^2 = 10^5 Pa = 10^{-1} MPa.

3.1.3.5
normal conditions
situation where absolute pressure, p_n, is 101,325 kPa (1 013,25 mbar) and temperature, T_n, is 0 °C (t_n of 273,15 K)

Note 1 to entry: For calculation purposes, a value of 273 K is used in this document.

3.1.3.6
standard conditions
situation where absolute pressure, p_n, is 101,325 kPa (1013,25 mbar) and temperature, T_n, is 15 °C (t_n of 288,15 K)

Note 1 to entry: For calculation purposes, a value of 288 K is used in this document.

3.1.3.7
volumetric flow rate
Q_n
volume of gas which flows through the control per unit of time, re-calculated to *normal conditions* (3.1.3.5)

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

3.1.3.8
vented flow rate
Q_v
flow rate vented to atmosphere via the *vent limiter* (3.1.2.13) 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* (3.1.3.5).

3.1.3.9
vented flow rate limit
Q_{vl}
maximum flow rate limited by the *vent limiter* (3.1.2.13) 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* (3.1.3.8) is expressed as air flow rate in l/h under *normal conditions* (3.1.3.5).

3.1.3.10
sound pressure level
L_{pA}
logarithmic measure of the effective pressure of a sound relative to a reference value and A-weighting, expressed in decibels (dB)

Note 1 to entry: 'A' frequency weighting is the standard weighting of the audible frequencies and reflects the response of the human ear to noise.

Note 2 to entry: All pressures specified in this document are static gauge pressures unless otherwise stated.

Note 3 to entry: Pressure is expressed in Pa, unless otherwise stated. 1 Pa = 0,001 kPa = 10^{-6} MPa = 10^{-5} bar = 0,1 mbar.

Note 4 to entry: For pressure expressed in bar: 1 bar = 1 000 mbar = 10^5 N/m^2 = 10^5 Pa = 10^{-1} MPa.

[SOURCE: IEC 61672:2013, 3.2 and 3.3]

3.1.4 Terms related to design and tests

3.1.4.1
component operating pressure
p
gas pressure occurring in any part of a control during operation

3.1.4.2
maximum component operating pressure
p_{max}
highest operating pressure at which a component of a control continuously operates within specified conditions

3.1.4.3
design pressure
DP
pressure on which design calculation are based

Note 1 to entry: In particular, maximum pressure for which the *body* (3.1.2.3), its *inner metallic partition walls* (3.1.2.8) and some other *pressure-containing parts* (3.1.2.7) are designed in accordance with the strength requirements in this document.

3.1.4.4
specific design pressure
DPD
pressure for which some *pressure-containing parts* (3.1.2.7) of differential strength controls are designed where *DPD < DP*

3.1.4.5
test pressure
PT
pressure applied to a section of the control for a limited period of time in order to prove certain characteristics

3.1.4.6
limit pressure
p_l
pressure at which yielding becomes apparent in any component of the control or its fixtures

3.1.4.7
safety factors
ratio of the *limit pressure* (3.1.4.6), p_l, to the maximum allowable *design pressure* (3.1.4.3), DP, or to the maximum allowable *specific design pressure* (3.1.4.4), DPD, applied to:

— the control *body* (3.1.2.3), S_b;

— the other *pressure-containing parts* (3.1.2.7) of the control, S.

3.1.4.8
maximum inlet pressure
p_{umax}
highest *inlet pressure* (3.1.3.1) at which the control can continuously operate within specified conditions

3.1.4.9
maximum differential pressure
Δp_{max}
highest value of allowable pressure difference between two parts of the control

3.1.4.10
nominal pressure
PN
alpha-numerical designation relating to pressure that is a convenient round number for reference purposes.

Note 1 to entry: It is intended that all equipment of the same nominal size (DN) designated by the same PN number shall have the same mating dimensions appropriate to the type of end connections.

Note 2 to entry: The permissible working pressure depends upon materials, design and working temperature and has to be selected from the pressure/temperature rating tables in corresponding standards.

Note 3 to entry: It comprises the letters PN followed by a dimensionless whole number.

EXAMPLE PN 16.

[SOURCE: ISO 7268:1983, Clause 2, modified — In the definition, "A numerical" has been replaced with "alpha-numerical"; the 2 paragraphs after the definition have been moved to Notes 1 and 2 to entry; Note 3 to entry and the EXAMPLE have been added.]

3.1.4.11
pressure class
pressure rating designation
CL
alphanumeric designation used for reference purposes related to a combination of mechanical and dimensional characteristics of a component of a pipework system. It comprises the word Class followed by a dimensionless whole number

Note 1 to entry: The number following the word Class does not represent a measurable value and should not be used for calculation purposes except where specified in the relevant standard.

Note 2 to entry: The designation Class is not meaningful unless it is related to the relevant component standard number.

Note 3 to entry: It is intended that all components with the same Class and NPS (see below) designations should have the same mating dimensions for compatible flange types.

EXAMPLE Class 150.

[SOURCE: EN 1759-1:2004 and ASME B 16.5:2003]

3.1.4.13
operating temperature range
temperature range at which the control components and fixtures are capable of operating continuously.

3.2 Symbols and abbreviated terms

For the purposes of this document, the symbols and the abbreviated terms given in Table 1 apply.

Table 1 — Symbols and abbreviated terms with relevant subclauses and units

Symbol	Description	Subclause	Unit
CL	Pressure rating designation	3.1.4.11	—
DN	Control nominal size	3.1.1.13	—
Δp	Differential pressure	3.1.3.3	MPa (bar)

Table 1 *(continued)*

Symbol	Description	Subclause	Unit
Δp_{max}	Maximum differential pressure	3.1.4.9	MPa (bar)
DP	Design pressure	3.1.4.3	MPa (bar)
DPD	Specific design pressure	3.1.4.4	MPa (bar)
DS	Differential strength	3.1.1.7	—
IS	Integral Strength	3.1.1.10	—
L_{pA}	Sound pressure level	3.1.3.10	In accordance with IEC 61672-1
NDT	Non-destructive test	3.1.1.11	—
p	Component operating pressure	3.1.4.1	MPa (bar)
p_b	Atmospheric pressure (absolute pressure)	3.1.3.4	MPa (bar)
p_d	Outlet pressure	3.1.3.2	MPa (bar)
p_{dmax}	Maximum outlet pressure	3.1.4.9	MPa (bar)
p_l	Limit pressure	3.1.4.6	MPa (bar)
p_{max}	Maximum component operating pressure	3.1.4.2	MPa (bar)
p_n	Reference absolute pressure for normal and standard conditions = 101,325 kPa (1,013 25 bar)	3.1.3.5; 3.1.3.6	kPa (mbar)
p_u	Inlet pressure	3.1.3.1	MPa (bar)
PN	Nominal pressure	3.1.4.10	MPa (bar)
Q_v	Vented flow rate	3.1.3.8	m^3/h
Q_{vl}	Vented flow rate limit	3.1.3.9	
Q_n	Volumetric flow rate	3.1.3.7	m^3/h
S	Design safety factor for all pressure-containing parts except bodies	3.1.4.7	/
S_b	Design safety factor for body		/
t_n	Reference temperature for normal or standard conditions	3.1.3.5	K
T_n	Reference temperature for normal or standard conditions	3.1.3.6	° C

4 Classification

4.1 General

Where appropriate, controls are classified for the application according to relevant criteria listed below:

— operating temperature;

— strength.

Additional criteria for gas pressure regulators and safety shut-off devices are detailed in their specific control standards.

4.2 Temperature classes

This document considers the following temperature classes:

— Class 1: operating temperature range from -10 °C to 60 °C;

— Class 2: operating temperature range from -20 °C to 60 °C.

4.3 Strength types

This document considers the following strength types of controls:

— Type IS: (integral strength type);

— Type DS: (differential strength type).

5 Materials

5.1 General

The quality of materials, the dimensions used and the method of assembling the various parts shall be such that construction and performance characteristics are satisfactory for the intended application.

Compliance of materials shall be verified by reviewing technical documentation and verifying specific conformity assessment as presented in 5.3.

In the documentation, the selected material standards shall be declared as presented in 5.3.

5.2 Requirements

5.2.1 Requirements for metallic materials

5.2.1.1 Pressure-containing parts and inner metallic partition walls

The pressure-containing parts, including those that become pressure-containing parts in the event of diaphragm or differential pressure seal failure, and the inner metallic partition walls shall be constructed of materials:

— chemically resistant to the fuel gases listed in Clause 1 and to the additive substances normally used for odorization and conditioning of gases;

— resistant to the permissible impurities in the gas;

— complying with the relevant international material standard for pressure application (chemical composition, mechanical characteristics and test procedures) and the restrictions given in Table 2.

NOTE A list of possible materials is given in Annex A.

5.2.1.2 Auxiliary devices, threaded sealing plugs, integral process and sensing lines, connectors and fasteners

Auxiliary devices, threaded sealing plugs, integral process and sensing lines, connectors and fasteners shall be constructed of materials:

— chemically resistant to the fuel gases listed in Clause 1 and to the additive substances normally used for odorization and conditioning of gases;

— resistant to the permissible impurities in the gas;

— complying with the relevant international material standard (chemical composition, mechanical characteristics and test procedures) and the restrictions given in Table 2.

NOTE A list of possible materials is given in Annex A.

5.2.1.3 Other parts

Parts of controls not subjected to differential pressure and not included in 5.2.1.1 and 5.2.1.2 shall be constructed of materials:

— chemically resistant to the fuel gases listed in Clause 1 and to the additive substances normally used for odorization and conditioning of gases;

— resistant to the permissible impurities in the gas.

Table 2 — Materials

Material group	Properties	Restrictions		
	A_{min} [a] %	DP_{max} MPa (bar)	$(DP \cdot DN^b)_{max}$ MPa · mm (bar · mm)	DN_{max} [e] mm
Pressure-containing parts and inner metallic partition walls				
Rolled and forged steel [c]	16	10 (100)	—	—
Cast steel [c]	15	10 (100)	—	—
Spheroidal graphite cast iron [d]	7	2 (20)	150 (1 500)	1 000
	15	5 (50)	500 (5 000)	300
Malleable cast iron	6	2 (20)	100 (1 000)	100
Copper-zinc wrought alloys	15	10 (100)	—	25
Copper-tin and copper-zinc cast alloys	5	2 (20)	100 (1 000)	100
	15	10 (100)	—	25
Aluminium wrought alloys	4	2 (20)	—	50
	7	5 (50)	—	50
		10 (100)	—	25
Aluminium cast alloys	1,5	1 (10)	25 (250)	150
	4	2 (20)	160 (1 600)	1 000
Integral process and sensing lines				
Copper	—	2,5 (25)	—	—
Steel	—	10 (100)	—	—
Connectors				
Steel	8	—	—	—
Fasteners				
Steel for bolts, screws, studs	9	5 (50)	—	—
	12	10 (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 (see ISO 6892-1:2016, 3.4.2) (according to the applicable document, relevant to the chosen material). ISO 2566-1 and ISO 2566-2 can be useful references for conversion of elongation values.

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

[d] The bending rupture energy measured in accordance with ISO 148-1 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 DP > 2,5 MPa (25 bar).

[e] DN_{max} refers to both inlet and outlet connection including technical solutions with enlarged outlet.

5.2.2 Requirements for non-metallic materials

5.2.2.1 General

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 materials shall be resistant to the permissible impurities in the gas.

5.2.2.2 Requirements for elastomers (including vulcanized rubbers)

Elastomeric materials shall be in accordance with the requirements shown in Annex B for fuel distributed gases in accordance with the classification of gas families and groups according to EN 437.

The following supplementary requirements should 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 ISO 10474:2013.

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

5.2.2.3 Requirements for non-metallic materials different from those in 5.2.2.2

The resistance to liquids of functional non-metallic parts shall meet the requirements in Table 3. The change in mass after immersion for 7 days with a tolerance of ±2 h at (23 ± 2) °C in test liquid B in accordance with ISO 1817, and after drying, shall comply the requirements in Table 3.

Table 3 — Requirements for non-metallic materials different than those in 5.2.2.2

Property	Determination of changes in mass	Requirements
Maximum change in mass after one week at 23 °C ± 2 °C	ISO 175	±5 %
Maximum change in mass after drying in an oven at 70 °C ± 2 °C	ISO 175	+5 %/-2 %

5.3 Validation and test of materials

5.3.1 Material inspection documents of metallic pressure-containing parts and inner metallic partition walls

Metallic pressure-containing parts and inner metallic partition walls shall be validated according to the following classification and requirements:

a) Pressure-containing parts and inner metallic partition walls of control bodies

— Bodies used for controls with DP x Volume ≥ 5 (50) shall be accompanied by a material inspection certificate type 3.2 in accordance with ISO 10474:2013.

For these bodies when the material manufacturer has an appropriate quality-assurance system, an inspection certificate type 3.1 in accordance with ISO 10474:2013 may be used.

— Bodies used for controls with no safety function and DP x Volume < 5 (50) shall be accompanied by a material test report at least type 2.2 in accordance with ISO 10474:2013.

b) Pressure-containing parts and inner metallic partition walls of other components used for controls:

— DP ≤ 2,5 MPa (25 bar) can be accompanied by a material test report at least type 2.2 in accordance with ISO 10474:2013;

— DP > 2,5 MPa (25 bar) shall be accompanied by a material inspection certificate at least type 3.1 in accordance with ISO 10474:2013.

5.3.2 Material inspection documents of threaded sealing plugs, integral process and sensing lines, connectors and metallic fasteners

Fasteners (bolts, screws, studs, nuts) and connectors (compression fittings) used in the pressure-containing parts of the controls shall bear the marking in accordance with applicable technical standards. They shall also be accompanied by a material test report type 2.2 in accordance with ISO 10474:2013.

5.3.3 Material inspection documents of non-metallic functional parts

Conformity of non-metallic materials used for functional parts in contact with the gas shall be verified by technical documentation review to check compliance with the requirements of 5.2.2.

5.3.4 Non-destructive testing for steel bodies

Raw materials for steel bodies shall be non-destructively tested in accordance with Tables 9 and 10.

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.

6 Design

6.1 General

6.1.1 Design approach

Conformity with the design requirements given in ISO 23555-1 is verified by:

— the test methods given herein or in the specific control standard; and

— using the construction materials specified in this document.

Alternative materials may be used if they provide performance at least equivalent to the specified materials.

Verification of compliance with general design requirements shall be made by technical documentation review and a combination of methods detailed in 6.2.3.1 to 6.2.3.2:

— calculations;

— experimental methods (e.g. lab tests).

Design strength of metallic pressure-containing parts and inner metallic partition walls shall be tested according to 6.2.3.3 and a combination of methods/tests detailed in 6.2.3.1 and 6.2.3.2.

6.1.2 Basic requirements

Controls shall be designed, manufactured and assembled so that the various functions operate correctly when installed and used according to the manufacturer's instructions.

All pressurized parts of a control shall withstand the mechanical and thermal stresses to which they are subjected without any deformation affecting safety.

Jointing compounds, such as liquids and pastes, shall not be used. However, jointing compounds may be used for permanent assemblies and shall remain effective under normal operating conditions.

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 controls may include:

— two or more safety or regulating control devices, complying with the requirements in ISO 23555-2;

— a token creep relief device, complying with the requirements in ISO 23555-2:2022, Annex H;

— a vent limiter, in accordance with the requirements in Annex C;

— auxiliary devices.

When controls incorporate electric devices (e.g. micro-switches, proximity switches), these integral electric devices shall not impact with the performance of the control. The integral electric device shall comply with their relevant product standard.

The control shall be protected against the relevant environment.

6.1.3 Hazard identification and residual risks

The operating instructions (installation, operation and maintenance manual) shall include information concerning the pressure residual risks not covered by design (see also ISO/IEC 27000:2018, 3.57).

NOTE 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 depends on the operating duty.

6.1.4 End connections

End connections can be one of the following:

— flanged connections in accordance with the applicable parts of the ISO 7005 series (some parts of these documents can be replaced by the equivalent documents when they are available);

— flangeless type (e.g. wafer body);

— threaded connections in accordance with ISO 7-1 for:

  — DN ≤ 50;

  — DN ≤ 80 and DP ≤ 1,6 MPa (16 bar);

  — compression fittings for DN ≤ 50;

— butt weld connections in accordance with EN 12627.

6.1.5 Flange ratings

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

— PN designated flanges 6, 10, 16, 20, 25, 40, 50, 63, 100 in accordance with the ISO 7005 series;

— PN designated flanges 20, 50 in accordance with the ISO 7005 series only for spheroidal graphite cast iron and malleable cast iron;

— pressure class designated flanges 150, 300, 600 in accordance with the ISO 7005 series.

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

6.1.6 Nominal sizes and face-to-face dimensions

Controls 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 4 are recommended.

Alternatively, the nominal sizes and the face-to-face dimensions may be taken from Table 5.

Flangeless controls (controls that have no line flanges but are intended to be installed by clamping between pipes flanges) are permitted as an alternative. In this case, controls should have the same nominal size at inlet and outlet and face-to-face dimensions should be taken from Tables 6 or 7.

The following controls are permitted:

— flanged types with different nominal inlet and outlet sizes;

— those with face-to-face dimensions differing from those given in Tables 4 and 5;

— angle pattern bodies in accordance with ISO 5752.

Table 4 — Recommended face-to face dimensions for flanged controls

Nominal size DN	Face-to-face dimensions, in mm, for nominal pressure						Limit deviations for face-to-face dimensions mm
	PN 6/10/16/20	CL 150	PN 25/40/50	CL 300	PN 63/100	CL 600	
25	184		197		210		
40	222		235		251		
50	254		267		286		
65	276[a]		292[a]		311[a]		
80	298		317		337		± 2
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	1 016		1 057		1 108		

SOURCE: IEC 60534-3-1:2000, Tables 1 and 2 (nominal pressure in accordance with the relevant parts of ISO 7005).

[a] Face-to-face dimensions according to IEC 60534-3:2000, Table 1.

Table 5 — Alternative face-to face dimensions for flanged controls

Nominal size DN	Face-to-face dimensions in mm for nominal pressure				Limit deviations for face-to-face dimensions mm
	PN 6/10/16/25/40/50	CL 150/300	PN 63/100	CL 600	
25	160		230		
40	200		260		
50	230		300		
65	290[a]		340[a]		
80	310		380		± 2
100	350		430		
150	480		550		
200	600		650		
250	730		775		
300	850		900		± 3
400	1 100		1 150		

SOURCE: IEC 60534-3-1:2000, Table 2, with the addition of PN 50 and the replacement of PN 100 by PN 110 (nominal pressure in accordance with the relevant parts of ISO 7005).

[a] Face-to-face dimensions according to IEC 60534-3:2000, Table 2.

Table 6 — Recommended face-to-face dimensions for flangeless controls

Nominal size DN	Face-to-face dimensions mm	Limit deviations for face-to-face dimensions 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

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

[SOURCE: IEC 60534-3-2 (nominal pressure in accordance with the relevant parts of the ISO 7005 series)]

Table 7 — Alternative face-to-face dimensions for flangeless controls

Nominal size DN	Face-to-face dimensions in mm for nominal pressure				Limit deviations for face-to-face dimensions mm
	PN 6/ 10/ 16/ 20/ 25/ 40/ 50	CL 150/300	PN 63/100	CL 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 control ends and the pipeline flanges.

NOTE 2 Nominal pressure in accordance with the relevant parts of the ISO 7005 series.

6.1.7 Sealing of the adjusting device

A means for sealing the adjusting device against unauthorized adjustment after installation shall be provided. If requested in the design documentation, the adjusting device shall be sealed.

6.1.8 Replaceable parts that can be affected by erosion or abrasion

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

6.1.9 Integral strength pressure controls

Controls classified as integral strength shall include only pressure-containing parts designed to withstand the design pressure DP, according to requirements and test method detailed in this document (see Table 11, 6.2.2 and 6.6.2; test method of 6.2.3.1, 6.2.3.3 and 6.6.3).

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

6.1.10 Differential strength pressure controls

Controls classified as differential strength regulators include some pressure-containing parts designed to withstand a specific design pressure DPD where DPD < DP, according to requirements and test method detailed in this document (see Table 11, 6.3.2 and 6.6.2; test method of 6.3.3.1, 6.3.3.3 and 6.6.3).

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

NOTE For both these controls (IS and DS), the maximum inlet pressure is p_{umax}.

6.1.11 Metallic flanges

Where flanges are used for end connections of controls, they shall be suitable for connection to pipeline flanges according to the following requirements.

The maximum allowable operating pressure for flanges in accordance with the relevant parts of ISO 7005 shall not be less than maximum allowable pressure DP.

Flanges shall be in accordance with dimensional connection specifications in applicable technical standards for steel or cast iron flanges (see for example EN 1092-1, EN 1092-2, EN 1092-3, EN 1092-4, EN 1759-1, EN 1759-3 and EN 1759-4, ANSI/ASME B 16 or JIS B 2220, JIS B 2239, JIS B 2240, JIS B 2241, JIS B 2301, CN GB/T 9124.1, CN GB/T 9124.2, CN HG/T 20592 up to CN HG/T 20635).

6.1.12 Minimum values of safety factor

The values listed in Table 8 shall be used to limit the stresses in the walls of metallic pressure containing parts and inner metallic partition walls at the design pressure.

Table 8 — Minimum values of design 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	2,50
Spheroidal graphite cast iron and malleable cast iron	2,5	3,13
Copper-zinc wrought alloys and aluminium wrought alloys	2,0	2,50
Copper-tin cast alloys and copper-zinc cast alloys	2,5	3,13
Aluminium cast alloys A_{min} 4 %	2,5	3,13
Aluminium cast alloys A_{min} 1,5 %	3,2	4,00

6.1.13 Springs requirements

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 (see, for example, EN 13906-1, EN 13906-2 and EN 13906-3).

6.2 Strength of metallic body and its inner metallic partition walls

6.2.1 General

The strength of these pressure-containing parts shall cover the pressure risk.

6.2.2 Requirements

The limit pressure p_l (determined or calculated in accordance with 6.2.3), maximum allowable pressure, DP, and maximum inlet pressure, p_{umax}, shall be as per Formula (1):

$$p_l \geq S_b \times DP \geq S_b \times p_{umax} \quad (1)$$

where S_b is the minimum value of safety factor for parts of the body stressed by forces from pipelines only (see Table 8).

Where a chamber in the control is separated into individual pressure-containing chambers by a metallic partition wall, the partition wall shall be designed taking into account the maximum differential pressure. Formula (2) shall be used:

$$p_l \geq S \times \Delta p_{max} \tag{2}$$

where S is the minimum value of safety factor for parts of inner metallic partition walls (see Table 8).

6.2.3 Design strength verification for metallic body and its inner metallic partition walls

6.2.3.1 Calculation method for metallic parts

Verification is made by proving the compliance of:

— the actual safety factors with those specified in 6.1.12; and

— minimum allowable thicknesses shown in drawings with values specified in the strength calculations.

Strength calculation of metallic parts (main components, welded joints and fasteners) shall be carried out according to relevant and applicable technical standards and calculation codes to comply with requirements of this document.

6.2.3.2 Experimental methods for metallic pressure-containing parts

Verification is made by proving the compliance of the actual safety factors with those specified in 6.1.12, taking into account the minimum allowable thicknesses shown in drawings and the minimum proof stress (yielding) for selected material.

Actual safety factors are obtained through one of the following two ways:

— hydrostatic pressure test applied until the first sign of yielding or failure becomes apparent in any component and verification that limit pressure, p_l, at which the first sign of yielding or failure becomes apparent with Formulae (3) and (4):

for the body only

$$p_l \geq DP \times S_b \times \frac{s_{ry}}{s_{min}} \times \frac{|R_{p0,2}|_r}{|R_{p0,2}|_{min}} \tag{3}$$

for its inner metallic partition walls

$$p_l \geq DP \times S \times \frac{s_{ry}}{s_{min}} \times \frac{|R_{p0,2}|_r}{|R_{p0,2}|_{min}} \tag{4}$$

— hydrostatic pressure test and verification that permanent deformations (see Note) do not exceed 0,2 % of the distance between any two points on a pressure-containing part before applying the test pressure, l_0, or 0,1 mm, whichever is greater, up to the following test pressures [see Formulae (5) and (6)]

for the body only

$$0{,}9 \times DP \times S_b \times \frac{s_{rw}}{s_w} \times \frac{|R_{p0,2}|_r}{|R_{p0,2}|_{min}} \tag{5}$$

for its inner metallic partition walls

$$0,9\times DP\times S\times\frac{s_{\mathrm{rw}}}{s_{\mathrm{w}}}\times\frac{\left|R_{p0,2}\right|_{\mathrm{r}}}{\left|R_{p0,2}\right|_{\mathrm{min}}} \tag{6}$$

where

s_{min} is the minimum design wall thickness at the point where the first sign of yielding occurs in mm;

s_{ry} is the measured wall thickness of test sample at the point where the first sign of yielding occurs in mm;

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

$|R_{\mathrm{p0,2}}|_{\mathrm{r}}$ is the measured proof stress (yielding) for the material of the test sample according to relevant document in N/mm^2;

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.

NOTE The percentage of the permanent deformation is calculated with Formula (7):

$$100\times\frac{l-l_0}{l_0} \tag{7}$$

where

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

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

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

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.

Control bodies and pressure-containing parts manufactured from different materials may be pressure-tested separately.

Special high strength clamping bolts and nuts and gaskets (between individual pressure-containing parts) may be used for hydrostatic testing.

For the components with the specific design pressure DPD, in Formulae (4) and (6) (not in those referred to body) replace the symbol “DP” with the symbol “DPD”.

For pressure-containing parts other than those specified in Formulae (3), (4), (5) and (6) and subjected to differential pressure, Δp_{max}, in Formulae (4) and (6), the pressure DP shall be replaced by Δp_{max}.

The verification of strength by the finite elements method (FEM/FEA) is an alternative method to the aforesaid experimental design method. ASME PTC 60/VandV 10-2006 is a reference for verification and validation of static computational models, calculated by FEM/FEA.

6.2.3.3 Strength test for verification of safety factors

Metallic pressure containing parts, including those that become pressure-containing 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 and acceptance criteria detailed in 6.2.3.2 for at least 3 min. Pressure-containing parts subjected to the strength test shall show no visible leakage.

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 air or nitrogen, if the necessary safety measures are taken.

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

6.3 Other pressure-containing metallic parts of integral and differential strength controls

6.3.1 General

The strength of these pressure-containing parts shall cover the pressure risk.

6.3.2 Requirements

Requirements shall be specified according the following classification.

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

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

2) parts that are connected to the body as a result of a failure of conditions and that are either designed to withstand a maximum allowable pressure equal to DP or that are designed to withstand a specific maximum allowable pressure of DPD which is lower than DP and with additional protective measures;

3) parts 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 DP or a specific maximum allowable pressure DPD which is lower than DP.

For pressure-containing parts group 1), the limit pressure, p_l, the design pressure, DP, and the maximum inlet pressure, p_{umax}, shall comply with Formula (8):

$$p_l \geq S \times DP \geq S \times p_{umax} \tag{8}$$

For pressure-containing parts group 2), the limit pressure, p_l, the design pressure, DP, and the maximum inlet pressure, p_{umax}, shall comply with Formula (9):

$$p_l \geq S \times DP \geq S \times p_{umax} \tag{9}$$

As alternative solution, pressure-containing parts of the group 2) can be protected against exceeding their allowable pressure by:

— a safety device integrated to control;

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

— an appropriate design (specific safety device, 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-containing parts, the specific design pressure, DPD, and the maximum pressure, p_{max}, reached in the event of a failure, shall comply with Formula (10):

$$p_l \geq S \times \mathrm{DPD} \geq S \times p_{max} \tag{10}$$

The set point of safety device shall be adjusted in such a way as to limit the pressure to the relevant specific design pressure, DP. Appropriate instructions on this subject shall be included in the operating and maintenance manual.

For pressure-containing parts group 3):

— where the parts are designed to withstand DP, the limit pressure, p_l, the design pressure, DP, and the maximum inlet pressure, p_{umax}, shall comply with Formula (11):

$$p_l \geq S \times DP \geq S \times p_{umax} \tag{11}$$

— where the parts are designed to withstand DPD, the limit pressure, p_l, the specific design pressure design pressure, DPD, and the maximum inlet pressure, p_{max}, reached in the event of a failure, shall comply with Formula (12):

$$p_l \geq S \times \mathrm{DPD} \geq S \times p_{max} \tag{12}$$

In this case, the markings shall include also the maximum component operating pressure, p_{max}, and the specific design pressure design pressure, DPD, as detailed in Clause 10.

Where S = Minimum value of safety factor for parts of the body not stressed by forces from pipelines (see Table 8).

6.3.3 Design strength verification for other pressure-containing parts of integral and differential strength controls

6.3.3.1 Calculation method for metallic parts

Shall be according to 6.2.3.1.

6.3.3.2 Experimental methods for metallic pressure containing parts

Shall be according to 6.2.3.2.

6.3.3.3 Strength test for verification of safety factors

Shall be according to 6.2.3.3 with the following modification:

— Replacement of *DP* by *DPD*.

6.4 Strength of parts transmitting actuating forces

6.4.1 General

The strength of these parts shall ensure the correct performances under stress.

6.4.2 Requirements

When the control device has a safety function, 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 ≥3 against permanent deformation.

6.4.3 Design strength verification for parts transmitting actuating forces

Verification is made by proving the compliance of the actual safety factors specified in 6.4.2 and the compliance of dimensions shown on drawings with values specified in the strength calculations.

As an alternative, verification shall be made by an actual test, checking that no permanent deformation are registered.

Additional design requirements are detailed in Annex E.

6.5 Strength of diaphragms (elastomeric parts)

6.5.1 General

The strength of a diaphragm shall ensure the correct performances under stress.

6.5.2 Requirements

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

— 30 kPa (0,3 bar) if Δp_{max} < 15 kPa (0,15 bar);

— 2 Δp_{max} if 15 kPa (0,15 bar) ≤ Δp_{max} < 500 kPa (5 bar);

— 1,5 Δp_{max} but at least 1 000 kPa (10 bar) if Δp_{max} ≥ 500 kPa (5 bar).

The values of the safety factors applicable to diaphragms when they both have the function of pressure-containing parts and inner partition wall are detailed in the specific standards.

6.5.3 Design strength verification for diaphragms (elastomeric parts)

Design requirements 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 7.3.5.1 and 7.3.5.2 for criteria), or failure, or visual damages shall be detected.

The diaphragm used in this test shall not be the same as used in routine test according to 7.3.5.3.

6.6 Welding

6.6.1 General

Fabrication welds in all pressure-containing parts shall be made using qualified welding procedures in accordance with ISO 15607, ISO 15609-1, ISO 15610, ISO 15611, ISO 15612, ISO 15613, ISO 15614-1 and ISO 15614-2, as applicable, and by qualified welders or welding operators according to ISO 9606-1, ISO 9606-2, ISO 9606-3, ISO 9606-4 and ISO 14732, as applicable.

Welding requirements shall be verified by NDT.

6.6.2 Requirements

For fabrication welds to make bodies, blind flanges, and bonnets:

— only full penetration welds shall be used;

— weld fabrication and heat-treatment shall be in accordance with EN 13445-4 or equivalent.

These additional requirements are not applicable to seal welding.

For welded joints both in pressure-containing 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.

6.6.3 Non-destructive testing of fabrication welds

Fabrication welds on pressure-containing parts shall be non-destructively tested in accordance with Tables 9 and 10.

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.

Table 9 — Non-destructive testing

	Type of non-destructive testing				
	Volumetric		Surface		
	Radiographic	Ultrasonic	Visual	Magnetic particle	Liquid penetrant
Sections to be examined and/or extent of coverage					
Steel castings	EN 12516-1:2014, C.2.1.2		Accessible surfaces	EN 12516-1:2014, C.2.1.3	
Forgings, bars, plates and tubular products	EN 12516-1:2014, C.2.2 and C.2.3		Not applicable		
Fabrication welds	According to Notes E and F in Table 10		Accessible surfaces	According to Note B in Table 10	
NDT procedures and acceptance criteria for castings, forgings and their fusion weld repairs	EN 12516-1:2014, Annex D	EN 12516-1:2014, Annex G	MSS SP 55[a] and ISO 17637[b]	EN 12516-1:2014, Annex E	EN 12516-1:2014, Annex F
NDT procedures and acceptance criteria for fabrication welds, including their repairs	EN 12516-1:2014, C.2.4 and Annex D	EN 12516-1:2014, C.2.4 and Annex G	ISO 17637[b]		

General requirements

— 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.

— The NDTs shall be carried out by qualified personnel in accordance with ISO 9712 or other equivalent documents.

[a] This document is applicable only to steel castings.

[b] This document is applicable only to fusion weld repairs.

Table 10 — 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	N.A.		C	C	D
	$50 \leq p_{max} < 100$			N.A.		
Full penetration fabrication welds	>25	A + F				
	$5 < p_{max} \leq 25$	A + E				
Partial penetration fabrication welds	≤ 25	A + B				

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.

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.

7 Performance and testing requirements

7.1 General

7.1.1 Approach to stable production phase

Stable production shall comply with relevant requirements of:

— type test (7.2.2.1 and 7.2.2.2);

— routine test (7.2.2.3);

— batch surveillance test (7.2.2.4).

Conditions and test tolerances of 7.1.2 and 7.1.3 shall be effective for testing of stable production.

NOTE See Table 11 for reference.

7.1.2 Test conditions

Except where otherwise stated, the tests shall be carried out:

— with air;

— at ambient temperature (i.e. in the temperature range from 5 °C to 35 °C).

All measured values shall be corrected to standard conditions: 15 °C, 101,325 kPa (1 013,25 mbar) dry.

Unless otherwise stated, pressures specified in this document are gauge pressures.

Controls which can be converted to another gas type by exchanging components are additionally tested with the conversion components.

Tests shall be carried out in the mounting position as stated in the installation and operating instructions. Where there are several mounting positions, tests shall be carried out in the least favourable position. Where possible, those tests already covered by other standards (e.g. by relevant parts of the IEC 60730-1 series) shall be combined.

All measurements shall be made after stable conditions have been reached.

7.1.3 Test tolerances

Except where otherwise stated in the relevant clauses, measurements shall be carried out with the maximum test tolerances indicated below:

— absolute pressures: ± 500 Pa or ± 4 %, whichever is greater;

— relative pressures: ± 50 Pa or ± 2 % of the measured value, whichever is greater (e.g. gauge pressures or differential pressures);

— flow rate: ± 3 % of the measured value;

— leakage rate: ± 10 cm^3/h;

— time: ± 0,1 % or ± 0,2 s, whichever is greater;

— temperatures: ± 2 K;

— torque: ± 10 %;

— force: ± 10 %;

— current: ± 1 %;

— voltage: ± 1 %;

— electrical power: ± 2 %;

— supply frequency: ± 0,1 Hz.

The full range of the measuring apparatus is chosen to be suitable for maximum anticipated value; pressure gauges are used in range from 25 % to 75 % of full range.

These measurement tolerances concern individual measurements. For measurements requiring a combination of individual measurements (e.g. efficiency measurements), lower tolerances for the individual measurements can be necessary to limit the total tolerance.

7.1.4 Overview table

This subclause provides the relevant test methods and requirements that shall be used for verification of compliance of controls with the requirements of this document.

Annex D shall be used to proof the full compliance with this document.

Additional applicable test methods and are detailed in the specific controls standards.

Table 11 gives an overview of the different tests and correlates them to the requirements and test methods detailed in relevant clauses.

Table 11 — Summary of test methods and requirements

Test schedule			Requirement	Test method	
T	M	S	Clause	Title	Clause
Design and constructional tests					
A	A	A	7.2.3	Dimensional check	7.3.2.1
A	A	A	7.2.3	Preliminary visual inspection	7.3.2.2
A	A	A	5.1; 5.2.1	Metallic materials check	5.3.1; 5.3.2; 7.3.1
A		A	5.1; 5.2.2	Non-metallic materials check	5.3.3
A			6.2.2 and 6.3.2	Verification of design strength of metallic pressure-containing parts, inner metallic partition walls and other parts of integral and differential strength controls	6.2.3.1, 6.3.3.1, 6.2.3.3 and 6.3.3.3
A			6.4.2	Verification of strength of parts transmitting actuating forces	6.4.3
A	A	A	6.6.2	Verification of strength of welded joints	6.6.3
A			6.5.2	Verification of strength of diaphragms (elastomeric parts)	6.5.3
Functional tests[a]					
A	A	A	7.2.4	Shell and inner metallic partition walls strength test	7.3.4
A	A	A	7.2.5.1; 7.2.5.2	External tightness at ambient temperature	7.3.5.1; 7.3.5.3

[a] Additional functional tests and relevant requirements are given in the specific control standards.

[b] If relevant according to the design requirements.

A = Applicable

S = Batch surveillance

M = Routine tests

T = Type test

Table 11 *(continued)*

Test schedule			Requirement	Test method	
T	M	S	Clause	Title	Clause
A			7.2.5.1; 7.2.5.2	External tightness test at limit temperatures	7.3.5.2; 7.3.5.3
A	A	A	7.2.5.1; 7.2.5.3	Internal tightness at ambient temperature	7.3.6
A			7.2.5.1; 7.2.5.3	Internal tightness at limit temperatures	7.3.6
A			7.2.6	Antistatic characteristics	7.3.7
A[b]		A[b]	7.2.7	Sound emission	7.3.8
A			7.2.8	Resistance to external surface corrosion	7.3.9
A	A	A	7.2.3	Final visual inspection	7.3.2.2

[a] Additional functional tests and relevant requirements are given in the specific control standards.

[b] If relevant according to the design requirements.

A = Applicable

S = Batch surveillance

M = Routine tests

T = Type test

7.2 Requirements

7.2.1 Test rig

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

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

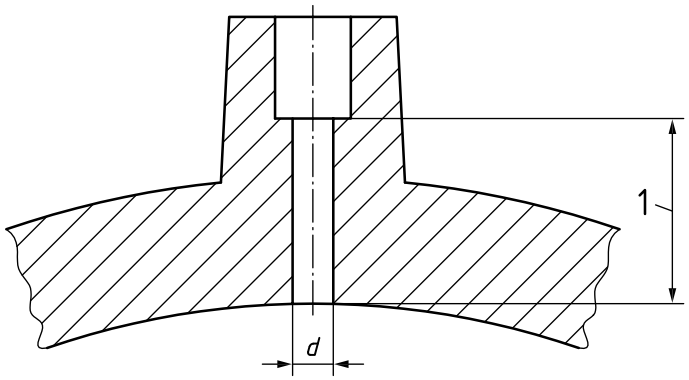
— 50 m/s for pressure ≥ 50 kPa (0,5 bar);

— 25 m/s for pressures <50 kPa (0,5 bar).

The connections between the control and the test rig pipework shall be made using concentric reducers according to ISO 3419 or equivalent. The pressure tapping diameter *d,* shown in Figure 1 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 2), it is permissible to increase the length of the pipework connecting the flow regulating valve 8 (see Figure 2) to the control, 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.

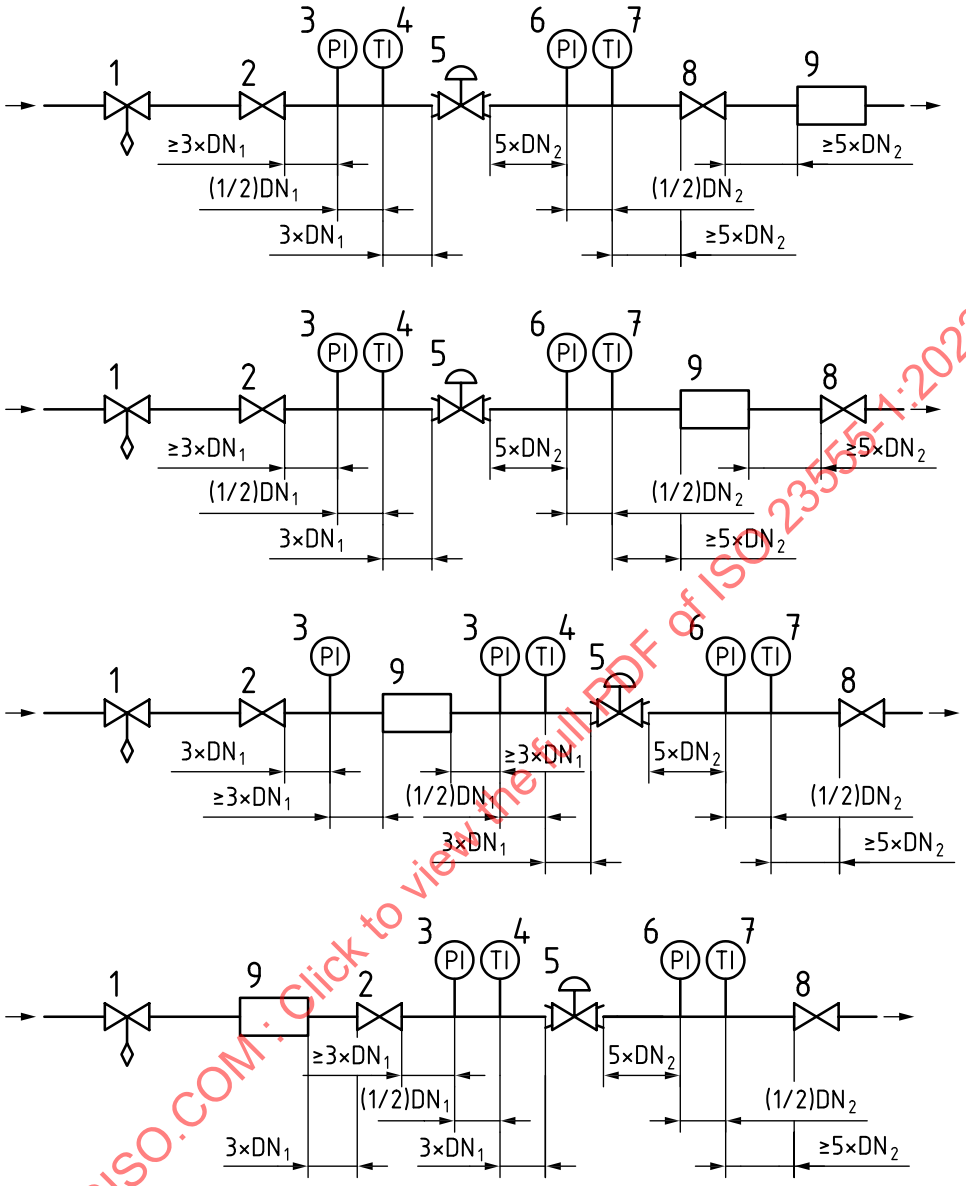


Key

d pressure tapping diameter

1 minimum 2,5 *d*, recommended 5 *d*

Figure 1 — Recommended pressure tapping



Key

1 shut-off device to prevent overpressure, if necessary
2 inlet full bore valve
3 inlet pressure indicator
4 inlet temperature indicator
5 control under test
6 outlet pressure indicator
7 outlet temperature indicator
8 flow regulating valve
9 flow meter
DN_1 nominal diameter of the upstream pipework connected to the control under test
DN_2 nominal diameter of the downstream pipework connected to the control under test

Figure 2 — Test rig requirements

7.2.2 Classification of stable production tests

7.2.2.1 Type tests

The tests in Table 11 carried out to establish the performance classification of the control or the series of controls. These tests include verification of the documentation listed in 8.2.1.

When changes are made to the design of a control or a series of controls in a manner that affects the tests, the manufacturer shall inform the parties involved in the compliance evaluation to this document, if any.

7.2.2.2 Selection of test samples for type test

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

— one control for each type of fixture and/or pilot;

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

— one control for each accuracy class (AC) or group (AG), or control class if applicable;

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

The operational check at the limit temperatures shall only be carried out on one test sample.

7.2.2.3 Routine tests

The tests in Table 11 carried out on each control 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.

Routine tests for integrated safety devices, if any, shall be those detailed in ISO 23555-2 and ISO 23555-3.

7.2.2.4 Batch surveillance

Those tests and verifications in Table 11 are carried out in order to confirm continuing compliance with this document.

Additionally, the tests and verifications include:

— verification of the routine test records;

— verification of drawings and material certificates.

7.2.3 Dimensional check and visual inspection

Dimensions of single parts and main components of controls from stable productions shall be in compliance with the design.

Visual inspection shall check any possible non-conformity of single parts and main components according to internal quality inspection procedures.

7.2.4 Shell strength

Pressure-containing parts subjected to routine and batch surveillance test in 7.3.4 shall show no visible leakage.

7.2.5 External/Internal tightness

7.2.5.1 General

The leakage rate at ambient and limit temperatures shall not be higher than the values listed in Table 12.

Table 12 — Maximum leakage rates

Nominal size DN	Air leakage rate [a] cm^3/h	
	external	internal
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.

The result of the external/internal tightness test is satisfactory if one of the following conditions is met:

— leakage not higher than the values listed in Table 12;

— bubble tight (for internal tightness as per test procedure according to IEC 60534-4).

7.2.5.2 External tightness

The pressure-containing parts and all connecting joints shall be leak-proof.

Acceptance criteria by bubble type can be defined by covering the control with a foaming liquid, by immersing the control in a tank of water or by other equivalent methods.

Additional detection methods for routine and product surveillance tests can be detailed in the specific control standards, with the purpose to combine other functional tests in just one test procedure.

7.2.5.3 Internal tightness

The control member in its closed position and inner metallic partition walls, which are subjected to inlet pressure, shall seal.

Test methods and acceptance criteria of internal tightness are detailed in the specific control standards.

If specified in the order specification, the leakage class of control device in accordance with IEC 60534-4:2006, Table 3, shall be declared. The test method to measure the leakage class shall be in accordance with IEC 60534-4.

7.2.6 Antistatic characteristics

Any external actuated part shall be electrically connected/bonded to the body in such way that the measured resistance does not exceed 10 Ω.

7.2.7 Sound emission

If sound emission is relevant according to the design requirements, the sound pressure level, L_{pA}, of the control shall be given for the operating conditions if the expected L_{pA} of the control exceeds 70 dB.

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 to 8 000 Hz;

— sound pressure level below 70 dB.

The accuracy of the sound pressure measurement or the calculated sound pressure level shall be given and shall not exceed ± 5 dB.

7.2.8 Resistance of external surfaces to corrosion

Control shall comply with at least following requirements:

— Rp 10 according to ISO 10289; and

— external tightness and specific performances of control (see also ISO 23555-2 and ISO 23555-3).

At least corrosivity category C2 of ISO 9223 can be taken as reference for the choice of the surface protection system. More restricted requirements can be subject of request in the order specification.

NOTE Durability of a surface protection system depends on many external factors such as the environment, the design of the control, the surface preparation, and the application. Durability is of course also linked to the chemical and physical characteristics of the surface protection system. These characteristics can be evaluated by artificial-ageing tests. However, results from artificial-ageing tests are used with caution, as it needs to be clearly understood that artificial ageing does not necessarily have the same effect as natural exposure.

7.3 Tests

7.3.1 Materials check at stable production phase

The actions to assess the compliance of the materials used or prescribed with the requirements in 5.1 and 5.2.

The verification of the materials prescribed and used shall be carried out by the review of the part list and relevant material certificates according to 5.3.

7.3.2 Dimensional check and visual inspection

7.3.2.1 Dimensional check before type test and batch surveillance

The actions listed below are relevant to assess the compliance of control before type test or batch surveillance:

— the dimensional compliance of pressure-containing parts with the applicable drawings;

— the compliance of the control construction with the related assembly drawing and the construction.

7.3.2.2 Visual inspection

Visual inspection shall be made:

— before the type test;

— upon completion of the type tests (after type test the test samples shall be dismantled and inspected to verify the compliance).

The control shall show no undue wear, binding, corrosion, damage or other defects which can affect its long-term performance.

Upon completion of the batch surveillance and of the routine tests, the control shall be just externally inspected. There shall be no visible evidence of damages and the markings shall comply with the applicable instructions.

7.3.3 Mounting position

Controls within the scope of this document shall function in any mounting position specified ±5°.

7.3.4 Shell strength

7.3.4.1 Verification method and test for shell and inner metallic partition walls strength

Pressure-containing parts, including those that become pressure-containing 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 13 for 3 min. The requirement in 7.2.4 applies.

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 air or nitrogen, if the necessary safety measures are taken.

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

Table 13 — Pressure values for the shell strength test for stable production

Test pressures	
Chambers with the design pressure design pressure DP	**Chambers with specific design pressure design pressure DPD**
1,5 × DP but at least DP + 0,2 MPa (2 bar) whichever is the greater	1,5 × DPD but at least DPD + 0,2 MPa (2 bar) whichever is the greater

The statistical strength test is applicable to pressure-containing parts of the shell where ($DP \times V$) and, when applicable ($DPD \times V$) is ≤ 5. The envelope volume is the volume under pressure excluding the space occupied by internal parts. The pressure value of DP or DPD is expressed in MPa, the volume V in litres.

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-containing parts shall be at least 10 % of the whole batch. In case 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-containing part fails, the test shall be extended to all pressure-containing parts of the batch.

After exposure, the control shall be tested according to 7.3.5.

7.3.4.2 Alternative verification method and test for shell and inner metallic partition walls strength

Hydrostatic strength test as detailed in 7.3.4.1 be replaced by other tests (e.g. pneumatic test) whose reliability shall be demonstrated. For tests other than the hydrostatic strength 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.

After exposure, the control shall be tested according to 7.3.5.

7.3.5 External tightness

7.3.5.1 Verification method and test for external tightness of metallic shell at ambient temperature

The assembled control and its fixtures are pneumatically tested to assess compliance with the requirements of 7.2.5. and 7.2.5.2.

The test is carried out at ambient temperature with air or gas at the test pressure specified in Table 14. The test on a strength-tested control shall be carried out after a stabilization time of:

— 15 min in the type test;

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

To double-check the compliance with bubble tight requirements, the test can be carried out by covering the control with a foaming liquid, by immersing the control in a tank of water or by other equivalent methods.

The test pressures in Table 14 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 way that deformations of the control 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.

7.3.5.2 Verification method and test for external tightness of shell at the limit temperatures

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

The test shall be conducted at the lowest temperature and subsequently tested at the highest temperature.

Before starting the procedure, the test medium shall be brought to the relevant temperature.

After above checks, the external tightness test in accordance with 7.3.5.1 is repeated at the lowest and highest limit temperatures.

Table 14 — Pressure values in the external tightness test

Test pressures		
Chambers subjected, or that can be subjected to gas pressures		
$>p_d$	$\leq p_d$ [a]	Chambers safeguarded in accordance with 6.3.3 with specific design pressure DPD
1,1 DP	1,2 p_{dmax} but at least 0,5 DP whichever is the greater	1,1 DPD

[a] Only if DP ≤ 2 MPa (20 bar). For DP > 2 MPa (20 bar), the test pressure shall be 1,1 DP.

Where p_{dmax} is the maximum outlet pressure of control

7.3.5.3 Verification method and test for external tightness 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:

— 20 kPa (0,2 bar), if Δp_{max} < 15 kPa (0,15 bar);

— 1,33 Δp_{max}, if 15 kPa (0,15 bar) ≤ Δp_{max} < 500 kPa (5 bar);

— 1,1 Δp_{max} but at least 665 kPa (6,65 bar), if Δp_{max} ≥ 500 kPa (5 bar).

The test method and acceptance criteria are those detailed in clause 7.3.5.1.

7.3.6 Internal tightness

The internal sealing test is carried out to assess compliance with the requirements, test methods and acceptance criteria detailed in the specific control standards.

Additional detection methods for routine and product surveillance tests can be detailed in the specific control standards, with the purpose to combine other functional tests in just one test procedure.

7.3.7 Antistatic characteristics

Any external actuated part shall be electrically connected/bonded to the body and the resistance shall be measured on dry regulators before pressure testing.

The electrical resistance between the external actuated part and the body shall be measured using a DC power source not exceeding 12 V.

7.3.8 Methods for calculating and measuring the sound pressure level

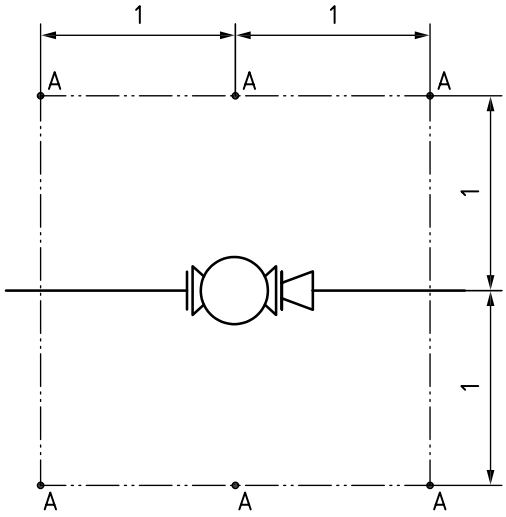
7.3.8.1 General

The following two methods can be used to determine the sound pressure level.

— Measured sound pressure level: the declared L_{pA} shall be measured in accordance with 7.3.8.2 or 7.3.8.3.

— Calculated sound pressure level: with reference to the wide variety of different operating conditions and data, it can be appropriate to determine the noise level by calculation. Calculation methods as detailed in IEC 60534-8-3 may be used. Alternative methods can be used by tailored formulae for a specific series of regulators, and the declared L_{pA} shall be calculated using a method established by the manufacturer.

Dimensions in metres



Key

A standard measurement points

Figure 3 — Points of measurement for sound pressure level

7.3.8.2 Microphone like sound pressure level measuring system

The measurement shall be related to the points of measurement indicated in Figure 3 at the same height as the regulator.

The fully assembled regulator with all its auxiliary devices shall be installed:

— between 0,8 m and 1,2 m above floor level;

— in accordance with the requirements specified in 7.2.1 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 3.

The sound pressure level measurement can be carried out on a test rig built in accordance with Figure 2 if the above requirements are met.

The test report shall include at least the following data:

— test procedure;

— sound measurement tool;

— 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.

7.3.8.3 Accelerometer like vibration measuring system

The fully assembled regulator with all its auxiliary devices shall be installed:

— between 0,8 m and 1,2 m above floor level;

— in accordance with the requirements specified in 7.2.1 with regard to the velocities of the fluid in the test rig.

When making measurements care should be taken that the frequency response of the measuring equipment is compatible with the intended application.

Assuming that all equipment is operating properly, the important variable in making a measurement is the attachment of the accelerometer to the pipe wall. Rigid attachment to the pipe wall is critical to accurate field results.

Ideally, the accelerometer should be rigidly attached to a small metal pad that is welded to the pipe. Also, some device should be used to electrically isolate the accelerometer from the pipe — such as an insulated stud or washer between surfaces. An alternative is to attach pads or studs to the pipe wall using an adhesive. As long as a stiff, thin-layered adhesive is used, this method can be effective over the specified range of the probe. Different adhesives are necessary depending on the temperature of the application.

Magnetic attachments should be of special design to give a firm bond to a cylindrical surface. Even with a good magnetic attachment, the high frequency response is limited. If a magnetic base is used, then the surface should be clean of paint and dirt to ensure maximum contact.

Hand-held accelerometers generally are limited to very low frequency measurements.

This method cannot be used if the accelerometer is located on a flange, elbow, valve body, or other pipe fitting. Measurements should be taken a minimum of two diameters from the end of a straight run of pipe.

The test report shall include at least the following data:

— test procedure;

— sound measurement tool;

— indication of the point where the accelerometer has been attached;

— the units of measurement used to express the results.

7.3.9 Method for testing of resistance of external surfaces to corrosion

Control, after the tests in accordance with Table 11, shall be:

a) installed with:

   — body ends; and

   — all connections to be connected to lines in normal operating conditions;

b) closed, in a spray cabinet and exposed to a neutral salt spray in accordance with ISO 9227 for at least:

   — 168 h (for indoor installations);

   — 240 h (for open-air installations).

During the period of exposure, the operating conditions of ISO 9227 shall be met.

After exposure as above, without any further intervention, the requirements related to external tightness and those related the performances of control shall be re-verified at ambient temperature only.

8 Documentation

8.1 General

Documentation that can be provided on paper, or online, or on digital or analogue media and it has the purpose to provide official information or evidence or to serve as a record.

The procedures of documentation are covered by relevant internal standard operating procedure.

In general, they can involve document drafting, formatting, submitting, reviewing, approving, distributing, reposting and tracking, etc.

Documentation should be easy to read and understand.

Clear, short, familiar words should be used to a maximum of 15 words per sentence.

Relevant requirements for documentation are detailed for each test class (see 8.2, 8.3 and 8.4).

8.2 Documentation related to type test

8.2.1 Documentation required prior to type test

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

— photographs and/or leaflets;

— scheme and related functional description;

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

— assembly drawing of the regulator;

— overall dimensional drawing;

— nameplate drawing;

— strength calculation or test report for all pressure-containing parts;

— parts list with material description for all components;

— manufacturing drawings of all pressure-containing parts and critical internal components;

— operating instructions (installation, operation and maintenance manual).

8.2.2 Type test report

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

8.3 Documentation related to batch surveillance

8.3.1 Documentation to be available for batch surveillance

For each series of control, the manufacturer shall have the following documentation available:

— type test report;

— records of inspections satisfactorily passed during the manufacturing process.

8.3.2 Batch surveillance report

The batch surveillance report shall detail the results of all tests and verifications listed in 7.1.4.

8.4 Documentation related to the routine tests

8.4.1 Documentation provided at the request of the customer

Following documents can be provided on request: inspection certificate, NDT certificate and/or material certificate in accordance with ISO 10474 for pressure-containing parts and for bolts, screws and studs, if applicable.

This documentation can be provided to the customer upon agreement.

8.4.2 Documentation provided with the control

Installation, operation and maintenance manual (operating instructions) shall be included with each control or shipment of controls, and it shall be written in the language of the country of destination or in the languages accepted by the user. It shall contain:

— information on safe use of the connections;

— safety requirements concerning commissioning and de-commissioning procedures;

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

— 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;

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

— provisions, if any, for transport and handling;

— appropriate instructions on how to trace the right spare parts;

— appropriate instructions on storage requirements for spare parts;

— a statement on installation according to the provisions of regional requirements;

— specific provisions for visual indication of 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;

— specific provisions as specified in 6.3 for the protection of pressure-containing parts in differential strength controls and for the specific markings IS and, where applicable, DS;

— a statement that the control does not require any protection against exceeding its design pressure when the upstream pressure the maximum downstream pressure is less than or equal to 1,1 × DP.

9 Marking

9.1 General

The 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 routine inspection certificate (see specific control standard).

9.2 Basic requirements

Each control put on the market shall carry markings containing at least the following data:

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

— manufacturer's address (town and country);

— strength type;

— serial number;

— end connection type (flanged, threaded, etc.);

— year of manufacture;

— nominal size, DN;

— flange ratings;

_ design pressure DP;

— maximum component operating pressure, $p_{max,}$ and the specific design pressure DPD of safeguarded chambers (for differential strength controls only);

— operating temperature range (class 1, class 2);

— leakage class in accordance with IEC 60534-4:2006, Table 3, if applicable;

— where necessary, warning drawing attention to dangerous misuses;

— additional marking in accordance with order specification.

The marking, where applicable, shall be accompanied by specific set range.

Other additional markings requirements shall be listed in the specific control standards.

9.3 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.

9.4 Marking of integrated safety devices

The safety devices shall be marked according to the specific control standard.

10 Packaging and transportation of finished product

10.1 General

The manufacturer should endeavour to acquire materials and components for packaging from suppliers who have a declared environmental policy as per ISO 14021, ISO 14024 or ISO 14025.

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.

To minimize the environmental impact efficient transport of finished product should be adopted.

Finished product features shall not be impacted by packaging, handling and transport operations.

10.2 Requirements

Before packaging, the control shall be subjected to the following:

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

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

10.3 Test

Conformity of packaging shall be verified by visual inspection and internal quality procedures effective at stable production phase.

Annex A
(informative)

List of materials

A.1 Steel materials for pressure-containing parts and inner metallic partition walls

The steel materials listed in Table A.1 with the restrictions listed in the last 5 columns, are suitable for the design of pressure-containing parts and inner metallic partition walls of controls complying with this document.

A.2 Metallic materials other than steel for pressure-containing parts and inner metallic partition walls

The metallic materials listed in Table A.2 with the restrictions listed in the last 5 columns, are suitable for the design of pressure bearing parts and inner metallic partition walls of regulators complying with this document.

A.3 Materials for auxiliary devices, integral process and sensing lines, connectors and fasteners

The materials listed in Tables A.1, A.2 and/or A.3 with relevant restrictions, are suitable for the design of auxiliary devices and threaded sealing plugs. The materials listed in Table A.3 with relevant restrictions are suitable for the design of integral process and sensing lines, connectors and fasteners of controls complying with this document.

Tables A.1 to A.3 differentiate the various parts of the controls.

Table A.1 — Steel materials for pressure-containing parts and inner metallic partition walls[a, b]

Materials			Control restrictions				
Group	Type	Relevant document	Operating temperature		DP_{max}	$[DP \times DN^{b}]_{max}$	$DN_{max}{}^{b}$
			-10 °C to 60 °C [a]	-20 °C to 60 °C	bar	bar x mm	mm
Pressure-containing 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 10025-1:2004 EN 10025-2:2004/AC: 2005	x		100	—	—
	S235J2G3/1.0116 and S235J2G4/1.0117, both with nominal thickness <1 mm and ≤ 150 mm S275J2G3/1.0144, S275J2G4/1.0145 and S355J2G3/1.0570, all with nominal thickness <2,5 mm and ≤ 150 mm	EN 10025-3:2004 EN 10025-4:2004 EN 10025-5:2004		X			
	S275JO/1.0143 and S355JO/1.0553, both with nominal thickness <1,5 mm and ≤ 250 mm and supplementary requirements KV 27 J average of three and 20 J min at -20 °C.	EN 10025-6:2004 +A1:2009					
	P235GH/1.0345, P265GH/1.0425, P295GH/ 1.0481, P355GH/1.0473, all with product thickness ≤ 150 mm	EN 10028-2:2009	x				
	P275NH/1.0487, P355NH/1.0565 with thickness ≤ 150 mm P355NL1/1.0566 with product thickness ≤ 5 mm and ≤ 150 mm	EN 10028-3:2009		x			
	All types	EN 10028-4:2009, 10028-5:2009		x			
	All grades from P355 to P 500 with product thickness ≤ 150 mm	EN 10028-6:2009		x			
	All austenitic steel designation, other steel designation with A_{min} ≥ 16 % [d] and impact properties at temperatures <-20 °C	EN 10028-7:2007		x			
	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 10083-1:2006	x				
	36CrNiMo4/1.6511 and 39NiCrMo3/1.6510 quenched and tempered (+QT) with supplementary requirements *Amin* = 16 % and KV 27 J average of three and 20 J min. at -20 °C			x			

[a] These materials can be used for operating temperature from -20 °C to 60 °C when DP ≤ 2,5 MPa (25 bar).

[b] Body inlet nominal size shall be considered. For the bodies of any other main component (pilot, controller, ...) and auxiliary device, this term shall refer to their inlet connections.

[c] t_R =thickness of ruling section (ref.: EN 10250)

[d] A_{min} = minimum percentage elongation after fracture (see ISO 6892-1:2016, 3.4.2), according to the applicable document, relevant to the chosen material). ISO 2566-1 and ISO 2566-2 can be a useful reference for conversion of elongation values.

Table A.1 *(continued)*

Materials			Control restrictions				
Group	Type	Relevant document	Operating temperature		DP_{max}	$[DP \times DN^{b}]_{max}$	$DN_{max}{}^{b}$
			-10 °C to 60 °C [a]	-20 °C to 60 °C	bar	bar x mm	mm
Rolled and forged steel	Steel designations quenched and tempered (+QT) with *Amin* ≥ 16 % and with supplementary requirements for cast analysis C ≤ 0,25 %.	EN 10083-2:2006	x		100	—	—
	All austenitic steel designations, other steel designations with longitudinal *Amin* ≥ 16 % and supplementary requirements KV 27 J average 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	x				
	P195TR2/1.0108, P235TR2/1.0255, P265TR2/1.0259 with supplementary requirements KV 27 J average of three and 20 J min. at -20 °C			x			
	All steel designations with *Amin* ≥ 16 % and supplementary requirements KV 27 J average of three and 20 J min at -20 °C	EN 10222-2 1999/AC:2000		x			
	All steel designations	EN 10222-3:1998		x			
	All steel designations	EN 10222-4:1998/A1:2001		x			
Rolled and forged steel	All steel designations martensitic type	EN 10222-5:1999/AC:2000	x		100	—	—
	All steel designations austenitic type, other steel types with *Amin* ≥ 16 % and supplementary requirements KV 27 J average 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 $t_{R \leq}$ 500 mm [c]			x			
	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 average of three and 20 J min at -20 °C	EN 10272:2007		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			

[a] These materials can be used for operating temperature from -20 °C to 60 °C when DP ≤ 2,5 MPa (25 bar).

[b] Body inlet nominal size shall be considered. For the bodies of any other main component (pilot, controller, ...) and auxiliary device, this term shall refer to their inlet connections.

[c] t_R =thickness of ruling section (ref.: EN 10250)

[d] A_{min} = minimum percentage elongation after fracture (see ISO 6892-1:2016, 3.4.2), according to the applicable document, relevant to the chosen material). ISO 2566-1 and ISO 2566-2 can be a useful reference for conversion of elongation values.

Table A.1 *(continued)*

Materials			Control restrictions				
Group	Type	Relevant document	Operating temperature		DP_{max}	$[DP \times DN^{b}]_{max}$	$DN_{max}{}^{b}$
			-10 °C to 60 °C [a]	-20 °C to 60 °C	bar	bar x mm	mm
	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 A 105/A105M:2014	x				
	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				
	A 106 grade B with supplementary requirements KV 27 J average of three and 20 J min. at -20 °C			x			
	Types F5a/F6a class 2 with supplementary requirements KV 27 J average 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				
	All austenitic types, all other grades with *Amin* ≥ 16 % and supplementary requirement KV 27 J average 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			
	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 average of three and 20 J min. at -20 °C	ASTM A 311/A 311M :2004 (2015)		x			
	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	100		
	A 516 all grades with KV 27 J average of three and 20 J min. at -20 °C (supplementary requirement S5)	ASTM A 516/A 516M:2010		x			
	A 564 H1075 with supplementary requirements *Amin* ≥ 16 % and KV 27 J average of three and 20 J min. at -20 °C, A 564 T630 H1150 and H1150M with supplementary requirements KV 27 J average of three and 20 J min. at -20 °C	ASTM A 64/564M:2013		x			

[a] These materials can be used for operating temperature from -20 °C to 60 °C when DP ≤ 2,5 MPa (25 bar).

[b] Body inlet nominal size shall be considered. For the bodies of any other main component (pilot, controller, ...) and auxiliary device, this term shall refer to their inlet connections.

[c] t_R =thickness of ruling section (ref.: EN 10250)

[d] A_{min} = minimum percentage elongation after fracture (see ISO 6892-1:2016, 3.4.2), according to the applicable document, relevant to the chosen material). ISO 2566-1 and ISO 2566-2 can be a useful reference for conversion of elongation values.

Table A.1 *(continued)*

Materials			Control restrictions				
Group	Type	Relevant document	Operating temperature		DP_{max}	$[DP \times DN^{b}]_{max}$	$DN_{max}{}^{b}$
			-10 °C to 60 °C [a]	-20 °C to 60 °C	bar	bar x mm	mm
Rolled and forged steel	A 694 all grades with supplementary requirement for chemical composition: C ≤ 0,25 %	ASTM A 694/A 694M:2014	x			-	-
	A 694 Gr F60 with supplementary requirement KV 27 J average of three and 20 J min at -20 °C			x			
	A 707M all grades from L2 to L8 and all classes	ASTM A 707/A 707M:2014		x			
	20,25 with *Amin* ≥ 16 %, supplementary requirement KV 27 J average of three and 20 J min at -20 °C	CN GB/T 699-2015		x	100		
	A105,25 with *Amin* ≥ 16 %, supplementary requirement KV 27 J average of three and 20 J min at -20 °C	CN GB/T 12228-2006		x	100		
	20,16Mn,15CrMo,14Cr1Mo,12Cr1MoV,12Cr2Mo1, 12Cr5Mo, with *Amin* ≥ 16 %, supplementary requirement KV 27 J average of three and 20 J min at -20 °C	CN NB/T 47008-2017		x	100		
	16MnD,08Ni3D ,06Ni9D ,20MnMoD,09MnNiD, with *Amin* ≥ 16 %, thickness ≤ 150 mm	CN NB/T 47009-2017		x	100		
	S30403(022Cr19Ni10), S30408(06Cr19Ni10), S30409(07Cr19Ni10), with *Amin* ≥ 16 %, thickness ≤ 100 mm	CN NB/T 47010-2017		x	100		
	F290, F360, F415, F450, F485, F555 with *Amin* ≥ 16 %, supplementary requirement KV	CN GB/T 29168.3-2012		x	100		
	Q345D with *Amin* ≥ 16 %, supplementary requirement KV 27 J average of three and 20 J min at -20 °C	CN GB/T 1591-2018		x	100		
Rolled and forged steel					100	—	—
	20Cr13,30Cr13,06Cr19Ni10(304),022Cr19Ni10(304L), 06Cr17Ni12Mo2(316), 022Cr17Ni12Mo2(316L), 06Cr18Ni11Ti (321), 12Cr17Mn6Ni5N(201) with *Amin* ≥ 16 %	CN GB/T 1220-2007		x			
	Q245R, Q345R, Q370R with thickness ≤ 16 mm and *Amin* ≥ 16 %	CN GB/T 713-2014		x			
	16MnDR, 09MnNiDR with thickness ≤ 36 mm and *Amin* ≥ 16 %	CN GB/T 3531-2014		x			
	06Cr18Ni11Ti (321), 6Cr18Ni11Ti(321H), 022Cr19Ni10(304L), 022Cr17Ni12Mo2(316L), 06Cr19Ni10(304/304H), 06Cr17Ni12Mo2(316/316H), 06Cr18Ni11Nb(347/347H), 06Cr23Ni13(309S), 06Cr25Ni20(310S), 06Cr25Ni20(310H), with *Amin* ≥ 16 %	CN GB/T 4237-2015		x			
	NCu30 with *Amin* ≥ 16 %	CN NB/T 47046-2015		x			

[a] These materials can be used for operating temperature from -20 °C to 60 °C when DP ≤ 2,5 MPa (25 bar).

[b] Body inlet nominal size shall be considered. For the bodies of any other main component (pilot, controller, ...) and auxiliary device, this term shall refer to their inlet connections.

[c] t_R =thickness of ruling section (ref.: EN 10250)

[d] A_{min} = minimum percentage elongation after fracture (see ISO 6892-1:2016, 3.4.2), according to the applicable document, relevant to the chosen material). ISO 2566-1 and ISO 2566-2 can be a useful reference for conversion of elongation values.

Table A.1 *(continued)*

Materials			Control restrictions				
Group	Type	Relevant document	Operating temperature		DP_{max}	$[DP \times DN^{b}]_{max}$	$DN_{max}{}^{b}$
			-10 °C to 60 °C [a]	-20 °C to 60 °C	bar	bar x mm	mm
	N6	CN GB/T 2054-2013		x			
	NS1101, NS1102, NS3304 with *Amin* ≥ 16 %	CN YB/T 5353-2012		x			
	NS111, NS112 with *Amin* ≥ 16 %	CN YB/T 5264-1993		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				
	A 216M WCB with supplementary requirement KV 27 J average 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 average of three and 20 J min. at -20 °C			x			
	All austenitic types, all other grades with supplementary requirements *Amin* ≥ 16 % and KV 27 J average 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				
	A 426 grade CPCA15 with KV 27 J average 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 average of three and 20 J min at -20 °C	AMS 5355 (Aerospace Material Specification)		x			
	ZG205-415(WCA) with *Amin* ≥ 16 %	CN GB/T 12229-2005	x			—	—
	ZG250-480(WCB), ZG275-485(WCC) with *Amin* ≥ 16 %, with supplementary requirement KV 27 J average and 20 J min at -20 °C	CN GB/T 12229-2005		x		—	—
	20 with thickness ≤ 16 mm and *Amin* ≥ 16 %, supplementary requirement KV 27 J average and 20 J min at -20 °C	CN GB/T 699-2015		x		—	—
	LCB, LCC, LC3, LC9 with *Amin*≥ 16 %, supplementary requirement KV 27 J average and 20 J min at –20 °C	CN JB/T 7248-2008		x		—	—

[a] These materials can be used for operating temperature from -20 °C to 60 °C when DP ≤ 2,5 MPa (25 bar).

[b] Body inlet nominal size shall be considered. For the bodies of any other main component (pilot, controller, ...) and auxiliary device, this term shall refer to their inlet connections.

[c] t_R =thickness of ruling section (ref.: EN 10250)

[d] A_{min} = minimum percentage elongation after fracture (see ISO 6892-1:2016, 3.4.2), according to the applicable document, relevant to the chosen material). ISO 2566-1 and ISO 2566-2 can be a useful reference for conversion of elongation values.

Table A.1 *(continued)*

Materials			Control restrictions				
Group	Type	Relevant document	Operating temperature		DP_{max}	$[DP \times DN^{b}]_{max}$	$DN_{max}{}^{b}$
			-10 °C to 60 °C [a]	-20 °C to 60 °C	bar	bar x mm	mm
	ZG16Cr5MoG, ZG15Cr1MoG, ZG12Cr2Mo1G, with *Amin* ≥ 16 %, supplementary requirement KV 27 J average and 20 J min at -20 °C	CN GB/T 16253-2019		x	100	—	—
	ZG03Cr18Ni10, ZG08Cr18Ni9, ZG12Cr18Ni9, ZG08Cr18Ni9Ti, ZG12Cr18Ni9Ti, ZG08Cr18Ni12Mo2Ti, ZG12Cr18Ni12Mo2Ti, CF3, CF3M, CF8, CF8M, CF8C with *Amin* ≥ 16 %	CN GB/T 12230-2005		x		—	—
	ZG20Cr13	CN GB/T 2100-2017					
	WC6, WC9, C12A with *Amin* ≥ 16 %, supplementary requirement KV 27 J average and 20 J min at -20 °C	CN JB/T 5263-2005		x		—	—
	ZTi1, ZTi2 with *Amin* ≥16 %, supplementary requirement KV 27 J average and 20 J min at -20 °C	CN GB/T 6614-2014		x		-	-

[a] These materials can be used for operating temperature from -20 °C to 60 °C when DP ≤ 2,5 MPa (25 bar).

[b] Body inlet nominal size shall be considered. For the bodies of any other main component (pilot, controller, ...) and auxiliary device, this term shall refer to their inlet connections.

[c] t_R =thickness of ruling section (ref.: EN 10250)

[d] A_{min} = minimum percentage elongation after fracture (see ISO 6892-1:2016, 3.4.2), according to the applicable document, relevant to the chosen material). ISO 2566-1 and ISO 2566-2 can be a useful reference for conversion of elongation values.

Table A.2 — Metallic materials other than steel for pressure containing parts and inner metallic partition walls

Materials			Control Restrictions				
Group	Type	Relevant document	Operating temperature		DP_{max}	$[DP \times DN^{b}]_{max}$	$DN_{max}{}^{b}$
			-10 °C to 60 °C [a]	-20 °C to 60 °C	bar	bar x mm	mm
Pressure-containing 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 1563:2011		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 1083:2004		x			
	EN-GJS400-18-LT/EN-JS1025, EN-GJS-400-18U-LT/EN-JS1049 with wall thickness ≤ 60 mm	EN 1563:2011	x	x			
	EN-GJS400-15/EN-JS1030, EN-GJS-400-18U-RT/EN-JS1059 with wall thickness ≤ 60 mm		x				
	EN-GJS400-18/EN-JS1020						
	400-18LT/S	ISO 1083:2004	x	x	50	5 000	300
	400-15/S, 400-18/S		x				
	A 395M	ASTM A395/A 395M:1999 (2014)	x				
	A 536 Grade 60-40-18	ASTM A 536:1984 (2014)					
Spheroidal graphite cast iron	QT400-18, QT400-18L, QT400-15 with *Amin* ≥ 7 %	CN GB/T 1348-2009 CN GB/T 12227-2005		x	16	1 500	1 000
	QT400-18, QT400-18L with *Amin* ≥ 15 %	CN GB/T 1348-2009 CN GB/T 12227-2005		x	16	5 000	300
Malleable cast iron	Grades 60-40-18, 65-45-12 and 80-55-06	ASTM A 536:1984 (2014)		x	20	1 000	100
	KTH300-06,KTH330-08,KTH350-10 with *Amin* ≥ 6 %	CN GB/T 9440-2010					
	All material designations with *A* ≥ 15 %	EN 1652:1997/AC:2003		x			
	All material designations with *A* ≥ 15 %	EN 12164:2011		x			
	All material designations with *A* ≥ 15 %	EN 12165:2011		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 DP ≤ 2,5 MPa (25 bar).

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

Table A.2 *(continued)*

Materials			Control Restrictions				
Group	Type	Relevant document	Operating temperature		DP_{max}	$[DP \times DN^{b}]_{max}$	$DN_{max}{}^{b}$
			-10 °C to 60 °C [a]	-20 °C to 60 °C	bar	bar x mm	mm
Pressure-containing parts and inner metallic partition walls							
Copper-zinc wrought alloys	ASTM B 283 – UNS No C 37700 and 64200	ASTM B 283:2014		x	100	—	25
	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			
	HPb 59-1 with *Amin* ≥ 15 %	CN YS/T 649-2007		x	20	—	25
	HPb59-1 with *Amin* ≥ 15 %	CN GB/T 29528-2013		x	20	—	25
	All material designations with *Amin* ≥ 15 %	CN GB/T 4423-2007		x	20	—	25
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 1982:2008		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
	All material designations with *Amin* ≥ 15 %	CN YS/T 649-2007		x	20	1 000	25
	ZCuZn40Pb2 with *Amin* ≥ 15 %	CN GB/T 12225-2018 CN GB/T 13819-2013		x	20	1 000	25
	All material designations with *Amin* ≥ 15 %	CN GB/T 4423-2007		x	20	1 000	25
	YZCuZn40Pb with *Amin* ≥ 5 %	CN GB/T 15117-1994		x	20	1 000	100
	YZZnAl4A(YX040A, YZZnAl4B(YX040B)with *A* ≥ 5 %	CN GB/T 13821-2009		x	20	1 000	25
Aluminium wrought alloys	All metallurgic state and thickness for which *Amin* ≥ 4 %	EN 485-2:2013		x	20	—	50
	All metallurgic state and dimensions for which *Amin* ≥ 4 %	EN 586-2:1994		x			
		EN 754-2:2013		x			
	All metallurgic state and thickness for which *Amin* ≥ 4 %	EN 755-2:2013		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 DP ≤ 2,5 MPa (25 bar).

[b] Body inlet nominal size has to be considered; for the bodies of any other main component (pilot, controller, …) and auxiliary device this term shall refer to their inlet connections.

Table A.2 *(continued)*

Materials			Control Restrictions				
Group	Type	Relevant document	Operating temperature		DP_{max}	$[DP \times DN^{b}]_{max}$	$DN_{max}{}^{b}$
			-10 °C to 60 °C [a]	-20 °C to 60 °C	bar	bar x mm	mm
Pressure-containing parts and inner metallic partition walls							
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)					
Aluminium wrought alloys	All metallurgic state and thickness for which *Amin* ≥ 7 %	EN 485-2:2013		x	50	—	50
	EN AW-6082	EN 573-3:2013 and 755-2:2013		x			
	All metallurgic state and dimensions for which *Amin* ≥ 7 %	EN 586-2:1994		x			
		EN 754-2:2013		x			
	All metallurgic state and thickness for which *Amin* ≥ 7 %	EN 755-2:2013		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 485-2:2013		x	100	—	25
	All metallurgic state and dimensions for which *Amin* ≥ 7 %	EN 586-2:1994		x			
		EN 754-2:2013		x			
	All metallurgic state and dimensions for which *Amin* ≥ 7 %	EN 755-2:2013		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 DP ≤ 2,5 MPa (25 bar).

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

Table A.2 *(continued)*

Materials			Control Restrictions				
Group	Type	Relevant document	Operating temperature		DP_{max}	$[DP \times DN^{b}]_{max}$	$DN_{max}{}^{b}$
			-10 °C to 60 °C [a]	-20 °C to 60 °C	bar	bar x mm	mm
Pressure-containing parts and inner metallic partition walls							
	Al Mg 0,5 Si 0,4 Fe 0,2 (6060) in T6 conditions	UNI 9006-1:1988 (withdrawn without replacement)		x	100	—	25
	Al Mg 1 Si 0,6 Cu 0,28 Cr 0,20 (6061) in T6 conditions with thicknesses/ diameters range for which $A \geq 7$ %	UNI 9006-2:1988 (withdrawn without replacement)		x			
Aluminium wrought alloys	Al Si 1 Mg 0,9 Mn 0,7 (6082) in T6 conditions with thicknesses/ diameters range for which $A \geq 7$ %	UNI 9006-4:1987 (withdrawn without replacement)		x			
	1060,3003 with *Amin* ≥ 4 %	CN GB/T 3880.2-2012		x	20	—	50
	6060,6061 with *Amin* ≥ 4 %	CN GB/T 6892-2015		x			
	6060,6061 with *Amin* ≥ 4 %	CN GB/T 3191-2019		x			
	5052,5083,5086 with *Amin* ≥ 7 %	CN GB/T 3880.2-2012		x	20	—	50
	5052,5083,6061,6063 with *Amin* ≥ 7 %	CN GB/T 6892-2015		x			
	5083, 6082 with *Amin* ≥ 7 %	CN GB/T 3191-2010		x			
	5083,6061 with *Amin* ≥ 7 %	CN NB/T 47029-2012		x			
Nickel and nickel wrought alloys	NCu30 with *Amin* ≥ 16 %	CN NB/T 47046-2015		x	100	—	—
	N6	CN GB/T 2054-2013					
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	1 600	1 000
	All alloy designations with elongation ≥ 4 %	ASTM B85:2014		x			
	YL102, YL104, YL112, YL113 All metallurgic state and thickness for which *Amin* ≥ 1,5 %	CN GB/T 15114-2009		x			
	ZL101A, ZL102, ZL104 with elongation *Amin* ≥ 1,5 %	CN GB/T 1173-2013		x	10	250	150
	YL102, YL104, YL112, YL113 with elongation *Amin* ≥ 1,5 %	CN GB/T 15115-2009		x			
	YL102, YL104, YL112, YL113 All metallurgic state and thickness for which *Amin* ≥ 4 %	CN GB/T 15114-2009		x	20	1 600	—
	ZL101A, ZL102, ZL104 with elongation *Amin* ≥ 4 %	CN GB/T 1173-2013		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 DP ≤ 2,5 MPa (25 bar).

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

Table A.3 — Materials for auxiliary devices, threaded sealing plugs, integral process and sensing lines, connectors and fasteners

Materials			Control Restrictions				
Component	Type	Relevant document	Operating temperature		DP_{max}	$[DP \times DN]_{max}$	DN_{max}
			-10 °C to 60 °C	-20 °C to 60 °C	bar x mm	mm	mm
Auxiliary devices and threaded sealing plugs							
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 *A*, $A_{min} \geq 16$ %	EN 10277-3:2008		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+ER-RATA 2015		x			
	All grades	ASTM A 106:2014		x			
	TP 304, TP 304L, TP 316, TP 316L	ASTM A 213/A 213M:2015		x			
Pipes	TP 304, TP 304L, TP 316, TP 316L	ASTM A 269:2014		x	100	—	—
	TP 304	ASTM A 312/A 312M:2015		x			
	Grade 6	ASTM A 333/A 333M:2013		x			
	Screwed and socket steel tube	EN 10255:2004+A1:2007		x			
	P235 TR2/ 1.0255	EN 10216-2:2013					
	Carbon and low alloy steel seamless pipe						
	10,20, Q345D with t ≤ 16 mm and with supplementary requirements for cast analysis C ≤ 0,30 %	CN GB/T 8163-2018		x	40	—	—
	10,20, Q345B, Q345B, Q345D,345E,15CrMo,12Cr2Mo, 10MoWVNb with t ≤ 16 mm and with supplementary requirements for cast analysis C ≤ 0,30 %	CN GB/T 6479-2013		x	100	—	—
	20G,20MnG,25MnG ,15CrMoG, 12Cr2MoG, 12Cr1MoVG, 10Cr9Mo1VNbN,07Cr19Ni11Ti (321H), 07Cr18Ni11Nb(347H) ,07Cr19Ni10 (304H), 08Cr18Ni11NbFG (347HFG) with t ≤ 16 mm and with supplementary requirements for cast analysis C ≤ 0,30 %	CN GB/T 5310-2017		x	100	—	—
	10,20 with *t* ≤ 16 mm and with supplementary requirements for cast analysis C ≤ 0,30 %	CN GB/T 3087-2008		x	40	—	—

Table A.3 *(continued)*

Materials			Control Restrictions				
Component	Type	Relevant document	Operating temperature		DP_{max}	$[DP \times DN]_{max}$	DN_{max}
			-10 °C to 60 °C	-20 °C to 60 °C	bar x mm	mm	mm
Pipes	10,20,15CrMo ,12Cr1Mo ,12Cr2Mo ,12Cr1MoV ,12Cr5MoI ,12Cr5MoNT ,12Cr9MoI ,12Cr9MoNT,07Cr19Ni11Ti (321H) , 07Cr18Ni11Nb (347H) ,07Cr19Ni10 (304H), 022Cr17Ni12Mo2(316L), with t ≤ 16 mm and with supplementary requirements for cast analysis C ≤ 0,30 %	CN GB/T 9948-2013		x	100	—	—
	10MnDG,16MnDG,06Ni3MoDG with *t* ≤ 16 mm and with supplementary requirements for cast analysis C ≤ 0,30 %	CN GB/T 18984-2016	x	x	100	—	—
	L245/B (PSL1)	CN GB/T 9711-2017			40	—	—
	L290/X42 (PSL2)L360/X52 (PSL2)L415/X60 (PSL2),L450/X65 (PSL2),L485/X70 (PSL2),L555/X80 (PSL2) with with supplementary requirements for cast analysis C ≤ 0,30 %,supplementary requirement KV 27 J average And 20 J min at –20 °C	CN GB/T 9711-2017		x	100	—	—
	H62, H59, HPb59-1	CN GB/T 1527-2017		x	100	—	—
	06Cr18Ni11Ti(321), 6Cr18Ni11Ti(321H), 022Cr19Ni10(304L),022Cr17Ni12Mo2(316L), 06Cr19Ni10(304/304H),06Cr17Ni12Mo2(316/316H), 06Cr18Ni11Nb(347/347H),06Cr23Ni13(309S), 06Cr25Ni20(310S),06Cr25Ni20(310H),with *Amin* ≥ 16 %	CN GB/T 14976-2012		x	100	—	—
Pipes	1060,1050A,1200,3003,5052 with *Amin* ≥ 4 %	CN GB/T 6893-2010		x	20	—	50
	5052,5083,6061,6063 with *Amin* ≥ 7 %	CN GB/T 6893-2010		x	20	—	50
	5052,5083,6061,6063 with *Amin* ≥ 7 %	CN GB/T 26027-2010		x	20	—	50
	5083,5454,6061,6063 with *Amin* ≥ 7 %	CN GB/T 4437.1-2015		x	20	—	50
	NCu30 (400), NCr15-8 (600)	CN GB/T 2882-2013		x	100	—	—
	NS3102(600),NS3306 (625) ,NS1101 (800) ,NS1402 (825)	CN GB/T 30059-2013		x	100	—	—
Connectors							
	All steel designations with A_{min} ≥ 8 % and thickness within the relevant limits specified by the document	EN 10277-3:2008		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			
	All grades	ASTM A 420/A 420M		x			
	All group and grates	CN GB/T 3765-2008		x			