BRITISH STANDARD

BS EN 12284:2003

Refrigerating systems and heat pumps — Valves — Requirements, testing and marking

The European Standard EN 12284:2003 has the status of a British Standard

ICS 23.060.20

British Standards

National foreword

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The UK participation in its preparation was entrusted to Technical Committee RHE/18, Refrigeration safety, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

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Refrigerating systems and heat pumps - Valves - Requirements, testing and marking

Systèmes de réfrigération et pompes à chaleur - Robinetterie - Exigences, essais et marquage

Kälteanlagen und Wärmepumpen - Ventile - Anforderungen, Prüfung und Kennzeichnung

This European Standard was approved by CEN on 21 April 2003.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Contents

Foreword

This document (EN 12284:2003) has been prepared by Technical Committee CEN /TC 182, "Refrigerating systems, safety and environmental requirements", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2004, and conflicting national standards shall be withdrawn at the latest by March 2004.

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

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

Annexes A, B, C, D are normative and annexes E and F are informative

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European standard specifies safety requirements, safety factors, test methods, test pressures used and marking of refrigerating valves and other components with similar bodies, hereinafter called valves, for use in refrigerating systems.

It describes the procedure to be followed when designing (by calculation or by an experimental design method) valve parts subjected to pressure as well as the criteria to be used in the selection of materials.

The standard describes methods by which reduced impact values at low temperatures may be taken into account in a safe manner.

This standard applies to the design of bodies and bonnets for pressure relief devices, including bursting disc devices, with respect to pressure containment but it does not apply to any other aspects of the design or application of pressure relief devices.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 378-1, *Refrigerating systems and heat pumps — Safety and environmental requirements — Part 1: Basic requirements, definitions, classification and selection criteria.*

EN 378-2:2000, *Refrigerating systems and heat pumps — Safety and environmental requirements — Part 2: Design, construction, testing, marking and documentation.*

EN 378-4, *Refrigerating systems and heat pumps — Safety and environmental requirements — Part 4: Operation, maintenance, repair and recovery.*

EN 764-4, *Pressure equipment — Part 4: Establishment of technical delivery conditions for metallic materials.*

EN 764-5, *Pressure equipment — Part 5: Compliance and Inspection Documentation of Materials.*

EN 1563, *Founding — Spheroidal graphite cast irons.*

EN 10045-1, *Metallic materials — Charpy impact test — Part 1: Test method.*

EN 10087, *Free-cutting steels — Technical delivery conditions for semi-finished products, hot-rolled bars and rods.*

EN 10204, *Metallic products — Types of inspection documents.*

prEN 12516-2, *Industrial valves — Shell design strength — Part 2: Calculation methods for steel valve shells.*

EN 13445-2:2002, *Unfired pressure vessels — Part 2: Materials.*

prEN 14276-1:2001, *Pressure equipment for refrigerating systems and heat pumps — Part 1: Vessels — General requirements.*

EN 60534-2-1:1998, *Industrial-process control valves — Part 2-1: Flow capacity — Sizing equations for fluid flow under installed conditions (IEC 60534-2-1:1998).*

EN ISO 6708:1995, *Pipework components — Definition and selection of DN (nominal size (ISO 6708:1995).*

ISO 7268:1983, *Pipe components — Definition of nominal pressure.*

CR-ISO 15608:2000, *Welding — Guidelines for a metallic material grouping system (ISO/TR 15608:2000).*

3 Terms and definitions

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

3.1
Valve
device with shut-off, non-return, regulating- or control functions for refrigerant flow or a filter device in similar dimensions. It can be operated by hand, by an actuator or by the system pressure of the plant

NOTE The expression ‘control valve' denotes an automatic valve with a feedback system and the expression ‘regulating valve’ denotes a hand-operated valve which may have a shaped cone to assist the regulating function.

3.2
Operating range
the combination of temperature and pressure conditions at which the valve can safely be operated

3.3
Nominal size (DN)
an alpha-numeric designation of size for components of a pipework system [See EN ISO 6708:1995]

3.4
Nominal pressure (PN)
a value of a pressure in the range of the maximum allowable pressure for planning a plant or a component (see ISO 7268:1983)

3.5
Corrosion
all forms of material wastage (e. g. oxidation, erosion, wear and abrasion)

3.6
Maximum design temperature
highest temperature that can occur during operation or standstill of the refrigerating system or during testing under test conditions

3.7
Minimum design temperature
lowest temperature that can occur during operation or standstill of the refrigerating system or during testing under test conditions

3.8
min $t_{0\ 100}$
the lowest temperature at which the valve can be used at a load of up to 100 % of the allowable design stress at 20 °C, taking the safety factors according to Table A.2 into account

3.9
min $t_{0\ 75}$
the lowest temperature at which the valve can be used, if is load amounts to 75 % maximum of the allowable design stress at 20 °C, taking the safety factors according to Table A.2 into account

3.10
min $t_{0\ 25}$
the lowest temperature at which pressure parts can be used, if their load amounts to 25 % maximum of the allowable design stress at 20 °C, taking the safety factors according to Table A.2 into account

4 List of Symbols

Symbols used in this Standard are given in Table 1:

Table 1 – List of symbols

A_L	Elongation after fracture where the measured length is equal or greater than 0,4 times of diameter of the rod	mm
A_5	Elongation after fracture where the measured length is equal 5 times of diameter of the rod	%
a	Lifetime in years; for valves 20 years	anno
C_Q	Factor to compensate for the quality of a casting	—
δ_e	Negative wall thickness tolerance	mm
e_{act}	Actual wall thickness at given measuring points of the valve to be tested	mm
e_c	Reduction in wall thickness caused by occurance of corrosion	mm
e_{con}	Component wall thickness as specified in the design drawing	mm
KV	Impact rupture energy	J
KV_0	Threshold value of impact rupture energy, where the impact rupture energy is defined as independent of the temperature	J
KV_0^t	Standard value of impact rupture energy at standard temperature of the material	J
$KV_{TS\ min}$	Impact rupture energy at minimum operating temperature TS_{min}	J
K_{VS}	is the rate of flow of water in cubic metres per hour for a differential pressure Δp of 1 bar (0,1 MPa) at the rated full opening	m^3/h
L	the leakage in percent of K_{VS}	%
N_6	is 31,6 according to Table 1 of EN 60534-2-1	—
PD	Design pressure	MPa
P_F	Maximum allowable design test pressure	MPa
PS	Maximum allowable pressure in common sense, without regarding any influence of temperature	MPa
PS_0	Maximum allowable pressure at ambient temperature (– 10 °C to + 50 °C) according to strength design (without temperature correction)	MPa
$PS_{TS\ max}$	Maximum allowable pressure at maximum operating temperature	MPa
$PS_{TS\ min}$	Maximum allowable pressure at minimum operating temperature	MPa
P_{Test}	Minimum burst test pressure (greater than P_F)	MPa
p_1	Upstream pressure	MPa
Δp	Differential pressure	MPa
p'	Testing pressure of each valve after production	MPa
Q_M	Mass flow rate	kg/h
Q_V	upstream flow rate	m^3/h
$R_{e\ 1,0}$	Yield strength, 1,0% offset	MPa, N/mm^2
$R_{e\ 1,0\ TS\ max}$	Yield strength, 1,0% offset at highest operating temperature	MPa, N/mm^2
$R_{e\ 0,2}$	Yield strength, 0,2% offset at ambient temperature	MPa, N/mm^2
$R_{p\ 0,2}$	Proof strength, 0,2% offset at ambient temperature	MPa, N/mm^2
$R_{p\ 0,2\ TS\ min}$	Proof strength, 0,2% offset at minimum operating temperature	MPa, N/mm^2
$R_{p\ 0,2/t}$	Proof strength, 0,2% offset at temperature t	MPa, N/mm^2
$R_{p\ 0,2\ TS\ max}$	Proof strength, 0,2% offset at highest operating temperature	MPa, N/mm^2
$R_{p\ 1,0}$	Proof strength, 1,0% offset at ambient temperature	MPa, N/mm^2
R_{eH}	Upper yield strength	MPa, N/mm^2
$R_{eH\ TS\ max}$	Upper yield strength at highest operating temperature	MPa, N/mm^2
R_m	Tensile strength	MPa, N/mm^2

Table 1 (*continued*)

$R_{m\ TS\ max}$	Tensile strength at highest operating temperature	MPa, N/mm^2
$R_{m\ act}$	Actual tensile strength of the material of the valve to be tested	MPa, N/mm^2
$R_{m\ con}$	Tensile strength used for the design	MPa, N/mm^2
ρ	Density of the actual fluid	kg/m^3
ρ_0	Density of water at 15,5 °C	kg/m^3
ρ_1	Upstream density	kg/m^3
S_C	Factor to compensate effects of corrosion	—
S_{con}	Factor for the calculation of the burst test pressure taking into account the tensile strength according to Table A.2 (see footnote[d] of Table A.2)	
S_F	Factor to allow for forming	—
$S_{TS\ min}$	Factor taking into consideration the impact strength reduction due to minimum operating temperature	—
$S_{TS\ max}$	Factor to allow for the reduction in strength due to the highest operating temperature	—
S_σ	Factor to allow for the test pressure	—
σ_{con}	Initial design stress	MPa, N/mm^2
σ_{corr}	Allowable stress values derived from σ_{con}	MPa, N/mm^2
TS	Operating temperature	°C
TS_{min}	Lowest operating temperature	°C
TS_{max}	Highest operating temperature	°C
V	Inner volume of a valve	l
X	Correction of the actual wall thickness relative to the wall thickness of the design	—
k	assignes the value $\frac{\Delta p}{P_1}$	—
Y	Correction on the basis of current strength values of the test sample relative to the strength parameters for the design of valves	—
Z	Factor to allow for the quality of a joint (e.g. welded joint)	—
∂	Wall thickness reduction per year	mm
NOTE 1 MPa = 10 bar		

5 General Requirements

5.1 Installation and operation

Valves shall be designed to be installed and operated in accordance with the requirements of EN 378 Parts 1, 2 and 4.

5.2 Components under pressure

All parts of the valve shall be designed and manufactured to remain leak proof and to withstand the pressures which may occur during operation, standstill and transportation, taking into account the thermal, physical and chemical stresses to be expected.

5.3 Excessive mechanical stress

After installation, valves, especially valves for hot gas defrosting, shall not be under excessive mechanical stress from fitting of the pipe or from temperature variations during operation.

NOTE Hot gas defrosting can produce hydraulic shocks resulting in transient pressures in excess of *PS*. Further information see subclause 6.3.2 in EN 378-2:2000.

5.4 Leakage

The valve shall not leak to the outside when tested as described in 9.4. Valve seats shall seal to a degree specified in 9.6.

5.5 Functioning of hand-operated valves

Proper functioning of hand-operated valves shall be ensured for the entire operating range up to the allowable pressure *PS* and the associated allowable temperature *TS*.

5.6 Functioning of actuator-operated valves

Proper functioning of actuator-operated valves operated by the fluid or by energy from an external source, shall be ensured for the entire operating range, which is to be specified by the manufacturer.

6 Materials

6.1 General

6.1.1 Using metalic materials

Metalic materials, included welding filler metals, solders, brazing metals and sealants, shall allow for the thermal, chemical and mechanical stresses arising in system operation. Materials shall be resistant to the refrigerants, solvents (in absorption systems) and refrigerant-oil mixtures used in each particular case.

NOTE Extensive lists of suitable materials for steel can be found in EN 13445-2, where also other useful information is found, or for other materials in Annex E of this standard.

6.1.2 Using non-metallic materials

It is permitted to use non-metallic materials, e.g. for gaskets, coatings, insulating materials, and sightglasses, provided that they are compatible with other materials, refrigerants and lubricants.

6.2 Requirements for materials to be used for pressurized parts

6.2.1 Materials listed in this standard (see Annex E) have been identified for use in refrigerating valves

6.2.2 Lamellar cast iron shall not be used but nodular cast iron according EN 1563 can be used down to temperatures at which it can be proved to achieve overall levels of safety equivalent to alternative materials.

6.2.3 Where new materials are proposed, the design shall be carried out using Annexes A to D provided the yield strength or proof strength, as applicable, at the maximum operating temperature and the impact strength at the lowest operating temperature are known. If these properties are not known the material shall not be used.

6.3 Compatibility of connections

Materials which are to be physically linked shall be suitable for an effective connection, depending on the particular materials used and on the dimensions of the piping specified.

6.4 Requirements to avoid brittle fracture

For valves with reduced ductility at low temperatures the allowed stress shall be reduced according to Annex D.

6.5 Requirements for documentation

The quality of materials is to be confirmed according to EN 10204.

6.6 Ductility

Materials which are to be considerably deformed shall be sufficiently ductile and capable of being heat treated where necessary.

6.7 Ageing

Materials for pressurized parts shall not be significantly affected by ageing.

6.8 Castings

Castings shall exhibit a low stress level. If they are not subjected to stress relief heat treatment, controlled cooling shall be ensured after the casting process and after any heat treatment which may have been applied.

6.9 Forged and welded components

Forged and welded components shall be fabricated from suitable materials (e.g. weldable close grain low carbon steel) and shall be heat treated where the combination of operating temperature, operating pressure and wall thickness indicates by calculation that heat treatment is necessary.

6.10 Nuts, bolts and screws

Materials for nuts, bolts and screws for jointing housing parts subject to pressure loads shall exhibit the correct characteristics for the material over the full range of the application limits for the nuts, bolts and screws defined by the operating temperature, whereby the following minimum values for the elongation at fracture and notched impact strength shall be achieved. The test piece for impact strength measurements shall be taken parallel to the drawing or rolling direction, and the notch orientation shall be perpendicular to the drawing or rolling direction.

a) for ferritic materials an elongation at fracture $A_5 \geq 14$ %;

b) for cold-formed austenitic materials an elongation at fracture $A_L \geq 0{,}4 \times d$;

c) a notched impact strength *KV* at 20 °C for tempered alloyed steels of at least 52 J and of at least 40 J for tempered carbon steels (ISO V test-piece).

The following values shall be achieved at the lowest operating temperature:

a notched impact strength *KV* for tempered alloyed steels and tempered carbon steels of at least 27 J (ISO V test-piece).

NOTE Some suitable materials are given in Annex E of this standard.

6.11 Spindles

Material for spindles shall be corrosion-resistant to ensure safe operation, and shall exhibit appropriate material characteristics over the complete operating temperature range.

NOTE Some suitable materials are given in Annex E.

6.12 Seat, valve plate and seal materials

Where soft materials are used for seats, valve plates and seals the material shall be fixed and restrained. Suitable materials are, for example, soft metals or polymers.

7 Design

7.1 General

The design requirements herein cover parts subject to pressure constructed of materials defined in clause 6. The dimensions of pressurized parts shall be such that the stress of the parts in the entire operating range shall be kept within safe limits. Valve strength design shall be based on European Standards (for example prEN 12516-2:2000).

The valve design shall be so that any liquid trapped internally shall be safely relieved or contained.

7.2 Maximum allowable pressure

The maximum allowable pressure *PS* of the refrigerant containing parts shall not be less than the value derived from the temperatures specified in 5.1.2 in EN 378-2:2000.

The maximum allowable pressure *PS* shall not be exceeded except during the short period of time necessary for the pressure relief device to operate with a maximum value of 1,1 times *PS*.

7.3 Design pressure

The design pressure *PD* shall not be less than *PS* which is derived from the temperatures specified in 5.1.2 in EN 378-2:2000.

7.4 Bodies and bonnets

Bodies and bonnets subjected to pressure shall be designed by strength calculation according to prEN 12516-2:2000 or by an experimental design method including a test with the maximum allowable design test pressure P_F and the minimum burst test pressure P_{Test} according to Annex A to D on a representative prototype.

Spindles, discs and gland seals are not subject to these calculations or tests.

7.4.1 Safety factors shall be used in the design of valve bodies, bonnets, flanges, nuts, bolts and screws.

Appropriate factors and methods of using them in design of valve bodies and bonnets are specified in normative Annexes A to D.

7.4.2 Cast or welded valves shall be designed to take account of possible imperfections in the casting or in the welded zone. These matters are covered in Annex A to C.

7.4.3 The material properties used to calculate the strength of bodies and bonnets subjected to pressure and of nuts, bolts and screws used as fasteners shall relate to a temperature of 20 °C.

7.4.4 Screwed bonnets shall be so constructed that it is impossible to screw the bonnet out of the valve body without removing a locking device.

7.5 Final assessment

The strength of the valve shall be verified by test with the maximum allowable design test pressures P_F and the minimum burst test pressure P_{Test}, see Annex A to D.

7.6 Pressure-sensitive components

The functioning of pressure-sensitive components which form part of metering, control and shut-off valves and which are subject to pressure from the refrigerant circuit shall not be impaired at pressures up to the allowable pressure.

When verifying the strength of pressure-sensitive components in a bursting test, a test pressure equal to 2.5 times the allowable pressure shall be applied.

Proof of adequate strength shall be deemed to have been provided if the pressure-sensitive component does not burst.

NOTE The bursting test pressure for pressure-sensitive components is less than the pressure used for testing the main assembly.

8 Construction and workmanship

8.1 General

The construction of a valve shall be suitable for using a valve at pressure and temperature of the refrigerant to which the valve is exposed.

Valves with flanges can only be used in connection with fitting companion flanges.

8.2 Body and bonnet

8.2.1 Particular attention shall be paid to smooth transitions of cross-sections in body design, as sharp edges are liable to reduce the deformability and may thus result in fracture.

8.2.2 Seals between body and bonnet shall be continuously located so that they are confined. Metal to metal seals are permissible provided sufficient force can be applied to seal by deformation.

8.2.3 The contact faces on body and bonnet, on the gland and on the valve head and on the seat faces shall be sufficiently smooth to ensure sealing.

8.3 Valve seats

Hand-operated valves with seat diameters above 25 mm shall be designed so as to prevent sliding friction occurring between the valve plate and the seat in the body, e.g. by providing a spindle capable of rotating against a non-rotating valve Plate.

8.4 Spindle seals and back seating for valves

8.4.1 Spindle seals, such as O-rings, bellows or gland packing, shall, at the operating temperature of the valve, be resistant to oil and refrigerants and remain tight when subjected to positive or negative pressures. In order to prevent breaking caused by freezing water, no moisture shall be allowed to penetrate into bellows seals.

8.4.2 Back sealing (sealing of the spindle by the valve retainer, when the valves is totally open) and spindle seals shall be so designed that the seal (e.g. gland or O-ring) can be replaced or re-tightened from the outside without any risk under operating conditions. The back seat shall be sufficiently tight when the valve is in the fully open position. Replacing and re-tightening from the outside does not apply to spindles which are seldom operated, e.g. for forced opening of solenoid valves, if they are covered by a sealing cap.

8.4.3 When the spindle is sealed by a bellows seal or a diaphragm, a back seat or a gland has to ensure, that the spindle remains sealed if the bellows or the diaphragm fractures. In addition a screwed sealing cap may be provided.

8.4.4 Shut-off valves without back seating e.g. gate-, butterfly-, ball-valves have to be installed in accordance to 7.1.6 in EN 378-2:2000, which states that it must be possible to isolate the shut-off valve from the system without interrupting the system (see 8.4.2).

8.4.5 Hand-operated shut-off valves intended for use during infrequent maintenance operations shall be fitted with a sealing cap in addition to the normal sealing of the valve unless the valve may be required during an emergency.

8.5 Screwed spindles

8.5.1 The valve spindle screw shall be sealed within the valve by the gland, unless the sealing is provided by bellows or diaphragms (see 8.4 3).

8.5.2 The valve spindle shall be designed to avoid additional stresses within the valve so there is no risk when the spindle fails under excessive torque.

8.5.3 Valve spindles shall be designed to avoid scuffing between the spindle, the bonnet and the thread piece, if any. This can be achieved by selecting materials which are compatible in respect of low frictional forces.

8.5.4 Valve spindles shall be manufactured from such materials, which are resistant against corrosion caused by refrigerant and its oil as well as the surrounding conditions (see Annex E).

8.6 Design of glands

It shall be impossible for any part of the gland assembly or the gland assembly as a whole to be unscrewed and thus ejected by internal pressure. One method of achieving this is by using screw threads of a different pitch whereby the screw thread of the gland nut is of the minor pitch.

Means to remove gland assemblies easily shall be provided. Possible methods of achieving this are by providing tapped holes or a collar.

NOTE Special design features may be required in the case of temperatures below about – 40°C in order to ensure proper functioning over the whole range of allowable temperatures. One method of achieving this is by providing a heated or thermally insulated extension of the bonnet.

8.7 Locking of spindles and shafts

Spindles and shafts of shut-off valves shall be secured against unintentional unscrewing.

8.8 Caps

The body or bonnet may be provided with a seal cap where the spindle passes through the gland. Caps of shut-off valves which are not, in normal circumstances, to be used shall be capable of being provided with a seal wire and a seal to prevent operation by unauthorized persons. Screwed caps which are intended to act as a seal shall remain tight up to the allowable pressure *PS* and shall be so designed that the internal pressure decreases on opening before the screw thread ceases to be capable of sustaining the load. Methods of achieving this include a relief bore in either the cap or the valve body.

Screw threads on valve caps shall be right-handed.

8.9 Hand-operated valves

8.9.1 Attention shall be paid to the need to equalize differential pressure if the valve nominal size and the pressure difference are sufficiently high to require it. Equalization may be by external or internal bypass, see Table 2.

NOTE For permissible manual forces see EN 12570: Industrial valves — Method for sizing the operating element.

Table 2— Hand operated valves: Suggested maximum differential pressure for closing by hand

PS	DN							
MPa	100	125	150	200	250	300	350	400
1,0	—	—	—	—	0,9	0,6	0,45	0,35
1,6	—	—	—	1,4	0,9	0,6	0,45	0,35
2,5	—	—	2,1	1,4	0,9	0,6	0,45	0,35
4,0	—	3,3	2,1	1,4	0,9	0,6	0,45	0,35
6,3	4,4	3,3	2,1	1,4	0,9	—	—	—

NOTE 1 Where there is pressure downstream over a valve, valves with PS */ DN* combinations above and to the left of the stepped line and pressure under the valve retainer can be closed manually when the differential pressure does not exceed the allowable pressure marked above.

NOTE 2 *PS / DN* combinations below and to the right of the stepped line normally cannot be closed manually at differential pressures equal to the allowable pressure. Guideline values of the differential pressures up to which closing and opening by hand is possible are listed in the boxes below the stepped line. For higher differential pressures, pressure relief devices (e.g. pressure relief cone, bypass) are to be provided.

NOTE 3 1 MPa = 10 bar

8.9.2 Valves to be used for design testing of pressure vessels, piping sections, or as valves for future extensions, shall be leak-tight in both directions. If the differential pressure is greater than given in Table 2 the required closing torques shall be stated by the manufacturer. If the end user requires such large differential pressures this shall be stated in the order.

NOTE Large valves subject to high piping test pressures in the field may require additional tightening of bonnet nuts, etc., after the test to ensure tightness in accordance with 9.4 and 9.5

8.10 Valves not to be operated by unauthorized persons

Valves which should not be operated when the system is in use shall be so designed as to prevent operation by unauthorized persons. This can be achieved for example by means of caps, sleeves or locks, which shall be operated with tools by authorized persons only. In the case of emergency valves, the tool shall be located nearby and shall be protected against misuse.

8.11 Opening characteristics

The opening characteristics of hand-operated regulating valves shall be so designed that the opening of the seat commences at about two complete turns of the spindle (e.g. by providing a cylindrical base on the cone), and that the open flow cross-section increases progressively.

8.12 Finish

There shall be no imperfections impairing safety, proper function or installation of the valves. This applies particularly to jointing surfaces.

Welds do not generally need to be machined.

Painting, coating, surface refinement and colour shall be at the manufacturer's discretion, unless such treatments have been ordered by the purchaser.

The marking, as specified in clause 10, shall remain durably legible.

8.13 Corrosion protection

Unless valves are made of non-corroding materials, surfaces which are exposed to corrosion, e.g. flange surfaces, screw threads or the interior, shall be provided with an anticorrosive agent or otherwise protected for dry storage at ambient temperature; this protection shall remain effective for at least one year under dry storage conditions.

8.14 Inner cleanness

All the internal surfaces and components likely to come into contact with the refrigerant shall be free of any foreign matter, such as rust, scale, dirt, chips and the like. After completion of manufacture and testing, the valve shall contain no liquid, except that required for corrosion protection, any such liquid being without adverse effect on the refrigerant circuit.

9 Testing

9.1 General

Valves shall be tested in accordance with 9.2 to 9.7. Exept for valves with a safety function, testing according to 9.6 is not necessary for valves with DN less than 25, because the limit is more difficult to reach at smaller flow rates.

NOTE 1 Strength pressure tests may be performed without internal parts which would not withstand the test pressure.

The manufacturer shall determine the level of non destructive testing (NDT) as determined by the joint coefficient (welding joint factor).The degree of Non Destructive Testing (NDT) consequently the valve of the joint coefficient (welding joint factor) shall be at the manufacturer’s discretion. If the end user requires a specific degree of NDT for part of the valve or the complete valve, this shall be stated in the order.

NOTE 2 A specific degree of NDT might be appropriate at the connections of cast steel valves where the tube connections are machined for butt welding.

9.2 Material testing

The manufacturer shall be able to prove that the material properties for metal parts subjected to pressure are in accordance with clause 6.1 of this standard. Proving and observation of material properties needs to fulfill the requirements of A 1.3.2.

Material certificates may be inspected at the premises of the manufacturer.

9.3 Strength pressure testing

9.3.1 To test the construction of a valve, a prototype has to be tested according the Annexes A to D. After production each valve shall be tested at a pressure p' not less than 1,43 times PS_0 or 1,25 times PS_0, if recognizing the maximum allowable temperature. This also applies to valve components tested separately.

NOTE When testing valves which are fitted with pressure sensitive components, such as bellows seals, diaphragms or armature tubes of solenoid valves, the test may be carried out using gas at 1,1 times the maximum allowable pressure PS_0 at ambient temperature, provided that the bodies and bonnets have been designed in accordance with 7.4. Tests of series production may be carried out on a statistical basis.

9.3.2 Under the test pressure, maintained for sufficient time to give reliable results, the specimen shall show no visible defects.

9.3.3 If the strength pressure test is carried out using gas (e.g. air or nitrogen) then it shall be conducted either in a special chamber strong enough to contain the effect of valve bursting or under-water in a tank equipped with means to prevent the ejection of fragments or using other suitable protection devices.

9.3.4 If the strength pressure test is carried out using a liquid, the valve shall be thoroughly dried after completion of the test or at least drained if this adequately satisfies the requirements given in 8.14.

9.4 Leakage testing

9.4.1 The leakage test shall be carried out following the strength pressure test.

NOTE It may however be combined with the strength pressure test described in 9.3.

9.4.2 The test shall be carried out using gas (e.g. air or nitrogen), the test pressure being equal to the maximum allowable pressure PS_0 at ambient temperature.

NOTE Equivalent tests, for example a helium leakage detection test, are permitted.

9.4.3 During the test, no bubbles shall form over a period of at least one minute when the specimen is immersed in water with low surface tension or when a foaming agent is applied with a paint brush.

9.4.4 The test shall be carried out with the valve partially open, or with the pressure applied to both sides simultaneously.

9.4.5 If any changes are made to the test procedure as described above (e.g. in the case of a helium leakage detection test) the test shall be carried out in a manner which ensures a reliable assessment.

9.5 Seat sealing capacity: Production test

9.5.1 The test of seat sealing capacity shall be carried out in accordance with 9.4.2 and 9.4.5.

NOTE There is a difference in the requirements for tightness between manually operated shut-off valves and other types of valve.

9.5.2 When testing the sealing capacity of the seat, the seat shall be closed before the test applying the prescribed closing force.

9.5.3 In the case of valves with multi-directional flow, the seat sealing capacity test shall be carried out for the directions for which the valve is designed.

9.5.4 For valves for which tightness is not essential (e.g. control valves) leakage rates for production test shall not exceed the values specified in 9.6 unless especially agreed between customer and manufacturer.

9.6 Seat sealing capacity: type test

9.6.1 Type tests shall include the tests given in 9.4 and 9.5.1 to 9.5.3

9.6.2 The leakage rate L is specified as a percentage of the K_{VS} value in the flow directions for which the valve is designed. The manufacturer shall measure the leakage in the whole differential pressure range for which the valve is designed using gas. Two-directional valves shall be measured in both directions. The greatest value measured is used for calculating L by means of the formula in 9.6.7 or 9.6.8.

9.6.3 L for regulating and control valves shall be less than 1 %. For shut-off valves not leading to the atmosphere, L shall be less than 0,02 %.

For valves for which tightness is a design feature the manufacturer shall specify L in the technical documentation.

9.6.4 If the limits in 9.6.3 are not suitable the manufacturer shall specify L in the technical documentation.

9.6.5 L can be converted for other media and for other differential pressures in accordance with EN 60534-2-1.

9.6.6 When measuring the leakage rate of the seat, the seat shall be closed before the test applying the prescribed closing force.

9.6.7 The leakage rate is calculated with incompressible fluid upstream using formula (1) from EN 60534-2-1 ignoring the piping geometry factor and the Reynolds number factor, both of which shall be assigned the value of 1.

$$Q_V = 3{,}162 \times K_{VS} \times \frac{L}{100} \times \sqrt{\frac{\Delta p}{\rho / \rho_0}}$$

where

Q_V is the upstream flow rate in cubic metres per hour;

K_{VS} is the rate of flow of water in cubic metres per hour for a differential pressure Δp of 1 bar (0,1 MPa) at the rated full opening;

L is the leakage, in percent of K_{VS};

Δp is the differential pressure in MPa;

ρ is the density of the actual fluid in kilograms per cubic metre;

ρ_0 is the density of water at 15,5°C in kilograms per cubic metre [999 kg/m^3].

NOTE 1 In EN 60534-2-1 the letter C is used for K_{VS}.

NOTE 2 Instead of the volume flow rate Q_v the mass flow rate Q_M can also be used, where $Q_M = \rho_1 \times Q_v$ in kilograms per hour, and ρ_1 is the upstream density in kilograms per cubic metre, even if expansion takes place downstream.

9.6.8 The leakage rate is calculated with compressible fluid (gas) upstream using formula 6 of EN 60534-2-1:1998 ignoring the expansion factor and piping geometry factor which shall be assigned the value of 1 (see note).

$$Q_M = 3{,}162 \times N_6 \times K_{VS} \times \frac{L}{100} \times \sqrt{k \times p_1 \times \rho_1}$$

where

Q_M is the mass flow rate in kilograms per hour,

N_6 is 31,6 according to Table 1 of EN 60534-2-1:1998;

K_{VS} is the rate of flow of water in cubic metres per hour for a differential pressure Δp of 1 bar at the rated full opening;

L is the leakage, in percent of K_{VS};

k is assigned the value $\frac{\Delta p}{p_1}$ to introduce a dimensionless term for computational reasons;

p_1 is the upstream pressure in MPa;

ρ_1 is the upstream density in kilograms per cubic metre.

NOTE A simplification is made by omitting the piping geometry factor in both cases. A further simplification is made by ignoring the Reynolds number factor in 9.6.7. This means that the true leakage rates in some cases will be somewhat lower than calculated. Leaving out the expansion factor in 9.6.8 will give a small deviation towards smaller true leakage rates at small Δp. With rising Δp the true leakage rate can decrease to 50 % of the calculated leakage rate.

9.6.9 Valves with back seat shall be checked to ascertain that the back seat is sufficiently tight to allow change of valve packing without danger to the operator.

9.7 Caps

Caps acting as seals shall be checked for adequate strength, for a clean sealing face and for the presence of a pressure relieving arrangement.

NOTE Tests of series production may be carried out on a statistical basis.

10 Marking and additional information

10.1 General

Marking of valves of greater than *DN* 25 shall include at least the information specified in 10.2 to 10.4 and shall be durably marked on the body or the flange or shall be given on a plate or label permanently attached to the valve.

10.2 Marking

a) Valve manufacturer's trade mark;

b) type identification;

c) Year of manufacture;

d) Allowable pressure *PS* [1)] ;

e) Nominal size *DN* together with Nominal pressure *PN* if appropriate;

f) Arrow indicating the direction of flow, if applicable.

NOTE A flange valve of nominal size 150 with an allowable pressure of 2,8 MPa will be marked as follows: D*N* 150 *PS* 2,8 or 28 (bar). When the valve has connections of nominal size *DN* 150 with a nominal pressure rating of flanges (40 [bar]), it may be appropriate to mark as follows:

DN 150 — 40	or:	DN 150 – 40
PS 2,8 MPa		PS 28

10.3 Hand-operated regulating valves

Hand-operated regulating valves shall additionally be marked with either:

a) letter ‘R' (denoting regulating valve) on upper body flange, or

b) a plate or label with the inscription ‘regulating valve' under the handwheel nut.

10.4 Caps

Caps with a free net internal volume of 1 litre or greater which act as a seal shall be marked with the allowable maximum pressure *PS.*

10.5 Valves of nominal size DN 25 and smaller

Marking of valves of nominal size DN 25 and smaller except valves with safety function shall include at least:

a), b) and f) according to 10.2.

---

1) in MPa or bar

11 Documentation

11.1 Documentation for valves

The manufacturer shall be able to supply the following documentation containing information relevant to safety:

a) assembly and installation instructions;

b) adequate instruction for use;

c) intended use of the device;

d) maintenance and user inspection instructions;

e) information requested in clause 10;

f) drawings and diagrams necessary to understand the instructions;

g) warnings against possible dangers caused by misuse of the valve assembly;

h) reference to this standard;

i) refrigerants for which the device is suitable;

j) K_{VS} value where appropriate (see 9.6);

k) material designation in respect of body parts subject to pressure;

l) pressure and temperature service ranges for actuator-operated control valves;

m) maximum allowable pressure (*PS*) as a function of the minimum and maximum allowable temperature (*TS*[2])).

NOTE The following Table 3 provides an example of how to give the pressure as a function of the temperature.

Table 3 — Pressure as a function of temperature within the documentation of a valve (example)

PS MPa[a]	***TS*** °C
2,2	50,1 to 150
2,8	–10,0 to 50,0
2,1	– 10,1 to – 60,0
0,7	– 60,1 to – 85

[a] 1 MPa = 10 bar

2) If the valve is marked with "bar" in the documentation shall also be used the unit "bar“.

11.2 Documentation for valves of nominal size DN 25 and smaller

Because of a lower risk using valves of nominal size DN 25 or smaller, except valves with safety functions the manufacturer of valves of nominal size DN 25 or smaller and less than category I shall be able only to supply the following documentation containing information relevant to safety:

a) permanent marking after testing by an authorizised representative of the manufacturer;

b) adequate instructions for use of the valve.

Annex A
(normative)

Procedure for the design of a valve by use of a simplified method of calculation

A.1 Guideline for the application of this Annex

A.1.1 General

The procedure described as follows for the design of valves is a procedure to design a valve body by formula (DBF) to withstand a load caused by static internal pressure and is to be applied for the valves designed according to this standard. Alternatively, it is allowed to carry out a design calculation by analysis (DBA) by means of a more sophisticated method based on fracture mechanics or the finite element method. Further reaction forces or moments which are relevant to the strength, as well as the weakening of the valve due to other influences (e.g. corrosion) shall also be taken into consideration.

NOTE Materials with the mechanical properties according to the specifications of prEN 14276-1:2001, EN 13445-2 (materials) or EN 1563 as well as Annex E of this standard may be used.

A.1.2 Method of design and field of application

In this procedure for the design of valves, the design calculation is carried out for the dimensioning of valve parts in accordance with prEN 12516-2:2000, or equivalent methods with a strength value at a temperature between – 10 °C and + 50 °C. A valve designed with these strength values can be used without any correction at temperatures from – 10 °C to + 50 °C, if the impact strength value *KV* for steel and cast steel valves exceeds at ambient temperature 27 J and 14 J or 17 J for spheroidal cast iron (materials EN-GJS-350-22-RT and EN-GJS-400-18-RT) at ambient temperatures according to EN 1563.

The influence of higher and lower temperatures on the dimensioning of the valve body is treated in Annex C and D. If the impact rupture energy for steel and cast steel is less than the above-mentioned values of 27 J or for spheroidal graphite cast iron (materials according to Table E.6) is less than 12 J at – 20 °C or – 40°C, the requirements for the prevention of brittle fracture according to Annex D of this standard shall apply.

The design on the basis of the maximum allowable pressure *PS* can be experimentally verified in accordance with the requirements of Annex B.

Any use of spheroidal cast iron according to EN 1563 at temperatures less than – 10 °C without considering the influence of the temperature to material values is not allowed.

A.1.3 Strength values for the design calculation and proof of material properties

A.1.3.1 Strength values for the design calculation

The strength values (i.e. 0,2 % proof strength $R_{p\,0,2}$, tensile strength R_m for the design calculation can be taken from the EN material standards. In Annex E, the EN standards which correspond to the listed materials are given. If the strength values are not taken from the EN material standards, these shall be verified by means of material certificates in accordance with EN 10204.

A.1.3.2 Proof and observation of material properties

The material for pressure-bearing parts of valves shall be delivered with inspection certificate of conformity and test certificate in accordance with EN 10204 3.1.B (3.1A, 3.1.C, 3.2) which is specific to the product.

Materials including welding consumables for valves of with DN less than 25, except valves with safety function as well as for other pressure carrying parts, shall be delivered with a test certificate 2.2 in accordance with EN 10204.

The material certificates according to EN 10204 shall be established in accordance with the requirements of prEN 764-4 and prEN 764-5.

If material properties are changed during the method of manufacture to such an extent that the strength and/or charpy notch energies are reduced, these reduced values shall be taken into consideration by corrections or shall be subject to suitable compensatory material treatment (e.g. heat treatment).

A.1.3.3 Design calculation of screws and fasteners

Screws and fasteners shall be dimensioned in accordance with the design requirements of Table A.1 (utilization 100 %). Modifications in length as a result of the temperature difference between the lowest and the highest temperature of the intended temperature range, shall be taken into consideration during the design of screws, fasteners, nuts and seals.

Table A.1 — Allowable stresses for the design calculation or testing at test pressure of screws and fasteners

Material	Design requirement[a] at maximum allowable pressure *PS*	Design at design test pressure P_F
Non-austenitic steel	MIN { $R_{m\,t}$ / 4,0; $R_{p\,0,2\,t}$ /3,0 }	MIN { $R_{m\,t}$ / 2,67; $R_{p\,0,2\,t}$ /2,0 }
Austenitic steel	$R_{m\,t}$ / 4,0	$R_{m\,t}$ / 2,67

[a] Index t means: The lower material strength values at the lowest and the highest operating temperature shall be used. The allowable stress shall not be exceeded within the operating temperature range.

A.1.4 Documentation

The strength values used for the calculation, e.g. for the tensile strength or proof strength, as well as the consideration of additional stress or other influences (e.g. corrosion), shall be recorded in the design documents.

A.2 Design stress to be used for the calculation of a valve

The allowable design stress value σ_{corr} to be used for the calculation shall be determined as follows:

$$\sigma_{corr} = \sigma_{con} / (S_C \times Z \times C_Q)$$

where

σ_{corr} is the allowable stress values derived from σ_{con};

σ_{con} is the initial design stress;

S_C is the factor to compensate effects of corrosion;

Z is the factor to allow for the quality of a joint (e.g. welded joint);

(according to Table B.3.2 only for the material with number 1 to 8 at Table A.2 (otherwise Z = 1,0));

C_Q is the factor, to compensate for the quality of casting

(according to Table B.3.3 only for the material with number 9 at Table A.2 (otherwise C_Q = 1,0)).

Table A.2 – Design stress σ_{con} as quotient of characteristic strength value and indicated numerical value (safety factor S_{con})

No.	Material[a]	σ_{con}		S_{con}
		Yield strength[b c]	Tensile strength[b d]	
1	Steel group 1.1 and 1.2	MIN { $R_{p\,0,2}$ / 1,5 ; R_m / 2,4 }		2,4
		$R_{p\,0,2}$ / 1,5	R_m / 2,4	
	Steel group 8.1			
2	at A ≥ 30%	$R_{p\,1,0}$ / 1,5	$R_m/(0,5 + R_m/R_{p\,1,0})$	$0,5 + R_m/R_{p\,1,0}$
3	at A ≥ 35%	MAX {MIN[R_m/3; $R_{p\,1,0}$ / 1,2] ; $R_{p\,1,0}$ / 1,5 }		
		$R_{p\,1,0}$ / [1,2 or 1,5]	R_m/3,0	3,0
4	Cast steel group 1.1 and 1.2	MIN { $R_{p\,0,2}$ / 1,9 ; R_m / 3 }		
		$R_{p\,0,2}$ / 1,9	R_m / 3,0	3,0
5	Aluminium group 21	R_{eH} / 1,5	$R_m / (0,5 + R_m/R_{eH})$	$0,5 + R_m/R_{eH}$
6	Aluminium groups 22 to 26	MIN { $R_{p\,0,2}$ / 1,5 ; R_m / 2,4 }		
		$R_{p\,0,2}$ / 1,5	R_m / 2,4	2,4
7	Copper groups 31 to 38	MIN { $R_{p\,0,2}$ / 1,5 ; R_m / 3,5 }		
		$R_{p\,0,2}$ / 1,5	R_m / 3,5	3,5
8	Titanium tube group 51	—	R_m / 3,0	3,0
9	Spheroidal graphite cast iron group 72.2	$R_{p\,0,2}$ / 2,4	R_m / 3,8	3,8
10	Free-cutting steel	$R_{p\,0,2}$ / 2,5	R_m / 4,0	4,0

[a] The classification into groups of materials is carried out in accordance with CEN report CR ISO 15608 (compare EN 13445-2); materials from this group are contained in Annex E.

[b] Stress values at a temperature of 20 °C or 25 °C shall be used. As a deviation, stress values within the temperature range from – 10 to + 50 °C can be used. Stress values at other temperatures may not be used in connection with these safety factors.

[c] For steel (ferritic and austenitic, as well as cast steel), $R_{p\,0,2}$ can be assessed by reducing $R_{p\,1,0}$ by 25 MPa.

[d] The values and terms of the denominator shall be used for the calculation of the maximum allowable design test pressures P_F and the minimum burst test pressure P_{Test} in accordance with Annex B (B 2 and B.3); compare column S_{con}.

Annex B
(normative)

Experimental design method for valves

B.1 Guideline for the application of this Annex

B.1.1 General

With the experimental design method, the resistance of a valve body against internal pressure in relation to a given choice of material is verified; other reaction forces or moments (e.g. through the spindle in the valve seat or sealing forces transmitted by the spindle in the valve seat or spindle mounting, sealing forces on flange gaskets or retention forces of driving appliances) as well as material weakening or loss due to other influences (i.e. corrosion) shall also be taken into account.

For the determination and/or verification of a maximum allowable pressure PS for which the strength was not or cannot be sufficiently determined by the calculation method according to prEN 12516-2:2000 or by equivalent methods, procedure shall be in accordance with the requirements of this Annex. The design by calculation method can be verified or complemented by this experimental design method.

The experimental design method (without any calculation) shall apply only for valves where the product

$PS \times V < 600 \text{ MPa} \times l$

Materials may be used, if they have mechanical properties in accordance with the requirements of prEN 14276-1:2001 or EN 13445-2 (materials) or EN 1563 or equivalent properties (see informative Annex E of this standard).

Valves, on which, prior to this method, for example a test with a pressure in excess of the allowable pressure PS was carried out by the manufacturer, shall not be used as prototypes for verification by the experimental method.

B.1.2 Procedure for the experimental design method

The following two tests has to be passed:

— testing of an original component in completely assembled condition at test pressure p_F according to the definitions in B.2 and

— testing of the valve body at a test pressure P_{Test} according to the definitions of B.3. This pressure is close to that in force when failure of the valve body occurs.

The influence of the temperature on the strength of a valve material shall be taken into account in accordance with the requirements of A.1.2.

B.1.3 Choice and verification of material properties

The characteristic values for materials for pressure components of the valve to be tested shall meet the requirements of A.1.3.

It shall be proven that the valve to be tested undergoes the same manufacturing process with respect to material properties (e.g. heat treatment) as is used for series production. In the case of material changes relevant to strength taking place during the manufacturing process (e.g. through welding), a compensatory tempering of the material shall take place (e.g. heat treatment). Materials with a deformation higher than 2 % normally has to be heat treated with the respective material specifications. Alternatively, the proof against inner pressure has to be verified by test, if no heat treatment is used. Screws and fasteners used shall meet the requirements of Table A.1.

B.1.4 Test procedure

The objective of the test is to verify or determine the allowable pressure stated by the manufacturer. The design testing as well as the strength testing of the valve body is carried out at ambient temperature (20 ± 5 °C). The respective pressure applied for the purpose of testing shall be maintained for 15 minutes.

By testing with P_F and P_{Test} at least three samples shall be used. The less favourable results shall be recorded as the result.

B.1.4.1 Testing at maximum allowable design test pressure P_F

This test is carried out on an original component in the completely assembled condition.

For the verification of the strength and external tightness at a pressure equal to the maximum allowable design test pressure P_F, the pressure in the valve is applied by gas (e.g. nitrogen, air, helium), whereby the valve opening during the test is such that the pressures before and after the valve seat are equal. Alternatively, the pressure shall be applied simultaneously on both sides. It is continuously increased until approximately 50 % of the intended level has been reached. Subsequently the pressure is increased in increments of about 10 % up to the intended maximum allowable design test pressure P_F. Although generally, at this pressure level, no rupturing of the valve body is to be expected, reference is made to 9.3.3 of this standard, according to which special precautions shall be taken when pressure testing using gas.

Until the testing pressure P_F is reached and during the time of exposure to this pressure, there shall be no leakage from or plastic deformation of the valve body.

The valve body is considered to be tight if, during the test period, no leakage is visually recognizable (e.g. formation of bubbles in water or foam, if foaming agents are used). To check the plastic deformation, the pressure is completely lowered and the valve body is checked for any deformation at a sufficient number of positions on the valve which are representative of the valve body.

B.1.4.2 Testing at minimum burst test pressure P_{Test}

To check the adequate dimensioning of a valve body at a pressure equal to the minimum burst test pressure P_{Test}, the pressure in the valve is applied with water. It is continuously increased to approximately 50 % of the minimum required burst test pressure P_{Test}. Subsequently, the pressure is increased in increments of about 10 % up to the required burst test pressure P_{Test}.

If, during the pressure increase up to the minimum burst test pressure P_{Test}, leakage occurs before this level has been reached, this shall be compensated for until the intended pressure is reached (e.g. by increase of flow volume) or the sealing forces are increased by complementary or supplementary constructional measures. Changes which have the effect of either increasing or decreasing the strength of the valve body when the burst test pressure is applied, in comparison to that of an unchanged design, may not be carried out; changes for the improvement of the tightness may be carried out: It is not necessary that the valve is fitted with all original components (e.g. screws, sealing elements) for this test. Pressure sensitive components which will not withstand the application of the minimum burst test pressure P_{Test}, may be disassembled or replaced before testing.

NOTE Components for a valve may be tested separately with pressures according to the material used.

B.1.5 Documentation

A report shall be made on the test, containing details of the valve, the testing procedure, test assembly including possible changes to the valve, the measuring instruments or measuring methods used and declarations of the accuracy of individual quantities to be measured.

At the end of a series of tests, the achievement of the original state of the measuring system shall be checked and documented.

In addition to the experimentally proved application and of the maximum allowable design test pressure P_F and the minimum burst test pressure P_{Test}, the documentation shall contain the maximum allowable pressure corresponding to the intended operating temperature range (see A.1.2) on the basis of the documentation established in Annex A (see A.1.4), taking into account the requirements of Annex C or D.

Processes during manufacture which are relevant to the strength (e.g. deep-drawing, heat treatment) shall be recorded as part of this documentation.

B.2 Determination of maximum allowable design test pressure P_F

A pre-requisite for the determination of the maximum allowable design test pressure P_F is that the maximum allowable pressure PS meets the design conditions according to Table A.2, with respect to its dimensioning. The maximum allowable design test pressure P_F is derived from the intended maximum allowable pressure PS_0 as:

$P_F = PS_0 \times S_\sigma \times X$ or $P_F = 1{,}25 \times PS_0 \times X \times Y$

where

P_F is the maximum allowable design test pressure;

PS_0 is the maximum allowable pressure at ambient temperature (– 10 °C to + 50 °C) according to strength design (without temperature correction);

S_σ is the factor to allow for the test pressure;

X is the correction of the actual wall thickness relative to the wall thickness of the design;

Y is the correction on the basis of current strength values of the test sample relative to the strength parameters for the design of valves. $Y = R_{m,\,act} / R_{m,\,con}$.

NOTE 1 $X = 1{,}05$, if the expression for X cannot be determined for the design of valves with DN ≤ 80

NOTE 2 $Y = 1{,}05$ for the design of valves with DN < 25

For the Factor S_σ, the values listed in Table B.2.1 shall be used for the respective material group.

Table B.2.1 — List of factors for the determination of the design test pressure P_F

Material[a]	Values of S_σ
Steel groups 1.1 and 1.2	1,43
Steel group 8.1 at A ≥ 30 % at A ≥ 35 %	 1,43 1,43
Cast steel groups 1.1 and 1.2	1,43
Aluminium group 21	1,43
Aluminium groups 22 to 26	1,43
Copper groups 31 to 38	1,57
Titanium tube group 51	1,35
Spheroidal graphite cast iron group 72.2	1,80
Free cutting steel	1,80

[a] The classification into groups of materials is carried out in accordance with CEN report CR ISO 15608; materials from this group are contained in Annex E.

B.3 Determination of the minimum burst test pressure P_{Test}

The minimum burst test pressure P_{Test}, which shall be maintained during the pressure test, shall be:

$$P_{Test} \geq 1{,}1 \times PS_0 \times S_{con} \times X \times Y \times Z \times C_Q$$

where

P_{Test} is the minimum burst test pressure;

PS_0 is the maximum allowable pressure at temperature (– 10 °C to + 50 °C) according to strength design (without temperature correction);

S_{con} is the factor for the calculation of the burst test pressure taking into account the tensile strength according to Table A-2 (see footnote d) of Table A.2);

X is the correction of the actual wall thickness relative to the wall thickness of the design (see B.4);

Y is the correction on the basis of current strength values of the test sample relative to the strength parameters for the design of valves. $Y = R_{m\,act} / R_{m\,con.}$;

Z is the factor to allow for the quality of a joint (e.g. welded joint);

C_Q is the factor, to allow for the quality of a casting.

NOTE 1 X = 1,05, if the expression for X cannot be determined for the design of valves with DN ≤ 80

NOTE 2 Y = 1,05 for the design of valves with DN ≤ 25

NOTE 3 Z is the factor to allow for the quality of a joint according to Table B.3.2 for materials with the number 1 to 8 according to Table A.2 (otherwise Z = 1,0).

NOTE 4 C_Q is the factor to allow for the quality of a casting according to Table B.3.3 for materials with the number 9 according to Table A.2 (otherwise C_Q = 1,0).

The test is completed, if there is no failure due to fracture of the valve body at this pressure.

Table B.3.2 — List of Factors to allow for the quality of the joint

Scope of test or inspection	Factor Z
No welding or 100 % non-destructive test	1,0
Random non-destructive test (1/0.85)	1,18
Visual test (1/0.70)	1,43

Table B.3.3 — List of Factors to allow for the casting quality (spheroidal graphite cast iron according to EN 1563)

Scope of test or inspection	Factor C_Q
casting or 100 % non-destructive test	1,0
Visual test and random non-destructive test	1,1
Visual test	1,25

B.4 Conditions of use taking other influences into account

Corrosion

To make allowances for a reduction of wall thickness, reference is made to prEN 14276-1:2001, subclause 6.2.

In addition, a reduction of the wall thickness due to corrosion can be allowed for during design by the use of a correction factor. Experience of the manufacturer can be considered or the factor to allow for corrosion shall be calculated as follows:

$$X = e_{act} / (e_{con} — \delta_e — e_c) \quad \text{for } DN > 80\text{; maximum value is 1,25}$$

where

e_{act} is the actual wall thickness at given measuring points of the valve to be tested;

e_{con} is the component wall thickness as specified in the design drawing;

δ_e is the negative wall thickness tolerance;

e_c is the reduction of wall thickness due to effects of corrosion.

NOTE Example for the reduction of wall thickness due to effects of corrosion

$$e_c = \partial \times a$$

where

∂ is the wall thickness reduction per year;

a is the life time in years; for valves 20 years.

If the reduction of wall thickness due to corrosion is not considered under designing by a correction factor, than X has to be calculated with e_C = 0,0 for calculating the burst test pressure.

Annex C
(normative)

Determination of the allowable pressure at the maximum operating temperature

C.1 Guideline for the application of this Annex

C.1.1 General

At higher operating temperature ($TS \geq 50$ °C) the allowable pressure *PS* based as the calculated or experimentally confirmed *PS* (according to Annex A or B) is to be corrected to the maximum allowable pressure $PS_{\text{TS max}}$ at the highest operating temperature TS_{max}.

C.1.2 Choice of materials and proof of material properties

Material properties of pressure parts of the valve body shall meet the requirements of A.1.3.

Screws, nuts and fasteners shall be designed in accordance with the requirements of Table A.1 for the highest operating temperature. Elongation resulting from the difference in temperature between the highest operating temperature and the ambient temperature (– 10 °C) shall be taken into consideration for the design of screws, fastenings and seals[3)].

C.1.3 Documentation

The reduction of the maximum allowable pressure at a higher operating temperature shall be documented.

C.2 Determination of the maximum allowable pressure at higher temperatures

The maximum allowable pressure at the maximum operating temperature is derived from the intended operating pressure *PS* at a temperature range (– 10 °C to + 50 °C).

$$PS_{\text{TS max}} = PS_0 \times S_{\text{TS max}}$$

where according to Table A.2:

$S_{\text{TS max}} = R_{\text{p0,2 TS max}} / R_{\text{p0,2}}$, if design is with $R_{\text{p0,2}}$;

$S_{\text{TS max}} = R_{\text{p1,0 TS max}} / R_{\text{p1,0}}$, if design is with $R_{\text{p1,0}}$;

$S_{\text{TS max}} = R_{\text{eH TS max}} / R_{\text{eH}}$, if design is with R_{eH};

$S_{\text{TS max}} = R_{\text{m TS max}} / R_{\text{m}}$, if design is with R_{m}.

3) If the valve is used within the range from the minimum to the maximum allowable operating temperature (from TS_{min} to TS_{max}) this complete temperature range shall be taken into consideration in the design of screws, fasteners, nuts and seals.

Annex D
(normative)

Determination of the allowable pressure at minimum operating temperature (Requirements to avoid brittle fracture)

D.1 Guideline for the application of the methods and the choice of materials

D.1.1 General

At a lower operating temperature (*TS* < – 10 °C) or when the impact values are less than the values given in A.1.2, the operating pressure based as the calculated or experimentally confirmed pressure *PS* is to be corrected to the maximum allowable pressure, $PS_{\text{TS min}}$ at the minimum operating temperature TS_{min}.

Possible procedures to avoid brittle fracture at minimum operating temperature TS_{min} are given in Annex D.3 and D.4 of this standard.

D.1.2 Requirements of materials and proof of material properties

The impact repture energy shall be confirmed by certificates.

For the design by fracture mechanics (*KV*-Method) described in Annex D.3, the *KV*-values at the minimum operating temperature or at a temperature not more than 30 K below the minimum operating temperature shall be determined and verified by means of an ISO V impact energy (Charpy-V-impact test specimen according to EN 10045-1).

For the empirical method (min-t_o-Method) indicated in clause D.4, the impact value *KV* for steel and cast steel, groups 1.1 and 1.2, of 27 J or higher values or for spheroidal cast iron group 72.2, (material LT for low temperatures) of at least 12 J or higher values is to be taken from the material standards (see D.4.1 and Annex E). An impact energy test is to be carried out at min $t_{0\ 100}$ in accordance with the conditions of the material standards.

Aluminium or aluminium alloys, groups 21 — 26 with the exception of aluminium-magnesium alloys with a content of magnesium of more than 6 %, copper or copper alloys, groups 31 — 38, and also titanium are not susceptible to brittle fracture and no particular arrangements for their use at temperatures down to – 196 °C.

Aluminium-Magnesium alloys with a content of magnesium of more than 6 % should be used to a temperature of – 100 °C, only.

NOTE The lattice (face-centred lattice) of aluminium and aluminium alloys, groups 21 — 26, and copper resp. copper alloys, groups 31 — 38, according CR ISO 15608:2000 is different in comparison to steel, groups 1.1 and 1.2 (body-centred lattice). Because of that these materials (groups 1.1 and 1.2) have more the tendency to embrittle at deep temperatures.

Screws and fasteners shall be designed for the minimum operating temperature in accordance with the requirements of Table A.1. Elongation due to the difference between the minimum operating temperature and the ambient temperature (50 °C) shall be taken into consideration in the design of screws, fasteners and seals.[3)]

D.1.3 Documentation

The reduction of the maximum allowable pressure of a valve when used at the minimum operating temperature shall be documented. The method chosen according to D.3 or D.4 shall be declared.

3) see page 29

D.2 Determination of the maximum allowable pressure at the minimum operating temperature

The maximum allowable pressure at the minimum operating temperature is derived from the maximum allowable pressure *PS* as:

$$PS_{\text{TS min}} = PS_0 \times S_{\text{TS min}}$$

$S_{\text{tS min}}$ is calculated in accordance with the method described in D.3 or taken as stated in D.4. With respect to the application for strength design, both methods are equivalent (see Annex F).

D.3 Determination of the maximum allowable pressure at the minimum operating temperature on the basis of fracture mechanics theory

This method is based on fracture mechanics theory and describes the temperature-related influence of a reduced ductility (relative reduction in the absorbed impact energy *KV*) at decreasing temperature. The influence of continuous reduction of impact energy with decreasing temperatures is calculated as follows:

$S_{\text{TS min}} = 1{,}0$ for $KV \geq KV_0$

and KV_0 = 27 J for steel and cast steel **at operating temperature ≤ 20 °C**

and KV_0 = 14 J or 17 J for spheroidal cast iron (material RT) **at ambient temperature ≤ 20 °C**

and KV_0 = 12 J for spheroidal cast iron (material LT) **at temperatures of ≤ (– 20 or – 40 °C)** according to Annex E, Table E.8

$S_{\text{TS min}} = (KV_0^{\mathbf{2}} / KV_0^{\mathbf{t}} / KV_{\text{TS min}})^{-0,75}$ for $6 \leq KV_{\text{TS min}} < KV_0^{t}$

$KV_{\text{TS min}}$ < 27 J at temperature TS_{min} and $KV_0^{\mathbf{t}} \geq$ 27 J for steel and cast steel
KV_0 = 27 J **at temperature of ≤ 20 °C**

and $KV_{\text{TS min}}$ < 12 J at temperature TS_{min} and $KV_0^{\mathbf{t}} \geq$12 J for spheroidal cast iron (material LT)
KV_0 = 12 J **at temperatures of ≤ (– 20 or – 40 °C)** according to Annex E, Table E.8;

The $KV_0^{\mathbf{t}}$-value is the real *KV*-value of the material corresponding to the temperatures mentioned above.

The limit of use for the materials is the temperature at which the impact energy *KV* or KV_0^{t} reaches a minimum value of 6 J. If the value for $KV_{\text{TS min}}$ is below 6 J, the design of a component by this method is not allowed. Measured values of KV, $KV_0^{\mathbf{t}}$ and $KV_{\text{TS min}}$ in connection with the corresponding temperature values must be certified in an inspection document 3.1 B according to EN 10204.

D.4 Determination of the maximum allowable pressure at the minimum operating temperature on the basis of an empirical method (min t_0-Method; procedure according to the individual temperature load case)

With this method, the prevention of brittle fracture is taken into consideration by various reduction factors, according to the individual temperature load case. The procedure described as follows is based on experience by using valves at low temperatures of refrigerating systems for a long period of time.

This procedure is based on the fact that the pressure in the refrigerant containing part of the valve, which is installed in a refrigerating plant, where the pressure is defined by the saturated vapour pressure of the refrigerant (the refrigerant is in the state of boiling), is decreasing by decreasing temperature of the refrigerant. Therefore, the stresses due to the refrigerant pressure at low temperatures are always less than the stresses at the design pressure according to the respective table in EN 378-2 (vapour pressure curve of common refrigerants, see Figure F.5 of this standard.

In the case of non boiling fluids, e.g. brine, the pressure does not change at lower temperatures. Therefore the allowed stress of the components is determined with higher safety factors.

Safety against brittle fracture is given if the temperature load cases described in the following are complied with. This Method cannot be used for fully or semi-killed types of steel or cast steel. A heat treatment shall be applied for welded constructions in accordance with the requirements of D.4.3.

D.4.1 Temperature load cases

Load case min $t_{0\ 100}$:

The lowest temperature according the European Standards of the respective materials at which the valve can be used at a load of up to 100 % of the allowable design stress at 20 °C, taking the safety factors according to Table A.2 into account.

The lowest temperature is that at which the *KV*-value is at least 27 J. If the minimum *KV*-value is given for ambient temperatures or 0 °C, the material may be used down to – 10 °C .

If the practical experience is confirmed in normative specifications in that way, that at an absorbed impact energy level of below 27 J, at the intended load of up to 100 %, the material is suitable in accordance with the requirements of Table A.2, then the lowest temperature corresponding to the respective load can be determined.

Load case min $t_{0\ 75}$:

The lowest temperature at which the valve can be used, if its load amounts to 75 % maximum of the allowable design stress at 20 °C, taking the safety factors according to Table A.2 into account.

In the case of boiling fluids the calculated allowable design stress shall be for application temperatures down to min $t_{0\ 75}$, reduced to 75 % of the allowable design stress calculated for min $t_{0\ 100}$.

In the case of non boiling fluids the allowable design stresses taken from Table A.2 have to be increased by 100/75 for σ_{con}.

Load case min $t_{0\ 25}$:

The lowest temperature at which pressure parts can be used, if their load amounts to 25 % maximum of the allowable design stress at 20 °C, taking the safety factors according to Table A.2 into account.

In the case of boiling fluids the calculated allowable design stress shall be for application temperatures down to min $t_{0\ 25}$ reduced to 25 % of the design stress calculated for min $t_{0\ 100}$.

In the case of non boiling fluids the allowable design stresses taken from Table A.2 have to be increased by 100/25 for σ_{con}.

D.4.2 Lowest application temperatures for the load cases min $t_{0\ 100}$, min $t_{0\ 75}$ and min $t_{0\ 25}$

D.4.2.1 Load case min $t_{0\ 100}$

Valves which are subjected to a load of up to 100 % of the calculated allowable design stress may be used down to the lowest application temperature (see D.4.1) which is given for the corresponding materials in connection with this method (see Annex E).

If the minimum impact energy is given for the ambient temperature or 0 °C, the material may be used down to – 10 °C (for austenitic steels see D.4.2.2).

D.4.2.2 Load cases min $t_{0\ 75}$ and min $t_{0\ 25}$

a) The following load cases apply to steel and cast steel (groups 1.1 and 1.2), for which min $t_{0\ 100}$ is at a temperature of – 10 °C:

— min $t_{0\ 75}$ down to a temperature difference of – 50 K, related to min $t_{0\ 100}$ and
— min $t_{0\ 25}$ down to a temperature difference of – 75 K, related to min $t_{0\ 100}$;

b) For steel and cast steel (group 1.1 and 1.2), for which min $t_{0\ 100}$ is at a temperature of ≤ – 20 °C , it is to be established that an impact value of 27 J is given at ≤ – 20 °C. The following load cases apply:

— min $t_{0\ 75}$ down to a temperature difference of – 50 K, related to min $t_{0\ 100}$ and
— min $t_{0\ 25}$ down to a temperature difference of – 80 K, related to min $t_{0\ 100}$;

c) Austenitic steels according group 8.1 with A ≥ 35 **%** may be used down to a temperature min $t_{0\ 100}$ of – 196 °C;

d) Aluminium or aluminium-alloys (groups 21 — 26) — with the exception of aluminium–magnesium alloys — with a content of magnesium of more than 6 % as well as titanium (group 51), copper or copper alloys (groups 31 — 38 according CR ISO 15608/2000) may be used down to an operating temperature min $t_{0\ 100}$ of – 196 °C. The use of semifinished products and castings is allowed. Aluminium-magnesium alloys with a content of more than 6 % magnesium should be used down to an operating temperature min $t_{0\ 100}$ – 100, only.

e) For screw joints nuts and fasteners, only min $t_{0\ 100}$ applies;

f) On the basis of practical experience over many years, spheroidal cast iron (group 72.2) according to EN 1563 may be used only down to min $t_{0\ 75}$, EN GJS-350-22LT down to a temperature of – 70 °C and EN-GJS-400-18LT down to a temperature of – 60 °C;

g) Based on practical experience during operation, valves up to DN 10 or valve bonnets and stuffing box parts DN 40 made from free-cutting steel according to EN 10087 may be used in load cases min $t_{0\ 75}$ down to – 40 °C and in load cases min $t_{0\ 25}$ down to – 60 °C.

Examples of materials and their application limits are given in Annex E.

D.4.3 Allowance for welded constructions

D.4.3.1 Welded joints

Under the following conditions, the same rules apply to welded joints as to the parent material :

— For testing of the weld seam, the lowest temperature at 100 % load (min $t_{0\ 100}$) shall be established as the test temperature for the impact test and

— With the ambient temperature as the lowest application temperature, the determination min $t_{0\ 100}$ = – 10 °C is sufficient. For weld seams subjected to these tests, the minimum application temperature for min $t_{0\ 75}$ and for min $t_{0\ 25}$ shall be determined on the basis of the difference between the temperature according to D.4.2 and the test temperature (compare Table D.1).

Table D.1 — Determination of the lowest application temperature taking into account different test temperatures for weld seams, for example for materials with min t_0 100 = – 10°C

Test temperature of weld seam °C	min $t_{0\ 100}$ °C	Temperature difference test temperature (compare D.4.2) K	min $t_{0\ 75}$ °C	Temperature difference test temperature (compare D.4.2) K	min $t_{0\ 25}$ °C
– 10	– 10	50	– 60	75	– 85
+ 20	– 10	50	– 30	75	– 55

D.4.3.2 Heat treatment after welding

For application temperatures below min $t_{0\ 100}$, heat treatment by stress-relieving is necessary for welded constructions.

For materials belonging to groups 1.1 and 1.2, heat treatment by stress-relieving is not necessary, if the reference thickness is less than 10 mm; the reference thickness shall be determined in accordance with clause D of EN 13445-2:2002.

D.4.4 Determination of the safety factor

Taking the above mentioned preconditions into account, the safety factor $S_{\mathrm{TS\ min}}$ is calculated by this method as:

$S_{\mathrm{TS\ min}}$ = 1,0 for $TS_{\mathrm{min}} \geq \mathrm{min}\ t_{0\ 100}$,

= 0,75 for $\mathrm{min}\ t_{0\ 75} \leq TS_{\mathrm{min}} \leq \mathrm{min}\ t_{0\ 100}$,

= 0,25 for $\mathrm{min}\ t_{0\ 25} < TS_{\mathrm{min}} \leq \mathrm{min}\ t_{0\ 75}$

If the value for the intended low operating temperature TS_{min} is below min $t_{0\ 25}$, a design of the component is no longer permitted by this method. As an alternative, a fracture mechanics analysis may be carried out.

Annex E
(informative)
Compilation of material characteristics of often used materials

The material characteristics of often used materials, sorted by the material group (see Table A.2), are listed in Tables E.1 to E.9.

NOTE 1 For the design calculation the values of strength of bodies, bonnets, flanges, screws and nuts according the annexes A – D of this standard the material characteristics indicated in Table E.1 to E.9 apply as an example. The characteristic values of the latest edition of material standards apply.

NOTE 2 Values of one standard are indicated as an example in case of more than one standard.

Table E.1 — Unalloyed steel (group 1.1 and 1.2)

Material				EN Standard	Strength Values		Elong. after fracture	Impact Energy KV_0			Product form					Operating Temperature [°C]				US-nomenclature	
Symbol	Number	Group	Condition		$R_{p0,2}$ [a] [MPa]	R_m [MPa]	A [%]	[J]	at [°C]	L/q	1	2	3	4	5	min $t_{0\ 25}$	min $t_{0\ 75}$	min $t_{0\ 100}$	max	Standard ASTM	Grade
P235GH	1.0345	1.1	N	10028-2 10273 10216-2	235	360 480	25	27	0	L			 X	 X	X	-85	-60	-10	400	A.42/414/ 515/516	55/C/65
P265GH	1.0425	1.1	N	10028-2 10273 10216-2	265	410 530	23	27	0	L			 X	 X	X	-85	-60	-10	400	A285/414/ 442/515/ 516	B/C/60/55
P295GH	1.0481	1.2	N	10028-2 10273	295	460 580	22	27	0	L			 X		X	-85	-60	-10	400	A106/414/ 516	C/70/F,G
P355GH	1.0473	1.2	N	10028-2 10273	355	510 650	21	27	0	L			 X		X	-85	-60	-10	400	A414/573	G/Class 1
P245GH	1.0352	1.1	NT QT	10222-2	220	410 530	25	27	0	q	X					-85	-60	-10	400		
P280GH	1.0426	1.2	N, NT, QT	10222-2	255	460 580	23	27	0	q	X					-85	-60	-10	400		
P235S	1.0112	1.1	N	10207	235	360 480	20	28	-20	L			X		X	-100	-70	-20	300		
P265S	1.0130	1.1	N	10207	265	410 530	17	28	-20	L			X		X	-100	-70	-20	300		
P275SL	1.1100	1.1	N	10207	275	390 510	19	28	-50	L			X		X	-130	-100	-50	300		

NOTE Measuring condition: L – in direction of rolling direction, q – at right angles of rolling direction. Product forms: 1-forging; 2-casting; 3-rolled bars; 4-tube; 5-plate.

[a] Nominal value up to a determined thickness like noted in the standard

Table E.1 — Unalloyed steel (group 1.1 and 1.2) *(continued)*

Material				EN Standard	Strength Values		Elong. after fracture	Impact Energy KV_0			Product form					Operating Temperature [°C]				US-nomenclature	
Symbol	Number	Group	Condition		$R_{p0,2}$ [a] [MPa]	R_m [MPa]	A [%]	[J]	at [°C]	L/q	1	2	3	4	5	min $t_{0\ 25}$	min $t_{0\ 75}$	min $t_{0\ 100}$	max	Standard ASTM	Grade
S235J2G3	1.0116	1.1	N	10025	235	340 470	26	27	-20	L			X		X	-100	-70	-20		A283/570/ 573/611	36/58C
S235J2G4	1.0117	1.1	N	10025	235	340 470	26	27	-20	L			X		X	-100	-70	-20			
S275J2G3	1.0144	1.1	N	10025	275	410 560	22	27	-20	L			X		X	-100	-70	-20			
S275J2G4	1.0145	1.1	N	10025	275	410 560	22	27	-20	L			X		X	-100	-70	-20			
S355J2G3	1.0570	1.1	N	10025	355	490 630	22	27	-20	L			X		X	-100	-70	-20			
S355J2G4	1.0577	1.1	N	10025	355	490 630	22	27	-20	L			X		X	-100	-70	-20			
P275NL1	1.0488	1.1	N	10028-3 10216-3	275	390 510	24	27	-20	q				X	X	-100	-70	-20	400	A662	A
P275NL2	1.1104	1.1	N	10028-3 10216-3	275	390 510	24	27	-50	q				X	X	-130	-100	-50	400		
P355NL1	1.0566	1.2	N	10028-3 10216-3	355	490 630	22	27	-20	q				X	X	-100	-70	-20	400		

NOTE Measuring condition: L – in direction of rolling direction, q – at right angles of rolling direction. Product forms: 1-forging; 2-casting; 3-rolled bars; 4-tube; 5-plate.

[a] Nominal value up to a determined thickness like noted in the standard

Table E.1 — Unalloyed steel (group 1.1 and 1.2) *(continued)*

Material				EN Standard	Strength Values		Elong. after fracture	Impact Energy KV_0			Product form					Operating Temperature [°C]				US-nomenclature	
Symbol	Number	Group	Condition		$R_{p0,2}$ [a] [MPa]	R_m [MPa]	A [%]	[J]	at [°C]	L/q	1	2	3	4	5	min $t_{0\ 25}$	min $t_{0\ 75}$	min $t_{0\ 100}$	max	Standard ASTM	Grade
P355NL2	1.1106	1.2	N	10028-3 10216-3	355	490 630	22	27	-50	q				 X	X	-130	-100	-50	400		
P255QL	1.0452	1.1	N	10216-4	255	360 490	23	27	-50	q				X		-130	-100	-50	400		
P265NL	1.0453	1.1	N	10216-4	265	410 570	24	27	-40	q				X		-120	-90	-40	400		
P285QH	1.0478	1.2	+ QT	10222-4	245	370 510	22	34	-40	L	X					-120	-90	-40			
P355QH1	1.0571	1.2	+ QT	10222-4	315	470 630	21	34	-40	L	X					-120	-90	-40			
P285NH	1.0477	1.2	N	10222-4	285	390 510	24	28	-40	L	X					-120	-90	-40	400		
P355NH	1.0565	1.2	N	10222-4	355	490 630	23	28	-40	L	X					-120	-90	-40	400		
DC04	1.0338	1.1	RR	10130	140 210	270 350	38	—	—	—	—				X	-85	-60	-10			

NOTE Measuring condition: L – in direction of rolling direction, q – at right angles of rolling direction. Product forms: 1-forging; 2-casting; 3-rolled bars; 4-tube; 5-plate.

[a] Nominal value up to a determined thickness like noted in the standard

Table E.2 — Steel (group 8.1)

Material				EN Standard	Strength Values		Elong. after fracture	Impact Energy KV_0			Product form					Operating Temperature [°C]				US-nomenclature	
Symbol	Number	Group	Condition		$R_{p0,2}$ [a] [MPa]	R_m [MPa]	A [%]	[J]	at [°C]	L/q	1	2	3	4	5	min $t_{0\ 25}$	min $t_{0\ 75}$	min $t_{0\ 100}$	max	Standard ASTM	Grade
X5CrNi 18-10	1.4301	8.1		10028-7 10216-5 10222-5 10272	230	540 750	45	60	-196	q	X		X	X	X			-196	550	A213/A240/ A276/A312/ A403	TP304/304/ WP304
X2CrNi 19-11	1.4306	8.1		10028-7 10216-5 10272	220	520 670	45	60	-196	q			X	X	X			-196	550	A213/A240/ A276/A312/ A403	TP304L/304L/ WP304L
X2CrNi 18-9	1.4307	8.1		10028-7 10216-5 10222-5 10272	220	520 670	45	60	-196	q	X		X	X	X			-196	550		
X2CrNiN 18-10	1.4311	8.1		10028-7 10216-5 10222-5 10272	290	550 750	40	60	-196	q	X		X	X	X			-196	550	A312	TP304NL
X5CrNiN 19-9	1.4315	8.1		10028-7	270	550 750	40								X			-196	550		
X1CrNi 25-21	1.4335	8.1		10216-5	190	490 690	40	60	-196	q				X				-196			

NOTE Measuring condition: L – in direction of rolling direction, q – at right angles of rolling direction. Product forms: 1-forging; 2-casting; 3-rolled bars; 4-tube; 5-plate.

[a] Nominal value up to a determined thickness like noted in the standard (EN 13480-2, EN 13445-2)

Table E.2 — Steel (group 8.1) *(continued)*

Material				EN Standard	Strength Values		Elong. after fracture	Impact Energy KV_0			Product form					Operating Temperature [°C]				US-nomenclature	
Symbol	Number	Group	Condition		$R_{p0,2}$ [a] [MPa]	R_m [MPa]	A [%]	[J]	at [°C]	L/q	1	2	3	4	5	min $t_{0\ 25}$	min $t_{0\ 75}$	min $t_{0\ 100}$	max	Standard ASTM	Grade
X5CrNiMo 17-12-2	1.4401	8.1		10028-7 10222-5 10216-5	220	530 680	40	60	-196	q	X			X	X			-196	550	A276/A312/ A403	316/WP316/
X2CrNiMo 17-12-2	1.4404	8.1		10028-7 10216-5 10272 10222-5	220	530 680	40	60	-196	q	X		X	X	X			-196	550	A213/A276 A312/A403/ A240	TP316L/ TP316LN/ 316L/ WP316L
X2CrNiMo 17-11-2	1.4406	8.1		10028-7 10225-5 10272	300	580 780	40	60	-196	q	X		X		X			-196	550	A276	316L
X2CrNiMoN 17-13-3	1.4429	8.1		10028-7 10216-5 10222-5	300	580 780	35	60	-196	q	X			X	X			-196	550	A213/A240/ A276	TP316LN/ 316L
X2CrNiMo 17-12-3	1.4432	8.1		10028-7 10222-5 10272	240	550 700	40	60	-196	q	X		X		X			-196	550		
X2CrNiMo 18-14-3	1.4435	8.1		10028-7 10222-5 10272	240	550 700	40	60	-196	q	X		X		X			-196	400	A240	317L

NOTE Measuring condition: L – in direction of rolling direction, q – at right angles of rolling direction. Product forms: 1-forging; 2-casting; 3-rolled bars; 4-tube; 5-plate.

[a] Nominal value up to a determined thickness like noted in the standard (EN 13480-2, EN 13445-2)

Table E.2 — Steel (group 8.1) *(continued)*

Material				EN Standard	Strength Values		Elong. after fracture	Impact Energy KV_0			Product form					Operating Temperature [°C]				US-nomenclature	
Symbol	Number	Group	Condition		$R_{p0,2}$ [a] [MPa]	R_m [MPa]	A [%]	[J]	at [°C]	L/q	1	2	3	4	5	min $t_{0\ 25}$	min $t_{0\ 75}$	min $t_{0\ 100}$	max	Standard ASTM	Grade
X3CrNiMo 17-13-3	1.4436	8.1		10222-5	205	510 710	45	60	- 196	q	X							- 196		A213/A240	TP316/317
X2CrNiMo 17-13-5	1.4439	8.1		10028-7	290	580 780	35	60	-196	q					X			-196	400		
X3CrNiMo 18-12-3	1.4449	8.1		10222-5	220	520 720	45	60	- 196	q	X							- 196			
X6CrNiTi 18-10	1.4541	8.1		10222-5 10028-7	220	520 720	40	60	-196	q	X				X			-196	550	A213/A240/ A276/A312/ A403/A 479	TP321/321/ TP311/ WP321
X6CrNiMoTi 17-12-2	1.4571	8.1		10222-5 10028-7	240	540 690	40	60	-196	q	X				X			-196	550	A213/A240/ A276/A312/ A403/A479	TP316L/316Ti/ TP316Ti/ WP316Ti
X6CrNiMo Nb17-12-2	1.4580	8.1		10272	215	510 740		60					X							A276	316CB
X6CrNi 18-10	1.4948	8.1		10216-5 10222-5	185	500 700	40	60	+ 20		X			X		- 85	- 60	- 10			
X8CrNiNb 16-13	1.4961	8.1		10216-5	205	510 690	35	60	+ 20					X		- 85	- 60	- 10	600		

NOTE Measuring condition: L – in direction of rolling direction, q – at right angles of rolling direction. Product forms: 1-forging; 2-casting; 3-rolled bars; 4-tube; 5-plate.

[a] Nominal value up to a determined thickness like noted in the standard (EN 13480-2, EN 13445-2)

Table E.3 — Cast steel (groups 1.1, 1.2 and 8.1)

Material				EN Standard	Strength Values		Elong. after fracture	Impact Energy KV_0			Product form					Operating Temperature [°C]				US-nomenclature	
Symbol	Number	Group	Condition		$R_{p0,2}$ [a] [MPa]	R_m [MPa]	A [%]	[J]	at [°C]	L/q	1	2	3	4	5	min $t_{0\ 25}$	min $t_{0\ 75}$	min $t_{0\ 100}$	max	Standard ASTM	Grade
GP240GH	1.0619	1.1	N	10213-2	240	420 600	22	27	20	L		X				-85	-60	-10	450	A216	WCA, WCB, WCC
GP240GH	1.0619	1.1	QT	10213-2	240	420 600	22	40	20	L		X				-85	-60	-10	450	A216	WCA, WCB, WCC
GP280GH	1.0625	1.2	N	10213-2	280	480 640	22	27	20	L		X				-85	-60	-10	450		
GP280GH	1.0625	1.2	QT	10213-2	280	480 640	22	35	20	L		X				-85	-60	-10	450		
G20Mo5	1.5419	1.2	QT	10213-2	245	440 590	22	27	20	L		X				-85	-60	-10	450	A217	WC1
G17Mn5	1.1131	1.1	QT	10213-3	240	450 600	24	27	-40	L		X				-120	-90	-40	300		
G20Mn5	1.6220	1.2	N	10213-3	300	480 620	20	27	-30	L		X				-110	-80	-30	300		
G20Mn5	1.6220	1.2	QT	10213-3	300	500 650	22	27	-40	L		X				-120	-90	-40	300		
G18Mo5	1.5422	1.2	QT	10213-3	240	440 790	23	27	-45	L		X				-125	-95	-45	300		

NOTE Measuring condition: L – in direction of rolling direction, q – at right angles of rolling direction. Product forms: 1-forging; 2-casting; 3-rolled bars; 4-tube; 5-plate.

[a] Nominal value up to a determined thickness like noted in the standard

Table E.3 — Cast steel *(continued)*

Material				EN Standard	Strength Values		Elong. after fracture	Impact Energy KV_0			Product form					Operating Temperature [°C]				US-nomenclature	
Symbol	Number	Group	Condition		$R_{p0,2}$ [a] [MPa]	R_m [MPa]	A [%]	[J]	at [°C]	L/q	1	2	3	4	5	min $t_{0\ 25}$	min $t_{0\ 75}$	min $t_{0\ 100}$	max	Standard ASTM	Grade
GX2CrNi 19-11	1.4309	8.1	+AT	10213-4	210	440 640	30	70	-196	L		X				–	–	-196	350		
GX5CrNi 19-10	1.4308	8.1	+AT	10213-4	200	440 640	30	60	-196	L		X				–	–	-196	300	A743/A744	CF8
GX2CrNiMo 19-11-2	1.4409	8.1	+AT	10213-4	220	440 640	30	70	-196	L		X				–	–	-196	300		
GX5CrNiMo 19-11-2	1.4408	8.1	+AT	10213-4	210	440 640	30	60	-196	L		X				–	–	-196	300	A351/A744	CF8M

NOTE Measuring condition: L – in direction of rolling direction, q – at right angles of rolling direction. Product forms: 1-forging; 2-casting; 3-rolled bars; 4-tube; 5-plate.

[a] Nominal value up to a determined thickness like noted in the standard

Table E.4 — Aluminium and Aluminium alloys (groups 21 to 26)

Material				EN Standard	Strength Values		Elong. after fracture	Impact Energy KV_0			Product form					Operating Temperature [°C]				US-nomenclature	
Symbol	Number	Group	Condition		$R_{p0,2}$ [a] [MPa]	R_m [MPa]	A [%]	[J]	at [°C]	L/q	1	2	3	4	5	min $t_{0\ 25}$	min $t_{0\ 75}$	min $t_{0\ 100}$	max	Standard ASTM	Grade
EN AW-Al 99,8 (A)	EN AW -1080A	21	H12 H22	573-3 12392	55	80									X			-196	200		
EN AW-Al 99,7	EN AW -1070A	21	H12 H22	573-3 12392	55	80									X			-196	200		
EN AW-Al 99,5	EN AW -1050A	21	H12 H22	573-3 12392	65	85							X	X	X			-196	200		
EN AW-Al Mn1Cu	EN AW -3003	22.1	H12 H22	573-3 12392	90	120							X	X	X			-196	250		
EN AW-Al Mn1	EN AW -3103	22.1	H12 H22	573-3 12392	85	115							X	X	X			-196	250		
EN AW-Al Mn0,5Mg0,5	EN AW -3105	22.1	H12 H22	573-3 12392	105	130									X			-196	200		
EN AW-Al Mg1(B)	EN AW -5005	22.1	H12 H32	573-3 12392	95	125							X	X	X			-196	200		
EN AW-Al Mg1,5(C)	EN AW -5050	22.1	H12 H32	573-3 12392	130	155									X			-196	200		
EN AW-Al Mg2	EN AW -5251	22.1	H12 H32	573-3 12392	150	190							X	X	X			-196	200		
EN AW-Al Mg2,5	EN AW -5052	22.1	H12 H32	573-3 12392	160	210							X	X	X			-196	200		

NOTE Measuring condition: L – in direction of rolling direction, q – at right angles of rolling direction. Product forms: 1-forging; 2-casting; 3-rolled bars; 4-tube; 5-plate.

[a] Nominal value up to a determined thickness like noted in the standard

Table E.4 — Aluminium and Aluminium alloys (groups 21 to 26) *(continued)*

Material				EN Standard	Strength Values		Elong. After fracture	Impact Energy KV_0			Product form					Operating Temperature [°C]				US-nomenclature	
Symbol	Number	Group	Condition		$R_{p0,2}$[a] [MPa]	R_m [MPa]	A [%]	[J]	at [°C]	L/q	1	2	3	4	5	min $t_{0\ 25}$	min $t_{0\ 75}$	min $t_{0\ 100}$	max	Standard ASTM	Grade
EN AW-Al Mg3Mn	EN AW -5454	22.3	H12 H32	573-3 12392	190	250							X	X	X			-196	200		
EN AC-Al Mg3(b)	EN AC -51000	22.3	F	1706	70	140						X[b]						-196			
EN AC-Al Mg3(a)	EN AC -51100	22.3	F	1706	70	140						X[b]						-196			
EN AC-Al Mg5	EN AC -51300	22.3	F	1706	90	160						X[b]						-196			
EN AC-Al Mg3(b)	EN AC -51000	22.3	F	1706	70	150						X[c]						-196			
EN AC-Al Mg3(a)	EN AC -51100	22.3	F	1706	70	150						X[c]						-196			
EN AC-Al Mg5	EN AC -51300	22.5	F	1706	100	180						X[c]						-196			
EN AC-Al Mg9	EN AC -51200	22.5	F	1706	130	200						X[d]						-196			
EN AW-Al Mg3,5A	EN AW -5154A	22.3	H12 H32	573-3 12392	190	250							X	X	X			-196	100		
EN AW-Al Mg3	EN AW -5754	22.3	H12 H32	573-3 12392	170	220					X		X	X	X			-196	100		
EN AW-Al Mg4,5Mn0,7	EN AW -5083	22.5	H116	573-3 12392	215	305					X		X	X	X			-196	65		
EN AW-Al Mg4	EN AW -5086	22.5	H116	573-3 12392	195	275							X	X	X			-196	65		

NOTE Measuring condition: L – in direction of rolling direction, q – at right angles of rolling direction. Product forms: 1-forging; 2-casting; 3-rolled bars; 4-tube; 5-plate.

[a] nominal value up to a determined thickness like noted in the standard
[b] sand casting
[c] permanent moulds casting
[d] pressure die casting

Table E.4 — Aluminium and Aluminium alloys (groups 21 to 26) *(continued)*

Material				EN Standard	Strength Values		Elong. After fracture	Impact Energy KV_0			Product form					Operating Temperature [°C]				US-nomenclature	
Symbol	Number	Group	Condition		$R_{p0,2}$[a] [MPa]	R_m [MPa]	A [%]	[J]	at [°C]	L/q	1	2	3	4	5	min $t_{0\ 25}$	min $t_{0\ 75}$	min $t_{0\ 100}$	max	Standard ASTM	Grade
EN Al Si7MG	EN AC -42000	23.1	T6	1706	180	220						X[b]						-196			
EN AC-Al Si7Mg0,3	EN AC -42100	23.1	T6	1706	190	230						X[b]						-196			
EN AC-Al Si7Mg0,6	EN AC -42200	23.1	T6	1706	210	250						X[b]						-196			
EN AC-Al Si10Mg(a)	EN AC -43000	23.1	T6	1706	180	220						X[b]						-196			
EN AC-Al Si10Mg(b)	EN AC -43100	23.1	T6	1706	180	220						X[b]						-196			
EN AC-Al Si9Mg	EN AC -43300	23.1	T6	1706	190	230						X[b]						-196			
EN AC-Al Si7Mg	EN AC -42000	23.1	T64	1706	200	240						X[d]						-196			
EN AC-Al Si7Mg0,3	EN AC -42100	23.1	T64	1706	180	250						X[d]						-196			
EN AC-Al Si7Mg0,6	EN AC -42200	23.1	T64	1706	210	290						X[d]						-196			
EN AC-Al Si10Mg(a)	EN AC -43000	23.1	T64	1706	200	240						X[d]						-196			
EN AC-Al Si10Mg(b)	EN AC -43100	23.1	T64	1706	200	240						X[d]						-196			
EN AC-Al Si9Mg	EN AC -43300	23.1	T64	1706	180	250						X[d]						-196			

NOTE Measuring condition: L – in direction of rolling direction, q – at right angles of rolling direction. Product forms: 1-forging; 2-casting; 3-rolled bars; 4-tube; 5-plate.

a nominal value up to a determined thickness like noted in the standard

b sand casting

c permanent moulds casting

d pressure die casting

Table E.5 — Copper and Copper alloys (groups 31 — 38)

Material				EN Standard	Strength Values		Elong. after fracture	Impact Energy KV_0			Product form					Operating Temperature [°C]				US-nomenclature	
Symbol	Number CW ...	Group	Condition		$R_{p0,2}$ [a] [MPa]	R_m [MPa]	A [%]	[J]	at [°C]	L/q	1	2	3	4	5	min $t_{0\,25}$	min $t_{0\,75}$	min $t_{0\,100}$	max	Standard ASTM	Grade
Cu-ETP	004A	31	R200 H040	1652	100	200 250									X			-196	150		
Cu- FRTP	006A	31	R220 H040	1652	140	220 260									X			-196	150		
Cu-OF	008A	31	R220 H040	1652	140	220 260									X			-196	150		
Cu-DLP	023A	31	R200	1653	40	200									X			-196	150		
Cu-DHP	024A	31	R200	1653	40	200									X			-196	150		
CuZn5	500L	32.1	R230 H045	1652	130	230 280									X			-196	150		
CuZn10	501L	32.1	R240 H050	1652 12449	140	240 290								X	X			-196	150		
CuZn15	502L	32.1	R260 H055	1652	170	260 310									X			-196	150		
CuZn20	503L	32.1	R270 H055	1652	150	270 320									X			-196	150		
CuZn30	505L	32.1	R270 H055	1652	160	270 350									X			-196	150		
CuZn33	506L	32.1	R280 H155	1652	170	280 380									X			-196	150		
CuZn36	507L	32.1	R300	1652	180	300 370									X			-196	150		
CuZn37	508L	32.1	R300	1652	180	300 370									X			-196	150		
CuZn40	509L	32.1	R340 H140	1652	240	340 420									X			-196	150		
CuZn20 Al2As	702R	32.2	R300 R390	1653	90 240	300 390									X			-196	150		

NOTE Measuring condition: L – in direction of rolling direction, q – at right angles of rolling direction. Product forms: 1-forging; 2-casting; 3-rolled bars; 4-tube; 5-plate.

a Nominal value up to a determined thickness like noted in the standard

Table E.5 — Copper and Copper alloys (groups 31 — 38) *(continued)*

Material				EN Standard	Strength Values		Elong. after fracture	Impact Energy KV_0			Product form					Operating Temperature [°C]				US-nomenclature	
Symbol	Number CW ...	Group	Condition		$R_{p0,2}$ 1) [MPa]	R_m [MPa]	A [%]	[J]	at [°C]	L/q	1	2	3	4	5	min $t_{0\ 25}$	min $t_{0\ 75}$	min $t_{0\ 100}$	max	Standard ASTM	Grade
CuZn38 AlFeNiPbSn	715R	32.2	R390 R430	1653	140 200	390 430	25 20								X			-196	150		
CuZn38 Sn1As	717R	32.2	R320 R340	1653	100 120	320 340	30 30								X			-196	150		
CuZn39Sn1	719R	32.2	R400	1653	200	400	18								X			-196	150		

NOTE Measuring condition: L – in direction of rolling direction, q – at right angles of rolling direction. Product forms: 1-forging; 2-casting; 3-rolled bars; 4-tube; 5-plate.

[a] Nominal value up to a determined thickness like noted in the standard

Table E.6 — Cast iron (group 72.2)

Material				EN Standard	Strength Values		Elong. after fracture	Impact Energy KV_0			Product form					Operating Temperature [°C]				US-nomenclature	
Symbol	Number	Group	Condition		$R_{p0,2}$ [a] [MPa]	R_m [MPa]	A [%]	[J]	at [°C]	L/q	1	2	3	4	5	min $t_{0\ 25}$	min $t_{0\ 75}$	min $t_{0\ 100}$	max	Standard ASTM	Grade
EN-GJS-350-22-RT	EN-JS 1014			1563	220	350	22	17	20			X				–	–	-10	300		
EN-GJS-400-18-RT	EN-JS 1024			1563	250	400	18	14	20			X				–	–	-10	300		
EN-GJS-350-22U-RT	EN-JS 1029			1563	220	350	22	17	20			X				–	–	-10	300		
EN-GJS-400-18U-RT	EN-JS 1059			1563	250	400	18	14	20			X				–	–	-10	300		
EN-GJS-400-18-LT	EN-JS 1025			1563	240	400	18	12	-20			X				-60	-60	-20	300		
EN-GJS-400-18U-LT	EN-JS 1049			1563	240	400	18	12	-20			X				-60	-60	-20	300		
EN-GJS-350-22-LT	EN-JS 1015			1563	220	350	22	12	-40			X				-70	-70	-40	300		
EN-GJS-350-22U-LT	EN-JS 1019			1563	220	350	22	12	-40			X				-70	-70	-40	300		

NOTE Measuring condition: L – in direction of rolling direction, q – at right angles of rolling direction. Product forms: 1-forging; 2-casting; 3-rolled bars; 4-tube; 5-plate.

[a] Nominal value up to a determined thickness like noted in the standard

Table E.7 — Unalloyed steel (free cutting steel)

Material[b]				EN Standard	Strength Values		Elong. after fracture	Impact Energy KV_0			Product form					Operating Temperature [°C]				US-nomenclature	
Symbol	Number	Group	Condition		$R_{p0,2}$ [a] [MPa]	R_m [MPa]	A [%]	[J]	at [°C]	L/q	1	2	3	4	5	min $t_{0\ 25}$	min $t_{0\ 75}$	min $t_{0\ 100}$	max	Standard ASTM	Grade
11SMn30	1.0715		a	10087		380 570							X			-60	-40	-10	300		
11SMnPb30	1.0718		a	10087		380 570							X			-60	-40	-10	300		
11SMn37	1.0736		a	10087		370 570							X			-60	-40	-10	300		
11SMnPb37	1.0737		a	10087		360 520							X			-60	-40	-10	300		

NOTE Measuring condition: L – in direction of rolling direction, q – at right angles of rolling direction. Product forms: 1-forging; 2-casting; 3-rolled bars; 4-tube; 5-plate.

a Nominal value up to a determined thickness like noted in the standard

b not qualified for welding; should not be used for valves bodies with DN greater than 10 mm for bonnets ≤ DN 40 see annex D.4.2.2 subclause g)

Table E.8 — Materials for spindles

Material				EN Standard	Strength Values		Elong. after fracture	Impact Energy KV_0			Product form					Operating Temperature [°C]				US-nomenclature	
Symbol	Number	Group	Condition		$R_{p0,2}$ [a] [MPa]	R_m [MPa]	A [%]	[J]	at [°C]	L/q	1	2	3	4	5	min $t_{0\ 25}$	min $t_{0\ 75}$	min $t_{0\ 100}$	max	Standard ASTM	Grade
X20Cr13	1.4021			10088-3									X					-10	400		
X5CrNi 18-10	1.4301	8.1		10088-3 10028-7	230	540 750	45	60	- 196	q			X		 X			-196	300		
X8CrNiS 18-9	1.4305			10088-3	190	500 750	35	–	–	L			X					+20	300		
X2CrNiMoN 22-5-3	1.4462	10.1		10088-3 10028-7	460	660 840	25	40	- 40	q			X		 X			-40	300		
X6CrNiTi 18-10	1.4541	8.1		10088-3 10028-7	220	520 720	40	60	- 196	q			X		 X			-196	300		
CuAl10 Ni5Fe4	CW307G	35	R590 R620	EN 1653	230 250	590 620	14	–	–				X					-196	250		
X12CrS13	1.4005	–		10088-3	450	650 850	– 12	60	–				X					-50	300		
X3CrNiMo 13-4	1.4313	7.2		10088-3 10028-7	520	650 830	15	60	- 60	q			X		 X			-100	300		

NOTE Measuring condition: L – in direction of rolling direction, q – at right angles of rolling direction. Product forms: 1-forging; 2-casting; 3-rolled bars; 4-tube; 5-plate.

[a] Nominal value up to a determined thickness like noted in the standard see EN 13480-2, EN 13445-2

Table E.9 — Steel for bolts, screws, nuts and other fasteners

Material						Elongation after fracture	Impact Energy KV_0			Strength Values		Mat. Group	PN Class up to	Marking of product	Operating Temperature [°C]			
bolts			nuts															
Symbol	Number	EN Standard	Symbol	Number	EN Standard	A [%]	[J]	at [°C]	L/q	$R_{p0,2}$ [a] [MPa]	R_m [MPa]				min $t_{0\ 25}$	min $t_{0\ 75}$	min $t_{0\ 100}$	max
C-St-5.6		ISO 898-1 1515-1											40 300	5.6			-10	300
			C-ST-5		20898-2 1515-1								40 300	5			-10	300
C-St-8.8		ISO 898-1 1515-1											40 300	8.8			-10	300
			C-St-8		20898-2 1515-1								40 300	8			-10	300
25CrMo4	1.7218	10269 1515-1											all				-10	450
			C 35 E C-St elev. temp	1.1181	10269 1515-1								all				-10	450
42CrMo4	1.7225	10269 1515-1											all				-10	450
			C 45 E C-St elev. temp	1.1191	10269 1515-1								all				-10	450
25CrMo4	1.7218	10269 1515-1											all				-60	400

NOTE Measuring condition: L – in direction of rolling direction, q – at right angles of rolling direction. Product forms: 1-forging; 2-casting; 3-rolled bars; 4-tube; 5-plate.

[a] Nominal value up to a determined thickness like noted in the standard

Table E.9 — Steel for bolts, screws, nuts and other fasteners *(continued)*

Material						Elongation after fracture	Impact Energy KV_0			Strength Values		Mat. Group	PN Class up to	Marking of product	Operating Temperature [°C]			
bolts			**nuts**															
Symbol	Number	EN Standard	Symbol	Number	EN Standard	A [%]	[J]	at [°C]	L/q	$R_{p0,2}$ [a] [MPa]	R_m [MPa]				min $t_{0\ 25}$	min $t_{0\ 75}$	min $t_{0\ 100}$	max
			A2-50 A2-70		1515-1 ISO3506-2								all	A2-50 A2-70			-200	400
42CrMo4	1.7225	10269 1515-1											all				-100	450
			42CrMo4	1.7225	10269 1515-1								all				-100	450
19MnB4	1.5523	10269											all				-60	300
			42CrMo4	1.7225	10269 1515-1								all				-100	300
20Mn5	1.1133	10269											all				-50	300
			25CrMo4	1.7218	10269 1515-1								all				-60	300
30CrNi Mo8	1.6580	10269 1515-1											all				-40	300
			42CrMo4	1.7225	10269 1515-1								all				-40	300
A4-50		1515-1 ISO3506-1											40 300	A4-50			-200	400

NOTE Measuring condition: L – in direction of rolling direction, q – at right angles of rolling direction. Product forms: 1-forging; 2-casting; 3-rolled bars; 4-tube; 5-plate.

[a] Nominal value up to a determined thickness like noted in the standard

Table E.9 — Steel for bolts, screws, nuts and other fasteners *(concluded)*

Material bolts Symbol	Num-ber	EN Standard	nuts Symbol	Num-ber	EN Standard	Elongation after fracture A [%]	Impact Energy KV_0 [J]	at [°C]	L/q	Strength Values $R_{p0,2}$ [a] [MPa]	R_m [MPa]	Mat. Group	PN Class up to	Mark-ing of product	Operating Temperature [°C] min $t_{0\ 25}$	min $t_{0\ 75}$	min $t_{0\ 100}$	max
			A4-50		1515-1 ISO 3506-2								40 300	A4-50			-200	400
A4-70		1515-1 ISO 3506-1											100 600	A4-70			-200	400
			A4-70		1515-1 ISO 3506-2								100 600	A4-70			-200	400
A2-50		1515-1 ISO 3506-1											40 300	A2-50			-200	400
			A2-50		1515-1 ISO 3506-2								40 300	A2-50			-200	400
A2-70		1515-1 ISO 3506-1											100 600	A2-70			-200	400
			A2-70		1515-1 ISO 3506-2								100 600	A2-70			-200	400

NOTE Measuring condition: L – in direction of rolling direction, q – at right angles of rolling direction. Product forms: 1-forging; 2-casting; 3-rolled bars; 4-tube; 5-plate.

[a] Nominal value up to a determined thickness like noted in the standard

Annex F
(informative)

Justification of the individual methods

F.1 Determination of the pressure level under test conditions

The correct construction concerning sealing and strength is proofed experimental with two levels of test pressure, the design test pressure and the burst test pressure.

Determination of the design test pressure is such that the design stress of the valve body material is nearly achieved by the static pressure load. Simultaneously, during this pressure test, the tightness of the sealing elements used is checked (see Annex B).

In order to check whether the ductility of the valve body material is adequate, the design test pressure is determined to be greater than the tensile strength, without the associated stress leading to mechanical failure (see Annex B).

F.2 Correction of the permissible pressure for application at the maximum or minimum operating temperature

The use of a valve at a higher operating temperature is taken into consideration by the reduction of the design stress (see Annex C). This is a generally recognized procedure.

At a lower operating temperature, failure as the result of brittle fracture at reduced impact strength is taken into consideration, either by a fracture mechanics theory (KV-Method) or by an empirical method gained from practical experience (min-t_0-Method). KV-Method is derived from a work of R. Sandstrøm [1] (see Annex D).

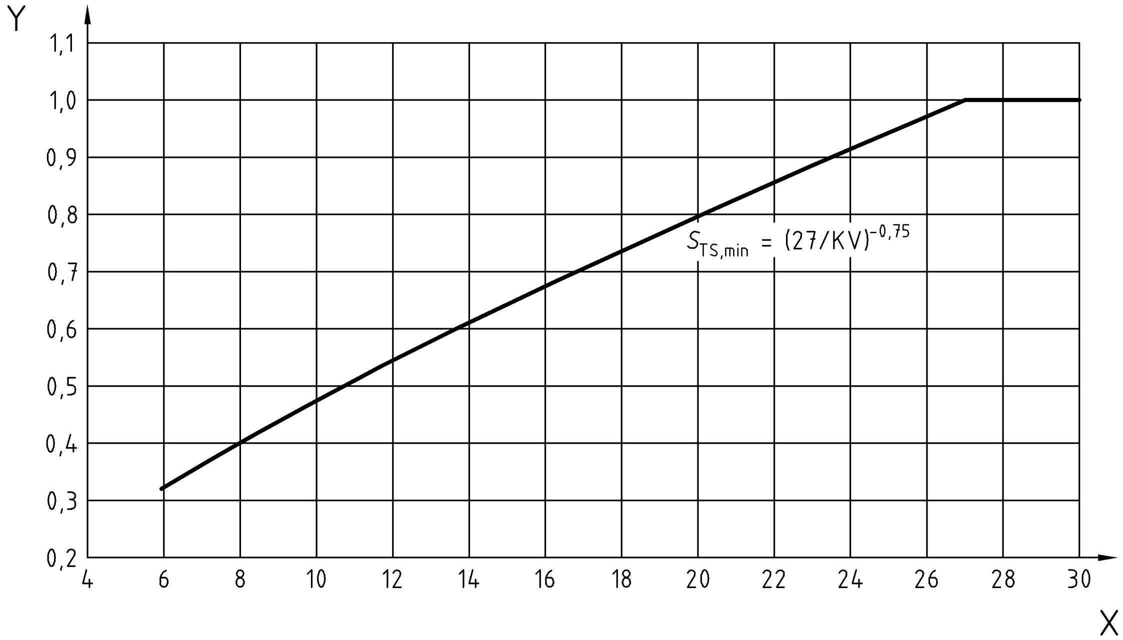
Both methods correspondingly take into account the risk of failure as a result of brittle fracture (restricted stress equalization at lower temperatures due to reduced ductility) due to a reduced load on the valve material.

The *KV*-Method can be applied as a relative method where the safety factor is a function of the impact ruptureenergy (see Figure F.2.1) and requires the impact value, determined by experiment at the minimum operating temperature as well as a factor for the calculation of the safety factor. Dependencies of the notch impact strength on the temperature of the design calculation which are specific to the material used can also be taken as a basis.

With the min-t_0-Method, the reduction of stress is chosen in the way which takes into account that the vapour pressure of the refrigerants is decreasing with decreasing temperature (see Figure F.2.5). With fluids or gases (e. g. brine, hotgas) outside the boiling condition, this stress level can be reached or exceeded in the valve body. Thus, in these cases, it is necessary to increase the allowable stress σ_{con} (see D.4.1).

The results achieved by the KV-Method are, to a high degree, in accordance with those achieved by the min t_0-Method. In the following, several examples are given, in which both procedures are compared with each other (see Figures F.2.2 to F.2.4).

The results are consistent within the frame of a technically acceptable dispersion, so that both procedures can be used for the correction of the operating pressure for application at low operating temperatures.

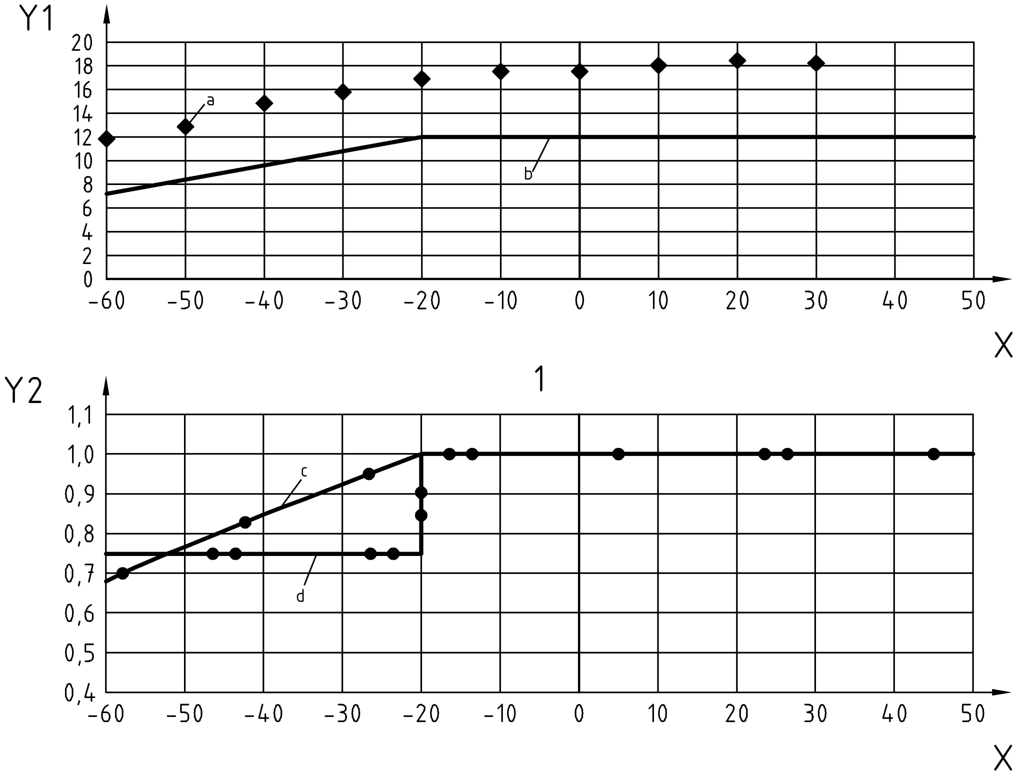


Key

X Impact rupture strength KV (J)

Y Strength reduction factor $S_{TS, min}$ [—]

Figure F.2.1 — Strength reduction factor as a function of the impact energy for a material with reduced notch impact rupture strength at the appropriate low temperature (KV_0^t = 27 J)



Key

Y1 Impact rupture strength (J)

X Temperature (°C)

Y2 $PS_{\text{TS min}}/PS$

1 Reduction factor

[a] Sandström-ref 1in J

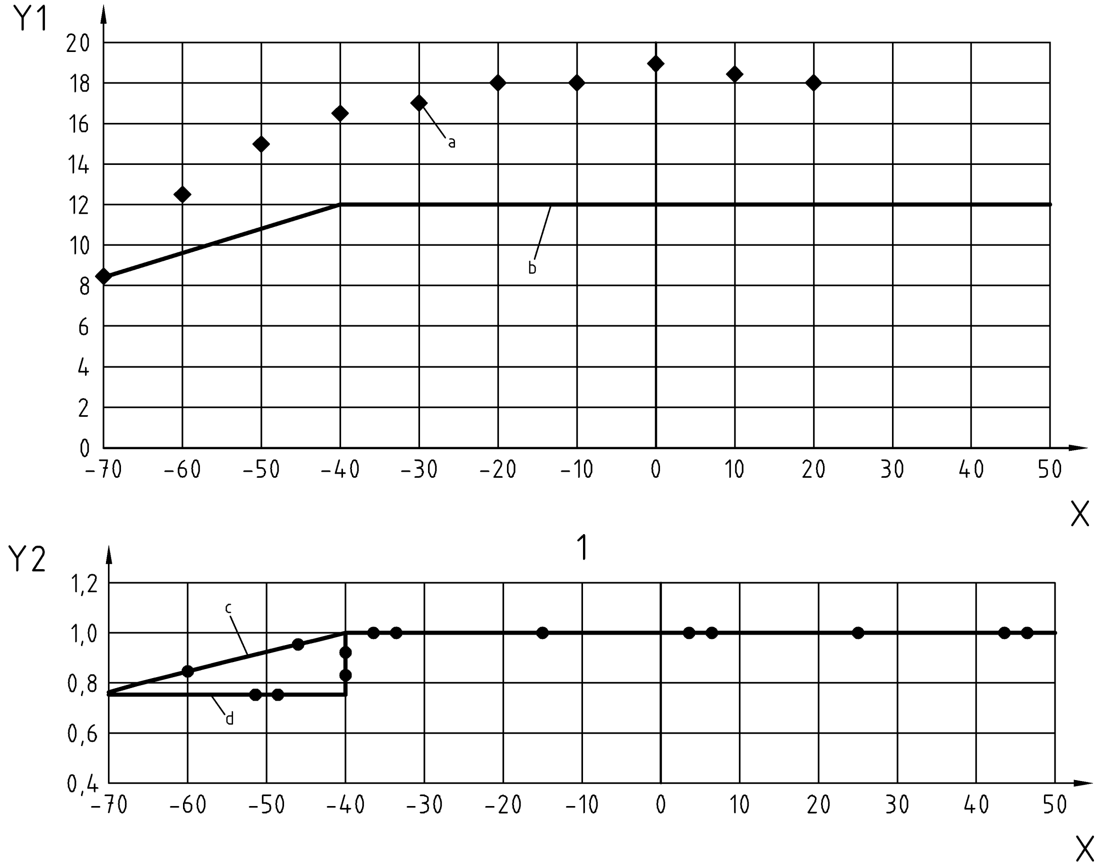
[b] Estimated KV-values from $S_{\text{TS, min}}$

[c] Fracture Mechanics Method

[d] min t_0 Method

EN-GJS-400-18-LT (GGG 40.3)				
	Fracture Mechanics Method			min t_0 Method
Temperature °C	KV (J)	for KV < 12,0 J $S_{\text{TS min}} = (12{,}0/\text{KV})^{-0{,}75}$ $S_{\text{TS min}}$	$PS_{\text{TS min}} / PS = S_{\text{TS min}}$ $S_{\text{TS min}}$	$PS_{\text{TS min}} / PS$ $S_{\text{TS min}}$
50	12,0	1,00	1,00	1,0
40	12,0	1,00	1,00	1,0
30	12,0	1,00	1,00	1,0
20	12,0	1,00	1,00	1,0
10	12,0	1,00	1,00	1,0
0	12,0	1,00	1,00	1,0
– 10	12,0	1,00	1,00	1,0
– 20	**12,0**	**1,00**	1,00	1,0
– 20	12,0	1,00	1,00	0,75
– 30	10,8	0,92	0,92	0,75
– 40	9,6	0,85	0,85	0,75
– 50	8,4	0,77	0,77	0,75
– 60	7,2	0,68	0,68	0,75

Figure F.2.2 — Comparison of *KV*-Method (here $KV_0 = KV_0^t$) with min t_0 - Method by means of material EN-GJS-400-18-LT (GGG 40.3)



Key

Y1 Impact rupture strength (J)

X Temperature (°C)

Y2 $PS_{\mathrm{TS\ min}}/PS$

1 Reduction factor

a Sandström-ref 1in J

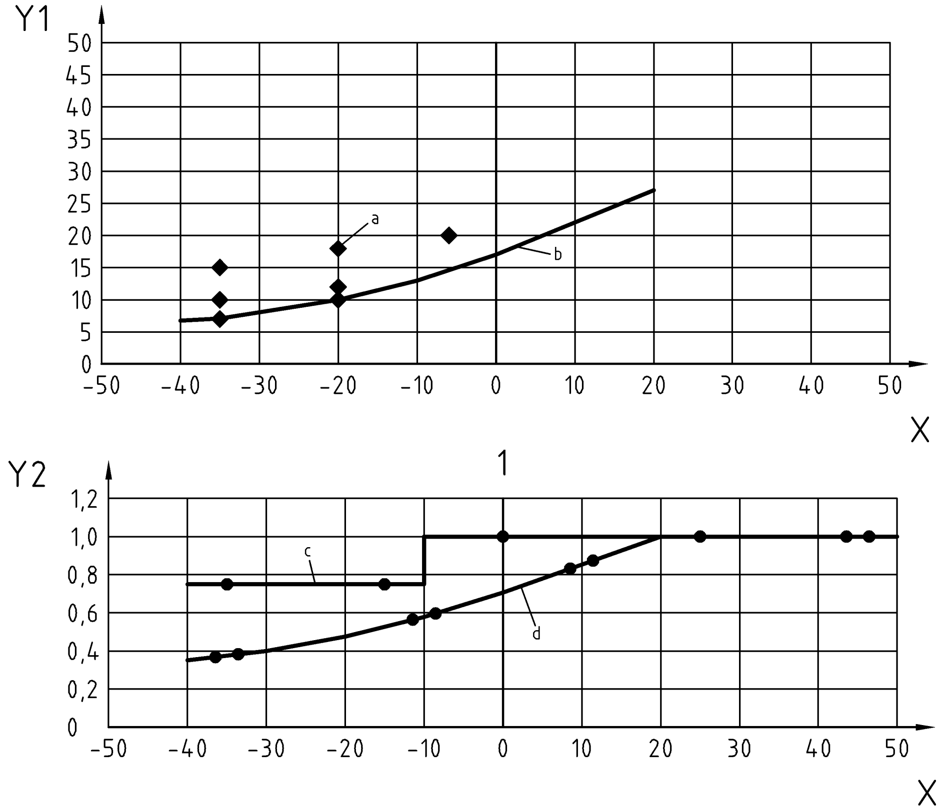
b Estimated KV-values from $S_{\mathrm{TS,\ min}}$

c Fracture Mechanics Method

d min t_0 Method

EN-GJS-350-22-LT (GGG 35.5)				
	Fracture Mechanics Method			min t_0 Method
Temperature °C	*KV* (J)	for *KV* < 12,0 J $S_{\mathrm{TS\ min}} = (12,0/KV)^{-0,75}$ $S_{\mathrm{TS\ min}}$	$PS_{\mathrm{TS\ min}}$ / PS = $S_{\mathrm{TS\ min}}$ $S_{\mathrm{TS\ min}}$	$PS_{\mathrm{TS\ min}}$ / PS $S_{\mathrm{TS\ min}}$
50	12,0	1,00	1,00	1,0
40	12,0	1,00	1,00	1,0
30	12,0	1,00	1,00	1,0
20	12,0	1,00	1,00	1,0
10	12,0	1,00	1,00	1,0
0	12,0	1,00	1,00	1,0
– 10	12,0	1,00	1,00	1,0
– 20	12,0	1,00	1,00	1,0
– 30	12,0	1,00	1,00	1,0
– 40	12,0	1,00	1,00	1,0
– 40	**12,0**	**1,00**	1,00	0,75
– 50	10,8	0,92	0,92	0,75
– 60	9,6	0,85	0,85	0,75
– 70	8,4	0,77	0,77	0,75

Figure F.2.3 — Comparison of *KV*-Method (here $KV_0 = KV_0^t$) with min t_0 - Method by means of material EN-GJS-350-22-LT (GGG 35.3).



Key

Y1 Impact rupture strength (J)

X Temperature (°C)

Y2 $PS_{\mathrm{TS\ min}}/PS$

1 Reduction factor

a Sandström-ref 1in J

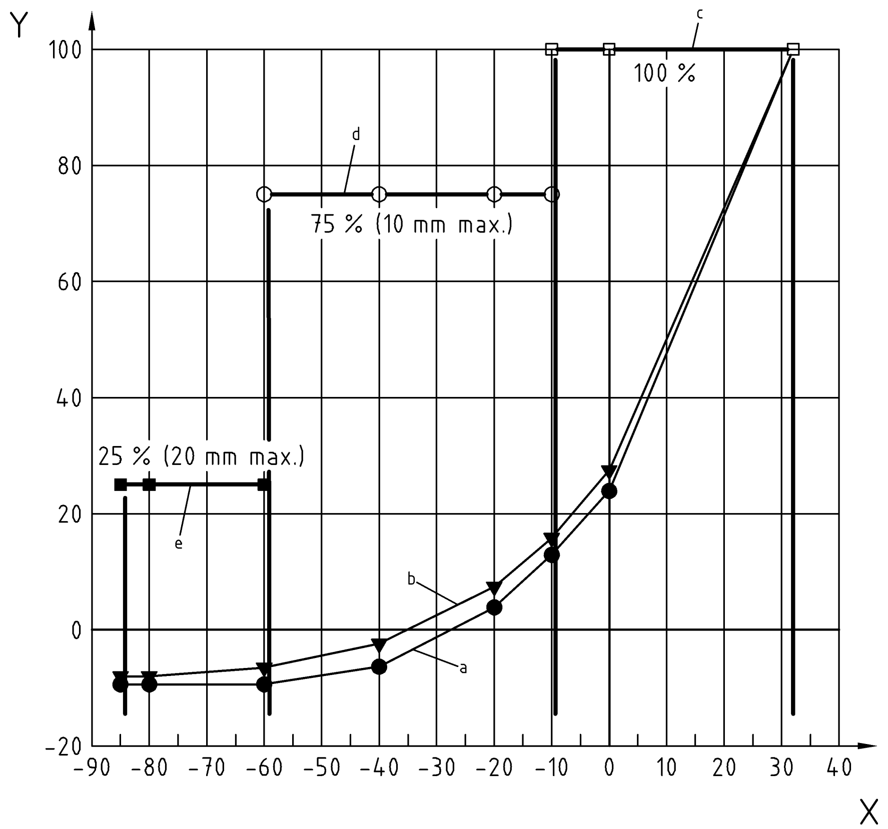
b Estimated KV-values from $S_{\mathrm{TS,\ min}}$

c Fracture Mechanics Method

d min t_0 Method

S235JRG2				
	Fracture Mechanics Method			**min t_0 Method**
Temperature °C	*KV* (J)	for *KV* < 27 J $S_{\mathrm{TS\ min}} = (27/KV)^{-0,75}$ $S_{\mathrm{TS\ min}}$	$PS_{\mathrm{TS\ min}} / PS = S_{\mathrm{TS\ min}}$ $S_{\mathrm{TS\ min}}$	$PS_{\mathrm{TS\ min}} / PS$ $S_{\mathrm{TS\ min}}$
50	>>27	1,00	1,0	1,0
40	>> 27	1,00	1,0	1,0
30	>> 27	1,00	1,0	1,0
20	**27**	**1,00**	1,0	1,0
10	22	0,86	0,86	1,0
0	17	0,71	0,71	1,0
– 10	13	0,58	0,58	1,0
– 10	13	0,58	0,58	0,75
– 20	10	0,47	0,47	0,75
– 30	8	0,40	0,40	0,75
– 40	6,7	0,35	0,35	0,75

Figure F.2.4 — Comparison of *KV*-Method (here $KV_0 = KV_0^t$) with min t_0 - Method by means of material S235JRG2



Key

X Temperature (°C)

Y Reduced pressure [%]

[a] Common refrigerant (example: R-134a)

[b] R717 (NH3)

[c] Stress case min $t_{0\ 100}$

[d] Stress case min $t_{0\ 75}$

[e] Stress case min $t_{0\ 25}$

Figure F.2.5 — Vapour pressure of common refrigerants (here the two typical refrigerants R 134a and R717) relative to design pressures (reduced pressure) at 32°C (acc. to EN 378-2, Tab. 1) and stress cases for steel and cast steel group 1.1 and 1.2 acc. to Annex D 4.2.1 and D 4.2.2

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 97/23/EC.

This European Standard has been prepared under a mandate given to CEN by the European Commission Free Trade Association to provide a means of conforming to Essential Requirements of the New Approach Directive 97/23/EC.

Once this standard is cited in the Official Journal of the European Communities under that Directive and has been implemented as a national standard in at least one Member State, compliance with the clauses of this standard given in table ZA confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations.

Table ZA – Correspondence between this European Standard and Directive 97/23/EC

Clause(s)/sub-clause(s) of this EN	Essential Requirements (Ers) of Directive 97/23/EC	Qualifying remarks/Notes
6.10	Annex I 7.5	Material characteristics
7	Annex I 2.2.2	Design for adequate strength
8	Annex I 3.1	Manufacturing procedures
9	Annex I 3.2	Final assessment
10	Annex I 3.3	Marking & labelling
11	Annex I 3.4	Operating instructions
Annex A	Annex I 2.2.3	Calculation method
Annex B	Annex I 2.2.4	Experimental design method
Annex C	Annex I 2.2.3	Calculation method
Annex D	Annex I 4.1.a), 7.5	Material characteristics

Warning: Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.

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EN 10216-3, *Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 3: Alloy fine grain steel tubes.*

EN 10216-4, *Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 4: Non-alloy and alloy steel tubes with specified low temperature properties.*

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[a] material group according to CR ISO 15608: 31

[b] material group according to CR ISO 15608: 32, 32.1, 32.1

[c] material group according to CR ISO 15608: 33

[d] material group according to CR ISO 15608: 33

[e] material group according to CR ISO 15608: 34

[f] material group according to CR ISO 15608: 35

[g] material group according to CR ISO 15608: 36

[h] material group according to CR ISO 15608: 37, 38

[i] material group according to CR ISO 15608: 38

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