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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*

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Published in Switzerland

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## Foreword

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

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

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

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

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

This document was prepared by Technical Committee ISO TC 86, *Refrigeration and air-conditioning*, Subcommittee SC 1, *Safety and environmental requirements for refrigerating systems*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 182, *Refrigerating systems, safety and environmental requirements*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This first edition is based on EN 12284:2003.

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

## Introduction

This document is intended to describe the safety requirements, safety factors, test methods, test pressures used, and marking of valves and other components with similar bodies for use in refrigerating systems.

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

## 1 Scope

This document specifies safety requirements, certain functional requirements, and marking of valves and other components with similar bodies, hereinafter called valves, for use in refrigerating systems including heat pumps.

This document includes requirements for valves with extension pipes.

This document describes the procedure to be followed when designing valve parts subjected to pressure as well as the criteria to be used in the selection of materials.

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

This document 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.

In addition, this document is applicable to valves with a maximum operating temperature not exceeding 200 °C and a maximum allowable pressure not exceeding 160 bar<sup>1)</sup>.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

ISO 5149-1, *Refrigerating systems and heat pumps — Safety and environmental requirements — Part 1: Definitions, classification and selection criteria*

ISO/TR 15608, *Welding — Guidelines for a metallic material grouping system*

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

EN 13445-3, *Unfired pressure vessels — Part 3: Design*

EN 14276-2:2020, *Pressure equipment for refrigerating systems and heat pumps — Part 2: Piping — General requirements*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5149-1 and the following apply.

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

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

— IEC Electropedia: available at <http://www.electropedia.org/>

1) 1 bar = 0,1 MPa.

**3.1**  
**valve**

device with a pressure enclosure and an intended additional functionality, such as influencing the fluid flow by opening, closing or partially obstructing the passage of the flow or by diverting or mixing the fluid flow, indicating moisture content or filtering the fluid flow

Note 1 to entry: A device with a pressure enclosure and an intended additional functionality is designated as pressure accessory according to the European Pressure Equipment Directive 2014/68/EU.

**3.2**  
**extension pipe**

pipng connected to a valve by the valve manufacturer, which does not influence the pressure strength of the valve itself

Note 1 to entry: Extension pipes often have different diameters in two ends.

Note 2 to entry: The application of extension pipes is determined by the manufacturer and has the advantage that the pressure strength verification of the extension pipes becomes independent of the safety factors used for the verification of the valve.

**3.3**  
**valve assembly**

combination of a valve and one or more extension pipes

EXAMPLE An example of a valve assembly is given in Clause H.6.

**3.4**  
**operating range**

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

**3.5**  
**nominal size**

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

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

Note 2 to entry: Where the nominal size is not specified, for the purpose of this document it is assumed to be the internal diameter of the pipe or component in mm (DN/ID).

Note 3 to entry: Nominal size is not the same as port size which is commonly used for the size of the valve seat opening.

Note 4 to entry: For additional information regarding the *DN* system, see [Annex I](#).

[SOURCE: ISO 6708:1995, 2.1, modified — Notes to entry added.]

**3.6**  
**nominal pressure**

*PN*  
numerical designation which is a convenient rounded number for reference purposes

Note 1 to entry: All equipment of the same nominal size (DN) designated by the same PN number shall have compatible mating dimensions.

[SOURCE: ISO 7268:1983/Amd.1:1984, modified]

**3.7**  
**corrosion**

all forms of material waste (e. g. oxidation, erosion, wear and abrasion)

**3.8****maximum operating temperature**

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

**3.9****minimum operating temperature**

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

**3.10****pressure bearing part**

part, which is subject to stress due to internal pressure greater than 50 kPa (0,5 bar) gauge

**3.11****main pressure bearing part**

part, which constitute the envelope under pressure, essential for the integrity of the equipment

Note 1 to entry: Examples are bonnets, housings, end covers and flanges.

[SOURCE: EN 13445-1:2014]

**3.12****seat tightness class**

letter from A to G indicating the internal tightness of the valve across the valve seat(s)

**3.13****competent body**

third party organisation which has recognized competence in the assessment of quality systems for the manufacture of materials and in the technology of the materials concerned

Note 1 to entry: National legislation can place additional requirements on the competent body depending on the market for which the valve is intended.

**3.14****type of valve connection**

standard and size of the valve connection to other equipment directly fixed to the valves end

Note 1 to entry: Possible types of valve connection are e.g.

- a) *NPS* 2, i.e. a butt-welding connection to ASME/ANSI B 36.10 2 inch steel pipe,
- b) *NPT* ½, i.e. a screwed connection with ½ inch male end according to ASME/ANSI B 1.20.1,
- c) EN 1092-1/11/C/DN 200 x 6,3/PN 40, i.e. a flange type 11 with facing type C (tongue) of nominal size *DN* 200, wall thickness 6,3 mm, *PN* 40.

**3.15****pressure sensitive part**

part of a valve which will not have a reliable function after exposure to the greater of 1,5 times *PS* and 1,25 times *PS*<sub>0</sub>

Note 1 to entry: Examples include bellows, diaphragms or float balls.

**3.16****spindle**

part of the valve which actuates the intended functionality, e.g. opening or closing for influencing the fluid flow

Note 1 to entry: A valve does not necessarily need to incorporate a spindle.

3.17

**maximum allowable pressure**

$PS$   
maximum pressure for which the valve or valve assembly is designed, as specified by the manufacturer

3.18

**maximum allowable pressure at ambient temperature (-10 °C to + 50 °C)**

$PS_0$   
maximum pressure for which the valve or valve assembly is designed, as specified by the manufacturer, at ambient temperature (-10 °C to + 50 °C)

**4 List of symbols**

Symbols used in this document 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 to 5 times of diameter of the rod	%
$a$	Lifetime in years for calculating effect of corrosion; typically 20 years	—
$C_Q$	Factor to compensate for the quality of a casting	—
$D$	Diameter of the hand-wheel	mm
$\delta_e$	Negative wall thickness tolerance	mm
$e_{act}$	Actual wall thickness at given measuring points of the valve to be tested	mm
$e_B$	Reference thickness is the minimum material thickness needed to give adequate strength to pressure bearing parts	mm
$e_c$	Reduction in wall thickness caused by occurrence of corrosion	mm
$e_{con}$	Component wall thickness as specified in the design drawing	mm
$F$	Operating manual force to size the manual operating element	N
$F_s$	Maximum manual force to size the manual operating element	N
$KV$	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
$K_{VS}$	Rate of flow of water in cubic metres per hour for a differential pressure $\Delta p$ of 1 bar (0,1 MPa) at the rated full opening	m <sup>3</sup> /h
$L$	Leakage in percent of $K_{VS}$	%
$l$	Length of the lever or radius of the crank circle	mm
$P_F$	Maximum allowable design test pressure	bar
$PS$	Maximum allowable pressure	bar
$PS_0$	Maximum allowable pressure at ambient temperature (-10 °C to + 50 °C)	bar
$PS_{TS_{max}}$	Maximum allowable pressure at maximum operating temperature	bar
$PS_{TS_{min}}$	Maximum allowable pressure at minimum operating temperature	bar
$P_{Test}$	Minimum burst test pressure (greater than $P_F$ )	bar
$p_1$	Upstream pressure	bar
$p_2$	Downstream pressure	bar
$\Delta p$	Differential pressure	bar
NOTE 1 bar = 0,1 MPa.		

Table 1 (continued)

$p'$	Testing pressure of each valve after production	bar
$Q_M$	Mass flow rate	kg/h
$Q_V$	Downstream volume flow rate	m <sup>3</sup> /h
$R_{e 1,0}$	Yield strength, 1,0% offset	MPa, N/mm <sup>2</sup>
$R_{e 1,0 TS \max}$	Yield strength, 1,0% offset at maximum operating temperature	MPa, N/mm <sup>2</sup>
$R_{e 0,2}$	Yield strength, 0,2% offset at ambient temperature	MPa, N/mm <sup>2</sup>
$R_{p 0,2}$	Proof strength, 0,2% offset at ambient temperature	MPa, N/mm <sup>2</sup>
$R_{p 0,2 TS \min}$	Proof strength, 0,2% offset at minimum operating temperature	MPa, N/mm <sup>2</sup>
$R_{p 0,2/t}$	Proof strength, 0,2% offset at temperature t	MPa, N/mm <sup>2</sup>
$R_{p 0,2 TS \max}$	Proof strength, 0,2% offset at maximum operating temperature	MPa, N/mm <sup>2</sup>
$R_{p 1,0}$	Proof strength, 1,0% offset at ambient temperature	MPa, N/mm <sup>2</sup>
$R_{eH}$	Upper yield strength	MPa, N/mm <sup>2</sup>
$R_{eH TS \max}$	Upper yield strength at maximum operating temperature	MPa, N/mm <sup>2</sup>
$R_m$	Tensile strength	MPa, N/mm <sup>2</sup>
$R_m TS \max$	Tensile strength at maximum operating temperature	MPa, N/mm <sup>2</sup>
$R_{m \text{ act}}$	Actual tensile strength of the material of the valve to be tested	MPa, N/mm <sup>2</sup>
$R_{m \text{ con}}$	Tensile strength used for the design	MPa, N/mm <sup>2</sup>
$\rho$	Density of the actual fluid	kg/m <sup>3</sup>
$\rho_0$	Density of water at 15,5 °C	kg/m <sup>3</sup>
$\rho_1$	Upstream density	kg/m <sup>3</sup>
$\rho_2$	Downstream density	kg/m <sup>3</sup>
$S_C$	Factor to compensate effects of corrosion	—
$S_{\text{con}}$	Factor for the calculation of the burst test pressure taking into account the tensile strength according to <a href="#">Table A.1</a>	—
$S_F$	Factor to allow for forming	—
$S_{TS \min}$	Factor taking into consideration the impact rupture energy reduction due to minimum operating temperature	—
$S_{TS \max}$	Factor to allow for the reduction in strength due to the maximum operating temperature	—
$S_\sigma$	Factor to allow for the test pressure	—
$\sigma_{\text{con}}$	Initial design stress	MPa, N/mm <sup>2</sup>
$\sigma_{\text{corr}}$	Allowable stress values derived from $\sigma_{\text{con}}$	MPa, N/mm <sup>2</sup>
$t_{\min 25}$	Lowest temperature at which pressure bearing parts can be used, if their load amounts to 25 % of the allowable design stress at 20 °C, taking the safety factors according to <a href="#">Table A.1</a> into account	°C
$t_{\min 75}$	Lowest temperature at which pressure bearing parts can be used, if their load amounts to 75 % of the allowable design stress at 20 °C, taking the safety factors according to <a href="#">Table A.1</a> into account	°C
$t_{\min 100}$	Lowest temperature at which pressure bearing parts can be used, if their load amounts to 100 % of the allowable design stress at 20 °C, taking the safety factors according to <a href="#">Table A.1</a> into account	°C
$T_R$	Design reference temperature is the minimum operating temperature $TS_{\min}$ adjusted. Used when determining $TS_{\min}$ based on reference thickness $e_B$	
$T_S$	Temperature adjustment of the design reference temperature $T_R$	
$T_{KV}$	Impact test temperature	
$TS$	Operating temperature	°C
$TS_{\min}$	Lowest operating temperature	°C
NOTE 1 bar = 0,1 MPa.		

**Table 1** (continued)

$TS_{max}$	Maximum operating temperature	°C
$\tau$	Torque, under specified conditions, to operate the valve	Nm
$\tau_s$	Maximum torque, under specified conditions, to seat or unseat the obturator or to overcome temporary intermediate dynamic conditions	Nm
$V$	Inner volume of a valve	l
$X$	Correction of the actual wall thickness relative to the wall thickness of the design	—
$K$	assigns 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)	—
$\partial$	Wall thickness reduction per year	mm
NOTE 1 bar = 0,1 MPa.		

## 5 General requirements

### 5.1 Installation and operation

Valves and valve assemblies shall be designed for the operational loads and conditions as specified in the relevant refrigerating system safety standard.

Relevant refrigerating system safety standards include:

- a) ISO 5149-1, ISO 5149-2 and ISO 5149-4,
- b) IEC 60335-2-40,
- c) ANSI/ASHRAE Standard 15,
- d) EN 378-1, EN 378-2 and EN 378-4.

The application of extension pipes is determined by the manufacturer.

NOTE 1 When extension pipes are applied, the finished device is a valve assembly (see 3.3) consisting of a valve (see 3.1) and extension pipes (see 3.2).

NOTE 2 The application of extension pipes has the advantage that the pressure strength verification of the pipes becomes independent of the safety factors used in the verification of the valve body.

The lowest operating temperature ( $TS_{min}$ ), maximum operating temperature ( $TS_{max}$ ), and the maximum allowable pressure ( $PS$ ) shall be the same for extension pipes and valve assemblies as for the valve incorporated in the valve assembly.

The manufacturer shall classify the category of the valve, extension pipe, and valve assembly according to Annex H as appropriate.

### 5.2 Components under pressure

All parts of the valve or valve assembly 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 and valve assemblies, 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  $PS$ .

### 5.4 Tightness

The valve or valve assembly shall not leak to the outside when tested as described in 9.2. Valve seats shall seal to a degree specified in 9.3.

### 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 metallic materials

Metallic 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 A list of suitable materials is found in Annex E of this document. Steel information can also be found in EN 13445-2 or ASME B 31.5, along with other useful information.

If material properties are changed during the method of manufacture (e.g. through welding or deep drawing) to such an extent that the strength and/or Charpy notch energies, according to ISO 148-1, 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).

Residual stress can e.g. decrease impact strength and increase stress corrosion (see Annex L). Where relevant, it shall be verified that the residual stress does not impose adverse implications.

Materials with a deformation higher than 2 % shall be heat treated with the respective material specifications. Alternatively, the proof against inner pressure shall be verified by test, if no heat treatment is used.

#### 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.

The compatibility of rubber and thermoplastic sealing materials and flat gaskets shall be evaluated according to Annex K.

## 6.2 Requirements for materials to be used for pressure bearing parts

Materials listed in this document (see [Annex E](#)) have been identified for use in valves.

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

NOTE EN 1563 contains information on nodular cast iron.

Free-cutting steel generally does not have the impact strength,  $KV_0$ , required for pressure bearing parts. It may be used for pressure bearing parts where pressure is not a significant design factor.

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 rupture energy 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 joined shall be suitable for an effective connection, depending on the particular materials used and on the dimensions of the piping specified.

## 6.4 Ductility

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

## 6.5 Ageing

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

## 6.6 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.

## 6.7 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.

Free-cutting steel is not qualified for welding.

## 6.8 Nuts, bolts and screws

Materials for nuts, bolts and screws for joining 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 rupture energy shall be achieved. The test piece for impact rupture energy 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) for lowest operating temperature  $TS_{\min} \geq -10$  °C: a notched impact rupture energy  $KV$  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);
- d) for lowest operating temperature of  $TS_{\min} < -10$  °C: a notched impact rupture energy  $KV$  at  $TS_{\min}$  of at least 40 J for tempered carbon steels and tempered alloyed steels (V test-piece).

NOTE Some suitable materials are given in [Annex E](#) of this document.

## 6.9 Spindles

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

## 6.10 Glass materials

Glass shall be free from listers, crystalline enclosures and surface irregularities.

Thermal reinforcement (tempering) of glass should only be applied for strength reasons.

## 6.11 Requirements for documentation

Material test certificates shall be provided by the manufacturer to ensure that the material used conforms with the required specification and that it is traceable from receipt through production up to the final test, preferably at the time of delivery and not later than the time of commissioning. Any required inspection certificate shall be prepared on behalf of and signed by the competent person who carried out the inspection, test, or checking.

Each certificate shall be one of the following 3 types:

- Certificate type 1: A certificate declaring compliance with the order.
- Certificate type 2: A test report showing compliance with the order. The material tested may be from a different batch than the material supplied.
- Certificate type 3: A certificate declaring compliance with the order and in which test results are supplied. The material tested shall be from the same batch as the material supplied.

NOTE 1 ISO 10474 inspection documents type 2.1, 2.2, and 3.1 are examples of certificate types 1, 2, and 3 respectively for steel and steel products.

NOTE 2 EN 10204 inspection documents type 2.1, 2.2, and 3.1 are examples of certificate types 1, 2, and 3 respectively for all metallic materials.

The requirements for material test certificates depend on the category of the valve, as defined in [Annex H](#), and the function of the material in the valve.

Certificate type 1 or higher is required for materials used in:

- valves and extension pipes of category less than I, and
- for non pressure bearing parts.

Certificate type 2 or higher is required for materials used in:

- Pressure bearing parts of category I valves and extension pipes, and
- Nuts, bolts and screws of valves of category II to IV, unless its failure would result in a sudden discharge of pressure energy.

Certificate type 3 is required for materials used in main pressure bearing parts of category II, III and IV valves and extension pipes, and for nuts, bolts and screws where its failure would result in a

sudden discharge of pressure energy. These certificates shall be verified by a competent body, or the manufacture shall be approved for doing this verification by a competent body.

NOTE 1 Nuts, bolts and screws are typically used in a way where the failure of a single nut, bolt or screw will result in a leak, but not result in a sudden discharge of pressure energy.

NOTE 2 European Pressure Equipment Directive 2014/68/EU allows “attachments” of category 1 valves to use inspection type 2.1, and for higher categories to use type 2.2. For simplicity the requirements in this document are slightly higher.

### 6.12 Impact energy KV measurement on sub-sized specimens

If full size Charpy specimen cannot be extracted from components and welds, sub-sized specimens shall be tested. Impact tests should be performed on the maximum thickness which can be extracted from the component under consideration.

The required energies for sub-sized specimens are given in [Table 2](#). To represent the behaviour of a full thickness specimen a lower impact test temperature shall be applied. The temperature shifts shall be in accordance with [Table 2](#).

**Table 2 — Equivalent impact energy requirements when sub-sized specimens are extracted from thicker sections**

Required impact energy	Specimen cross-sectional geometry	Sub-sized specimen requirement		
		KV [J]	Specimen cross-sectional geometry [mm × mm]	Impact test temperature
27	10 × 10	20	7,5 × 10	$T_{KV} - 5 \text{ K}$
27	10 × 10	14	5 × 10	$T_{KV} - 20 \text{ K}$
40	10 × 10	30	7,5 × 10	$T_{KV} - 5 \text{ K}$
40	10 × 10	24	5 × 10	$T_{KV} - 20 \text{ K}$
20	7,5 × 10	14	5 × 10	$T_{KV} - 15 \text{ K}$
30	7,5 × 10	20	5 × 10	$T_{KV} - 15 \text{ K}$
14	5 × 10	—	—	—
20	5 × 10	—	—	—

## 7 Design

### 7.1 General

The construction of a valve or valve assembly shall be suitable for using a valve or valve assembly at the pressure and temperature specified by the manufacture.

The design requirements herein cover parts subject to pressure constructed of materials defined in [Clause 6](#).

Particular attention shall be paid to smooth concave transitions of cross sections of the body design, as sharp edges are liable to increase stress and may directly result in fracture or in stress corrosion cracking (see [Annex L](#)).

Pressure enclosures using glass as material shall be in accordance with requirements of [Annex J](#).

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  $PS$  shall be defined by the manufacturer and the valve or valve assembly strength shall be verified taking the  $PS$  into account.

NOTE ISO 5149-2 does not allow the system to exceed the maximum allowable pressure  $PS$  except during the short period of time necessary for the pressure relief device to operate with a maximum value of 1,1 times  $PS$ .

A valve or valve assembly can have a  $PS$  which depends on the operating temperature. See [Table 6](#).

## 7.3 Valve and valve assembly strength design

The valve and valve assembly design shall be verified for sufficient strength in the entire operating range.

There are two methods of verification for valves:

- a) By calculation according to [Annex A](#), [C](#) and [D](#), or
- b) By experimental method according to [Annex B](#), [C](#) and [D](#).

[Annexes A](#) and [B](#) are used to verify the maximum allowable pressure at ambient temperatures  $PS_0$ , [Annex C](#) is used to determine  $PS_0$  based on the maximum allowable pressure  $PS$  at higher temperatures and [Annex D](#) is used to determine  $PS_0$  based on the maximum allowable pressure  $PS$  at lower temperatures. [Annex F](#) provides background information for the methods of [Annex D](#).

The verification required depends on the category of the valve, as defined in [Annex H](#). For valves of category I or higher:

- For valves categorized by nominal size ( $DN$ ) in [Annex H](#): Where  $PS$  times  $DN$  is less than 3 000 the verification shall be done either by calculation or by experimental method. Where  $PS$  times  $DN$  is 3 000 or more the verification shall be done by calculation.
- For valves categorized by volume ( $V$ ) in [Annex H](#): Where  $PS$  times  $V$  is less than 6 000 the verification shall be done either by calculation or by experimental method. Where  $PS$  times  $V$  is 6 000 or more the verification shall be done by calculation.

For valves of category less than I the verification shall be done either by calculation or by experimental method.

NOTE National legislation can place additional requirements on design approval.

For valves materials with reduced ductility at low temperatures the allowed stress shall be reduced according to [Annex D](#).

In addition to the verification of the valve incorporated in a valve assembly, the valve assembly shall be verified for sufficient strength according to [Annex G](#).

EXAMPLE [Figure 1](#) illustrates the relation between  $PS_0$  and  $PS$ . A  $PS_0$  value of 28 bar has been verified in the operating range -10 °C to 50 °C, the maximum allowable pressure at 150 °C has been verified using [Annex C](#), and the maximum allowable pressures at 60 °C and -80 °C have been verified using [Annex D](#).

From this verification the manufacture can choose to state  $PS$  as a function of temperature (e.g.  $PS$  option 1 in [Figure 1](#)), or any other value of  $PS$  (e.g.  $PS$  option 2 or 3 in [Figure 1](#)), as long as it doesn't exceed the values which have been verified.

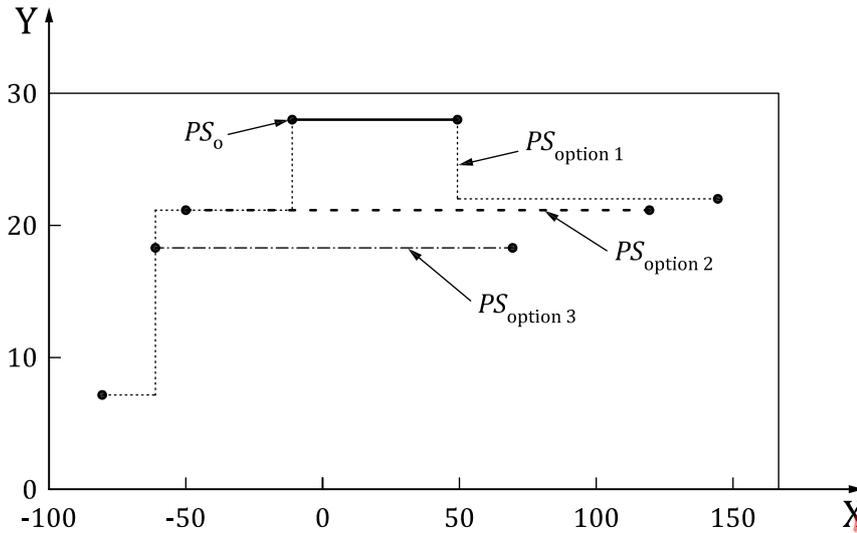


Figure 1 — Example: relationship between  $PS_0$  and  $PS$

#### 7.4 Bodies and bonnets

The strength design of bodies and bonnets subjected to pressure shall be verified by the procedure in [7.3](#).

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

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 Nuts, bolts, screws, fasteners and seals

The complete temperature range (from  $TS_{min}$  to  $TS_{max}$ ) shall be taken into consideration in the design of screws, fasteners, nuts and seals.

In order to prevent breaking caused by freezing water, no moisture shall be allowed to penetrate into bellows seals.

Where soft materials are used for seals the material shall be fixed and restrained.

#### 7.6 Seat tightness

##### 7.6.1 General

Where internal seat tightness is a design feature, the seat tightness shall be classified according to [Table 3](#).

Table 3 — Test requirements for seat tightness

Seat tightness class	Type test <sup>a</sup>
A	Zero bubbles or equivalent measured during one minute <sup>b</sup>
B	Zero bubbles or equivalent measured during one minute
C	0,1% of $K_{VS}$
D	0,25% of $K_{VS}$
E	0,5% of $K_{VS}$
F	1% of $K_{VS}$
G	— <sup>c</sup>

<sup>a</sup> For type test the manufacturer shall measure the leakage at ambient temperature covering the whole differential pressure range. For manual valves, see Table 4 for suggested upper limits to the maximum differential pressure.

<sup>b</sup> For safety valves the manufacturer shall measure the leakage up to  $0,85 \times$  set pressure of the valve.

<sup>c</sup> For seat tightness class G, testing shall be conducted to verify the seat tightness specified in the technical literature.

The required seat tightness class depends on the intended application of the valve:

- Valves leading to the atmosphere permanently shall be seat tightness class A.
- Valves leading to the atmosphere during service shall be seat tightness class A or B.
- For other valves, seat tightness classes with lower requirements are allowed.

Components with several valve seats, may have several seat tightness classes.

NOTE Safety valves are examples of valves where seat tightness class A is required, while most stop valves will require seat tightness classes A or B.

For manually closed valves, when testing the seat tightness, the seat shall be closed before the test applying the prescribed closing force.

For valves of the double seating type such as many gate, plug, and ball valves, the test pressure shall be applied successively to each end of the closed valve and tightness to the opposite end checked.

As alternate methods for valves with independent double seating (such as double disc or split wedge gate valves), at the option of the manufacturer, the pressure may be applied inside the bonnet (or body) of the closed valve and each seat checked for tightness at the valve ports, or the pressure may be applied to the valve ports and the sum of seat leakage measured at the bonnet (or body). These alternate methods may be used at the option of the manufacturer for valves with single discs (such as solid or flexible wedge gate valves) provided a supplementary closure member test across the disc is performed.

For other valve types, the test pressure shall be applied across the closure member in the direction producing the most adverse seating condition. For example, a globe valve shall be tested with pressure under the disc. A check valve, or other valve type designed, sold, and marked as a one-way valve, requires a closure test only in the appropriate direction. A stop check valve requires both tests.

### 7.6.2 Seat tightness: type test

The leakage rate  $L$  is specified as a percentage of the  $K_{VS}$  value in the flow directions for which the valve is designed to shut off the flow.

The manufacturer shall measure the leakage covering the whole differential pressure range for which the valve is designed using gas (for instance air or nitrogen). The leakage rate  $L$  shall not exceed the limits given in Table 3 for type test.

For seat tightness class G the leakage rate  $L$  shall be specified in the technical literature.

Two-directional valves shall be measured in both directions. The greatest value measured is used for calculating  $L$  by means of [Formula \(1\)](#) or [\(2\)](#).

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

The leakage rate  $L$  can be determined by:

$$L = 100 \% \times \frac{Q_M / \rho_2}{K_{VS}} \quad (1)$$

or

$$L = 100 \% \times \frac{Q_V}{K_{VS}} \quad (2)$$

where

$Q_M$  is the mass flow rate in kilograms per hour of leaked air;

$Q_V$  is the downstream volume flow rate in cubic metre per hour of leaked air;

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

$\rho_2$  is the downstream density in kilograms per cubic metre.

NOTE The calculation of the acceptable leak rate is independent of the pressure used when measuring the leak.

EXAMPLE 1 A valve has  $K_{VS}$  equal to 4,6 m<sup>3</sup>/h and the maximum seat leakage  $Q_V$  measured downstream of 15 mm<sup>3</sup> air per minute is measured i.e.  $Q_V = 0,0009$  m<sup>3</sup>/h.  $L$  can be calculated:  $L = 100\% \times 0,0009 / 4,6 = 0,02$  %.

EXAMPLE 2 A valve has  $K_{VS}$  equal to 300 m<sup>3</sup>/h and the maximum seat leakage  $Q_V$  measured downstream of 1 000 mm<sup>3</sup> (1 cm<sup>3</sup>) air per minute is measured i.e.  $Q_V = 0,06$  m<sup>3</sup>/h.  $L$  can be calculated:  $L = 100\% \times 0,06 / 300 = 0,02$  %.

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.

## 7.7 Screwed spindles and shafts

Spindles and shafts shall be secured against unintentional unscrewing.

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

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.

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](#)).

## 7.8 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.

Special design features are required in the case of temperatures below about  $-40\text{ }^{\circ}\text{C}$  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.

Elevated temperatures require special design features to ensure a proper function of the valve.

### 7.9 Valve seats

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. This does not apply for ball valves.

Where soft materials are used for seats and valve plates the material shall be fixed and restrained.

### 7.10 Caps

Caps acting as seals shall be designed for adequate strength.

The body or bonnet may be provided with a seal cap where the spindle passes through the gland. 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 (see [Figure 2](#)).

Caps of valves which are not, in normal circumstances, to be used shall be capable of being provided with a seal wire and a seal to allow only operation by authorized persons.

Screw threads on valve caps shall be right-handed.

Valves intended for manual operation 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.

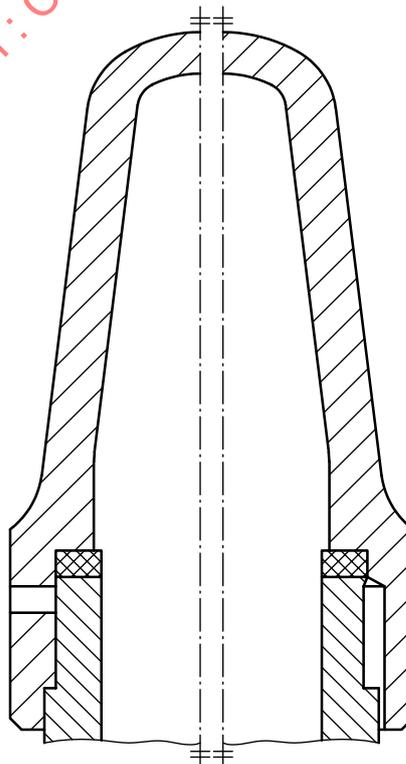


Figure 2 — Example: Relief bore (left) and relief slot (right)

### 7.11 Hand operated valves

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. Please see [Table 4](#) for information on maximum differential pressure for closing by hand. Valves with *DN* less than 50 can be operated by hand with differential pressure up to 90 bar.

The manual forces and sizing of the operating element (hand-wheel or lever) shall be according to [Annex M](#).

**Table 4 — Hand operated valves — Maximum differential pressure for closing by hand**

<i>DN</i>	50	65	80	100	125	150	200	250	300	350	400
Maximum differential pressure [bar] <sup>a</sup>	90	70	60	44	33	21	14	9	6	4,5	3,5
<sup>a</sup> 1 bar = 0,1 MPa											

Valves to be used for strength 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 4](#) the required closing torques shall be stated by the manufacturer.

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.

For hand operated valves used at extreme temperatures provisions shall be taken to avoid the operator getting burned or getting frost bite by the extreme temperatures.

### 7.12 Corrosion protection

Unless valves and valve assemblies 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 anti-corrosive agent or otherwise protected for dry storage at ambient temperature; this protection shall remain effective for at least one year under dry storage conditions.

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 Appropriate manufacturing procedures

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

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.

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 Production testing

### 9.1 Strength pressure testing

After production each valve and/or valve assembly shall be tested at a pressure  $p'$  not less than the greater of 1,5 times  $PS$  and 1,25 times  $PS_0$ . This also applies to valve components tested separately.

For series produced valves of category I and less and series produced valve assemblies of category I and less, as defined in [Annex H](#), the production strength pressure test may be performed on a statistical basis. The statistical method shall be documented.

**NOTE** The European legislation for pressure equipment allows production strength pressure tests on a statistical basis for category I, but it is state of the art not to use this for category I.

**EXAMPLE 1** A valve is designed with a  $PS$  of 21 bar, a minimum operating temperature  $T_{S_{min}} -30$  °C and  $PS_0$  of 28 bar. The test pressure is the greater of

- $1,5 \times 21$  bar = 31,5 bar and
- $1,25 \times 28$  bar = 35 bar.

I.e. the test pressure for production testing at ambient temperature is at least 35 bar.

**EXAMPLE 2** A valve designed with a  $PS$  depending on the the operating temperature (see [Table 6](#)), and the maximum value of  $PS$  is 28 bar. The value of  $PS_0$  is also 28 bar. The test pressure is the greater of

- $1,5 \times 28$  bar = 42 bar and
- $1,25 \times 28$  bar = 35 bar.

I.e. the test pressure for production testing at ambient temperature is at least 42 bar.

When testing valves or valve assemblies which are fitted with pressure sensitive parts, the test may be carried out at 1,1 times the maximum allowable pressure at ambient temperature  $PS_0$ , provided that tests according to [B.1.4](#) are carried out on a statistical basis.

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

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

If the strength pressure test is carried out using gas (e.g. air or nitrogen) then provisions shall be taken to avoid risk when a valve is bursting. For instance, conducting the test 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.

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 [Clause 8](#).

### 9.2 Tightness testing

A tightness test shall be conducted, but only after the valve or valve assembly has been verified for sufficient pressure strength.

If a strength pressure test is conducted, the tightness test shall follow the strength pressure test.

Tightness testing may however be combined with the strength pressure test described in [9.1](#).

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

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.

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

Equivalent tests, for example a helium leakage detection test, are permitted. 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. It shall be documented that the tightness test achieves at least the same performance as the bubble test.

For environmental and safety reasons, nitrogen, helium, and carbon dioxide are preferred test media. Radioactive tracers can be added to the test gases. Air and gas mixtures should be avoided as certain mixtures can be dangerous. Air can be used if the hazard of ignition is eliminated and the safety of the workers is ensured. Oxygen shall not be used for tightness tests.

After testing, care shall be taken to ensure that the test medium is relieved safely.

### 9.3 Seat sealing capacity

Where internal seat tightness is a design feature the following applies.

For seat tightness class A to F as defined in 7.6.1 each valve shall be tested.

A leak shall not be detectable when tested at the differential pressure,  $\Delta p$ , given in Table 5 with measuring equipment being able to detect a leak given in Table 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.

**Table 5 — Production test requirements for seat tightness**

Seat tightness class	Minimum test pressure	Leak detection ability
A	Maximum differential pressure <sup>a, b</sup>	Zero bubbles or equivalent measured during one minute
B	Maximum differential pressure <sup>a</sup>	0,02% of $K_{VS}$
C	5,5 bar	0,1% of $K_{VS}$
D	5,5 bar	0,25% of $K_{VS}$
E	5,5 bar	0,5% of $K_{VS}$
F	5,5 bar	1% of $K_{VS}$
G <sup>c</sup>	—	—

<sup>a</sup> For manual valves, see Table 4 for suggested upper limits to the maximum differential pressure.

<sup>b</sup> For safety valves, the maximum differential pressure shall be the to  $0,85 \times$  set pressure of the valve.

<sup>c</sup> For seat tightness class G, testing should be carried out to verify the seat tightness specified in the technical literature. For instance, by statistical methods.

### 9.4 Caps

Caps acting as seals shall be checked for the presence of a pressure relieving arrangement.

## 10 Marking and additional information

### 10.1 General

Marking of valves or valve assemblies of category I or greater, as defined in Annex H, shall include at least the information specified in 10.2 and 10.4.

Marking of valves or valve assemblies of category lower than I shall include at least the information a), b), g) and h) specified in [10.2](#).

The marking shall be durably marked on the body or the flange or shall be given on a plate or label permanently attached to the valve or valve assembly.

Valve assemblies shall be marked according to the category of the valve assembly. Valves incorporated in a valve assembly need not be marked.

## 10.2 Marking

- a) Manufacturer's trade mark;
- b) Type identification;
- c) Year of manufacture;
- d) Maximum allowable pressure ( $PS$ ) in bar and corresponding temperature range ( $TS_{\min}$  and  $TS_{\max}$ ). If the maximum allowable pressure  $PS$  is a function of the temperature, then the relationship shall be marked;
- e) Nominal size  $DN$ , together with Nominal pressure  $PN$  if appropriate;
- f) Volume (in  $L$ ) if used for categorization according to [Annex H](#);
- g) Indication for type of valve or valve assembly connection;
- h) Arrow indicating the direction of flow, if applicable.

## 10.3 Example how to mark the allowable limits of pressure and temperature

[Table 6](#) provides an example of how to give the pressure as a function of the temperature.

**Table 6 — Maximum allowable pressure as a function of operating temperature (example)**

$PS$ bar	$TS$ °C
22	50,1 to 150
28	-10,0 to 50,0
21	-10,1 to -60,0
7	-60,1 to -85

## 10.4 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.

## 10.5 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  $PS$ .

NOTE These caps are typically category I or larger, according to [Annex H](#), when the free net internal volume is considered as a pressure vessel.

## 11 Documentation

### 11.1 General

For valves of category I or greater, as defined in [Annex H](#), the manufacturer shall be able to supply the documentation specified in [11.2](#).

For valves of category less than I, as defined in [Annex H](#), the manufacturer shall at least be able to supply the documentation specified in [11.2](#) a), b), c), e), f), g), h), i), j), l), and m).

For valve assemblies, the manufacturer shall be able to supply the documentation specified in [11.3](#) in addition to the documentation for the valve as specified above.

### 11.2 Documentation for valves

For valves of category I or greater, as defined in [Annex H](#), 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;
- h) reference to this document, i.e. ISO 21922;
- i) refrigerants for which the device is suitable;
- j)  $K_{VS}$  value where appropriate;
- k) material designation in respect of body parts subject to pressure;
- l) maximum allowable pressure ( $PS$ ), which may be indicated as a function of the temperature;
- m) lowest operating temperature ( $TS_{min}$ ) and maximum operating temperature ( $TS_{max}$ );
- n) detailed information on type of valve connection.

Material certificates may be inspected at the premises of the valve manufacturer (see [6.11](#)).

NOTE For certain applications a copy of the material certificates is needed by the customer.

### 11.3 Additional documentation for valve assemblies

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

- a) Detailed information on type of valve assembly connection;
- b) for valve assemblies of category I or greater, material designation of extension pipes.

For valve assemblies of category less than I, the detailed information on type of valve connection can be omitted for the incorporated valve. The type of valve assembly connection cannot be omitted.

Material certificates may be inspected at the premises of the valve manufacturer (see [6.11](#)).

## Annex A (normative)

### Procedure for the design of a valve by calculation

#### A.1 Calculation method

##### A.1.1 General

This Annex defines the allowable design stress value  $\sigma_{\text{corr}}$  to be used for the calculation of strength at the maximum allowable pressure  $PS$ . Calculation methods includes design by formula (DBF) to withstand a load caused by static internal pressure and design calculation by analysis (DBA) by means of a more sophisticated method based on fracture mechanics or the finite element method.

The calculation method shall incorporate appropriate safety coefficients using comprehensive methods which are known to incorporate adequate safety margins against all relevant failure modes in a consistent manner.

The calculation methods described in the following standards are considered appropriate:

- EN 12516-2;
- EN 13445-3.

Alternatively, other recognized methods, such as ASME Section VIII, Div. 1 and ASME B 31.5, with appropriate safety factors and of equivalent validity may be used.

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.

The Annex also gives safety factors for use with the experimental design method of [Annex B](#).

##### A.1.2 Strength values for the design calculation

The strength values (i.e. 0,2 % proof strength  $R_{p0,2}$ , tensile strength  $R_m$ ) for the design calculation can be taken from the material standards. In [Annex E](#), standards which correspond to the listed materials are given. If the strength values are not taken from the material standards, these shall be verified by means of material certificates in accordance with [6.11](#).

##### A.1.3 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

##### A.2.1 Design stress for main pressure bearing parts

The allowable design stress value  $\sigma_{\text{corr}}$  to be used for the calculation shall be determined as follows:

$$\sigma_{\text{corr}} = \sigma_{\text{con}} / (S_C \times Z \times C_Q) \quad (\text{A.1})$$

where

$\sigma_{corr}$  is the allowable stress values derived from  $\sigma_{con}$ ;

$\sigma_{con}$  is the initial design stress;

$S_C$  is the factor to compensate effects of corrosion;

$Z$  is the factor to compensate for the quality of a joint (e.g. welded joint) (according to Table A.2 only for the material with number 1 to 8 at [Table A.1](#) (otherwise  $Z = 1,0$ ));

$C_Q$  is the factor, to compensate for the quality of casting (according to Table A.3 only for the material with number 9 at [Table A.1](#) (otherwise  $C_Q = 1,0$ )).

**Table A.1 — Design stress  $\sigma_{con}$  as quotient of characteristic strength value and indicated numerical value (safety factor  $S_{con}$ )**

No.	Material <sup>a</sup>	$\sigma_{con}$		$S_{con}$	$S_{\sigma}$
		Yield strength <sup>b c</sup>	Tensile strength <sup>b d</sup>		
1 <sup>e</sup>	Steel group 1.1 and 1.2	MIN { $R_{p0,2} / 1,5$ ; $R_m / 2,4$ }	$R_m / 2,4$	2,4	1,43
2	Steel group 8.1 at $A_5 \geq 30\%$	$R_{p1,0} / 1,5$	$R_m / (0,5 + R_m / R_{p1,0})$	$0,5 + R_m / R_{p1,0}$	1,43
3	at $A_5 \geq 35\%$	MAX { MIN [ $R_m / 3$ ; $R_{p1,0} / 1,2$ ]; $R_{p1,0} / 1,5$ }		3,0	1,43
4 <sup>e</sup>	Cast steel group 1.1 and 1.2	MIN { $R_{p0,2} / 1,9$ ; $R_m / 3$ }	$R_m / 3,0$	3,0	1,43
5	Aluminium group 21	$R_{eH} / 1,5$	$R_m / (0,5 + R_m / R_{eH})$	$0,5 + R_m / R_{eH}$	1,43
6 <sup>e</sup>	Aluminium groups 22 to 26	MIN { $R_{p0,2} / 1,5$ ; $R_m / 2,4$ }	$R_m / 2,4$	2,4	1,43
7 <sup>e</sup>	Copper groups 31 to 38	MIN { $R_{p0,2} / 1,5$ ; $R_m / 3,5$ }	$R_m / 3,5$	3,5	1,57
8	Titanium tube group 51	—	$R_m / 3,0$	3,0	1,35
9	Spheroidal graphite cast iron group 72.2	$R_{p0,2} / 2,4$	$R_m / 3,8$	3,8	1,80
10	Free-cutting steel	$R_{p0,2} / 2,5$	$R_m / 4,0$	4,0	1,80

<sup>a</sup> The classification into groups of materials shall be carried out in accordance with ISO/TR 15608. Materials from these groups are contained in [Annex E](#).

<sup>b</sup> 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 °C to +50 °C can be used. Stress values at other temperatures may not be used in connection with these safety factors.

<sup>c</sup> For steel (ferritic and austenitic, as well as cast steel),  $R_{p0,2}$  can be estimated by reducing  $R_{p1,0}$  by 25 MPa.

<sup>d</sup> The values and terms of the denominator is used for determining  $S_{con}$ .

<sup>e</sup> For  $\sigma_{con}$ , the upper line shall be used if both  $R_{p0,2}$  and  $R_m$  are available. If they are not both available the lower line shall be used.

**Table A.2 — Factor to compensate for the quality of a joint**

Scope of test or inspection	Factor Z
No welding, or destructive and non-destructive tests which confirm that the whole series of joints show no significant defects	1,0
Random destructive or non-destructive test (1/0,85)	1,18
Visual test (1/0,70)	1,43

**Table A.3 — Factor to compensate for the casting quality (spheroidal graphite cast iron)**

Scope of test or inspection	Factor $C_Q$
No casting, or 100 % non-destructive test	1,0
Visual test and random non-destructive test	1,1
Visual test	1,25

### A.2.2 Design calculation of screws, fasteners, nuts and bolts

Screws, fasteners, nuts and bolts shall be dimensioned with design stresses of no more than the allowable stresses of [Table A.4](#) (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.4 — Allowable stresses for the design calculation or testing at test pressure of screws and fasteners**

Material	Allowable stress at maximum allowable pressure $P_S$	Allowable stress at design test pressure $P_F$
Non-austenitic steel	$\text{MIN} \{ R_{m t} / 4,0; R_{p0,2 t} / 3,0 \}$	$\text{MIN} \{ R_{m t} / 2,67; R_{p0,2 t} / 2,0 \}$
Austenitic steel	$R_{m t} / 4,0$	$R_{m t} / 2,67$

Index t: The lower of the material strength values at the minimum and the maximum operating temperature shall be used.  
The allowable stress shall not be exceeded within the operating temperature range.

## Annex B (normative)

### Experimental design method for valves

#### B.1 Experimental design method

##### B.1.1 General

With the experimental design method, the resistance of a sample valve 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.

##### B.1.2 Choice and verification of material properties

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.

##### B.1.3 Procedure for the experimental design method

The design testing as well as the strength testing of the valve is carried out at ambient temperature ( $20 \pm 5$  °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 tests shall be recorded as the result. The following two tests shall be passed:

- a) testing of an original component in completely assembled condition at test pressure  $P_F$  according to the definitions in [B.2](#) and
- b) testing of the valve 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 occurs.

##### B.1.4 Testing at maximum allowable design test pressure $P_F$

This test is carried out on an original component in the completely assembled condition. However, it is allowed to disassemble or replace pressure sensitive parts, provided they are not pressure bearing parts.

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. The pressure is increased gradually up to the maximum allowable design test pressure  $P_F$ . The pressure shall be held at 10 minutes at the 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 [9.1](#) of this document 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 plastic deformation of the pressure bearing parts. However, for pressure sensitive parts plastic deformation is allowed, provided they do not leak.

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.1.5 Testing at minimum burst test pressure $P_{\text{Test}}$

To check the adequate dimensioning of a valve at a pressure equal to the minimum burst test pressure  $P_{\text{Test}}$ , the pressure in the valve is applied with water. Care shall be taken to vent out any air from the valve.

The pressure is increased gradually up to the required burst test pressure  $P_{\text{Test}}$ . The pressure shall be held at 10 minutes at the burst test pressure  $P_{\text{Test}}$ .

If, during the pressure increase up to the minimum burst test pressure  $P_{\text{Test}}$ , 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 pressure bearing parts 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 parts (e.g. screws, bolts, sealing elements) for this test. Parts not fitted during the test shall be verified for strength using other methods, see 7.3. Pressure sensitive parts which will not withstand the application of the minimum burst test pressure  $P_{\text{Test}}$  may be disassembled or replaced before testing.

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

### B.1.6 Documentation

The calculation of the maximum allowable design test pressure  $P_{\text{F}}$  and the minimum burst test pressure  $P_{\text{Test}}$  shall be documented.

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.

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 $P_{\text{F}}$

A pre-requisite for the determination of the maximum allowable design test pressure  $P_{\text{F}}$  is that the maximum allowable pressure  $PS$  meets the design conditions according to [Table A.1](#), with respect to its dimensioning.

The maximum allowable design test pressure  $P_{\text{F}}$  is derived from the intended maximum allowable pressure at ambient temperature  $PS_0$ .  $P_{\text{F}}$  shall be chosen to be one of the following:

$$P_{\text{F}} = PS_0 \times S_{\text{A}} \times X \quad \text{or} \quad P_{\text{F}} = 1,25 \times PS_0 \times X \times Y \quad \text{but not less than} \quad P_{\text{F}} = 1,5 \times PS \times X \times Y \quad (\text{B.1})$$

where

$P_F$  is the maximum allowable design test pressure;

$PS$  is the maximum allowable pressure;

$PS_0$  is the maximum allowable pressure at ambient temperature ( $-10\text{ °C}$  to  $+50\text{ °C}$ ) according to strength design (without temperature correction);

$S_\sigma$  is a safety factor;

$X$  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:  $Y = R_{m, act} / R_{m, con}$ .

If the expression for  $Y$  cannot be determined for the design of valves of category less than I (see [Annex H](#)), then  $Y$  shall be set to 1,05.

For the Factor  $S_\sigma$ , the values listed in [Table A.1](#) shall be used for the respective material group.

### 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:

$$P_{Test} \geq 1,1 \times PS_0 \times S_{con} \times X \times Y \times Z \times C_Q \quad (B.2)$$

where

$P_{Test}$  is the minimum burst test pressure;

$PS_0$  is the maximum allowable pressure at ambient temperature ( $-10\text{ °C}$  to  $+50\text{ °C}$ ) 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.1](#);

$X$  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 compensate for the quality of a joint (e.g. welded joint);

$C_Q$  is the factor to compensate for the quality of a casting.

If the expression for  $Y$  cannot be determined for the design of valves of category less than I (see [Annex H](#)), then  $Y$  shall be set to 1,05.

$Z$  is the factor to compensate for the quality of a joint according to [Table A.2](#) for materials with the number 1 to 8 according to [Table A.1](#) (otherwise  $Z = 1,0$ ).

$C_Q$  is the factor to compensate for the quality of a casting according to [Table A.3](#) for materials with the number 9 according to [Table A.1](#) (otherwise  $C_Q = 1,0$ ).

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

#### B.4 Correction for the actual wall thickness

The difference between the actual wall thickness and the wall thickness of the design needs to be taken into account, using a correction factor. In addition, a reduction of the wall thickness due to corrosion can be allowed for during design by this correction factor.

NOTE EN 14276-1:2020, 6.2 contains more information about how to take corrosion into account.

Experience of the manufacturer can be considered or the factor to compensate for corrosion shall be calculated as follows:

$$X = e_{\text{act}} / (e_{\text{con}} - \delta_e - e_c) \quad (\text{B.3})$$

where

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

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

$\delta_e$  is the negative wall thickness tolerance;

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

If the expression for  $X$  cannot be determined for the design of valves with  $DN \leq 80$ , then  $X$  shall be set to 1,05.

For  $DN > 80$  the maximum value of  $X$  shall be 1,25.

EXAMPLE The reduction of wall thickness due to effects of corrosion  $e_c$  when the wall thickness is expected to decrease with a constant amount per year can be calculated as:

$$e_c = \partial \times a \quad (\text{B.4})$$

where

$\partial$  is the wall thickness reduction per year;

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

If the reduction of wall thickness due to corrosion is not considered under designing by a correction factor, then  $X$  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 Relation of the allowable pressure and higher temperatures

##### C.1.1 General

For maximum operating temperature higher than 50 °C the maximum allowable pressure at ambient temperature (−10 °C to + 50 °C),  $PS_0$  is based on the maximum allowable pressure  $PS$ , and shall be corrected based on the maximum allowable pressure  $PS_{TS\ max}$  at the maximum operating temperature  $TS_{\max}$ .

##### C.1.2 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 ambient temperature (−10 °C to +50 °C),  $PS_0$  is derived from the maximum allowable pressure at the maximum operating temperature,  $PS_{TS\ max}$ :

$$PS_0 = PS_{TS\ max} / S_{TS\ max}$$

where

if design is based on  $R_{p0,2}$  then:  $S_{TS\ max} = R_{p0,2\ TS\ max} / R_{p0,2}$ ;

if design is based on  $R_{p1,0}$  then:  $S_{TS\ max} = R_{p1,0\ TS\ max} / R_{p1,0}$ ;

if design is based on  $R_{eH}$  then:  $S_{TS\ max} = R_{eH\ TS\ max} / R_{eH}$ ;

if design is based on  $R_m$  then:  $S_{TS\ max} = R_{m\ TS\ max} / R_m$ .

## Annex D (normative)

### Determination of the allowable pressure at minimum operating temperature — Requirements to avoid brittle fracture

#### D.1 Relation of the allowable pressure and lower temperatures

##### D.1.1 General

At low operating temperature or when the impact rupture energy is less than the values given below, the maximum allowable pressure at ambient temperature ( $-10\text{ °C}$  to  $+50\text{ °C}$ ),  $PS_0$ , is based on the maximum allowable pressure,  $PS$ , and is to be corrected based on the maximum allowable pressure,  $PS_{TS_{\min}}$  at the minimum operating temperature  $TS_{\min}$ .

The safety factors of [Table A.1](#) takes into account the minimum  $KV$  values at ambient temperature for material groups:

- a) for steel, 27 J;
- b) for spheroidal cast iron material RT, 17 J or 14 J (see [Table E.6](#));
- c) for spheroidal cast iron material LT, 12 J.

The above are the  $KV_0$  values used in this annex.  $PS_0$  is to be corrected when the minimum operating temperature  $TS_{\min}$  is less than  $-10\text{ °C}$  or the impact rupture energy  $KV$  is less than  $KV_0$ .

**EXAMPLE** Materials EN-GJS-350-22-RT and EN-GJS-400-18-RT are spheroidal cast iron, if the impact rupture energy of EN-GJS-350-22-RT exceeds 17 J or of EN-GJS-400-18-RT exceeds 14 J, and the temperature operating range is  $-10\text{ °C}$  to  $+50\text{ °C}$ , then no correction is needed.

**NOTE** Examples of materials and their application limits are given in [Annex E](#).

##### D.1.2 Requirements of materials and proof of material properties

If the minimum impact rupture energy  $KV$  is given for the ambient temperature or  $0\text{ °C}$  then no particular arrangements for use of the material at temperatures down to  $-10\text{ °C}$  is required.

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

Aluminium-Magnesium alloys with a content of magnesium of more than 6 % should be used to down to a temperature of  $-100\text{ °C}$ , only.

**NOTE** The lattice (face-centred lattice) of aluminium and aluminium alloys, groups 21 to 26, and copper and copper alloys, groups 31 to 38, according to ISO/TR 15608, 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 tendency to embrittlement at low temperatures.

##### D.1.3 Documentation

The impact rupture energy shall be confirmed by certificates (see [6.11](#)).

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

The method chosen, according to [D.3](#) or D.4 shall be declared.

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

The maximum allowable pressure at ambient temperature ( $-10\text{ °C}$  to  $+50\text{ °C}$ ),  $PS_0$ , is derived from the maximum allowable pressure at the minimum operating temperature,  $PS_{TS\ min}$  as:

$$PS_0 = PS_{TS\ min} / S_{TS\ min}$$

$S_{TS\ min}$  is taken as stated in [D.3](#). With respect to the application for strength design, both methods are equivalent (see [Annex F](#)).

The method of Clause [D.4](#) can be used for C, CMn, fine grain steels, Ni-alloyed steels with not more than 1,5 % of Ni with a specified minimum yield strength  $\leq 500\text{ MPa}$  and austenitic-ferritic steels with a specified minimum yield strength  $\leq 550\text{ MPa}$ . If the method of Clause [D.4](#) is used, then  $S_{TS\ min}$  is 1.

## D.3 Determination of the maximum allowable pressure at the minimum operating temperature on the basis of an empirical method ( $t_{\min}$ -Method)

### D.3.1 General

With this method, the prevention of brittle fracture is taken into consideration by reduction factors depending on whether the minimum operating temperature ( $TS_{\min}$ ) is above one of the three load case temperatures  $t_{\min\ 100}$ ,  $t_{\min\ 75}$  and  $t_{\min\ 25}$ . The procedure described in the following is based on experience by using valves at low temperatures of refrigerating systems for a long period of time.

The  $KV$  value is to be taken from the material standards (see [Annex E](#)).

### D.3.2 Determining $t_{\min\ 100}$ , $t_{\min\ 75}$ and $t_{\min\ 25}$

If the minimum impact rupture energy  $KV$  is given for the ambient temperature or  $0\text{ °C}$  then  $t_{\min\ 100}$  is not less than  $-10\text{ °C}$ .

The following load cases apply to steel and cast steel (groups 1.1 and 1.2), for which  $t_{\min\ 100}$  is at a temperature of  $> -20\text{ °C}$  and  $\leq -10\text{ °C}$ :

- a)  $t_{\min\ 75}$  is equal to  $t_{\min\ 100} - 50\text{ K}$ , and
- b)  $t_{\min\ 25}$  is equal to  $t_{\min\ 100} - 75\text{ K}$ .

The following load cases apply to steel and cast steel (groups 1.1 and 1.2), for which  $t_{\min\ 100}$  is at a temperature of  $\leq -20\text{ °C}$ , it is to be established that an impact rupture energy of  $KV_0$  or more is given at  $\leq -20\text{ °C}$ . The following load cases apply:

- c)  $t_{\min\ 75}$  is equal to  $t_{\min\ 100} - 50\text{ K}$ , and
- d)  $t_{\min\ 25}$  is equal to  $t_{\min\ 100} - 80\text{ K}$ .

Austenitic steels according to group 8.1 with  $A_5 \geq 35\%$  may be used down to a temperature  $t_{\min\ 100}$  of  $-196\text{ °C}$ .

Aluminium or aluminium-alloys (groups 21 to 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 to 38) according to ISO/TR 15608 may be used down to an operating temperature  $t_{\min\ 100}$  of  $-196\text{ °C}$ . 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  $t_{\min 100} - 100$  K, only.

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 (see [Table E.7](#)) may be used in load cases  $t_{\min 75}$  down to  $-40$  °C and in load cases  $t_{\min 25}$  down to  $-60$  °C.

The values for  $t_{\min 75}$  in [Table E.6](#) for EN-GJS-350-22LT and EN-GJS-400-18-LT are based on practical experience, and these materials should not be used below  $t_{\min 75}$ .

### D.3.3 Welded constructions

The same rules apply to welded joints as to the parent material provided that the lowest temperature at 100 % load ( $t_{\min 100}$ ) of the weld seam is documented through the impact rupture energy test.

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

For materials belonging to groups 1.1 and 1.2, stress-relieving by heat treatment is not required provided the thickness the materials welded are less than 10 mm.

EXAMPLE See [Table D.1](#) for an example of determining  $t_{\min 75}$  and  $t_{\min 25}$  for a weld seam with a  $t_{\min 100}$  of  $-10$  °C.

**Table D.1 — Example of determination of the lowest application temperature for cast steel**

Test temperature of weld seam °C	$t_{\min 100}$ °C	Temperature difference test temperature (see <a href="#">D.3.2</a> ) K	$t_{\min 75}$ °C	Temperature difference test temperature (see <a href="#">D.3.2</a> ) K	$t_{\min 25}$ °C
- 10	- 10	50	- 60	75	- 85
+ 20	- 10	50	- 30	75	- 55

### D.3.4 Determination of the safety factor

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

$$\begin{aligned}
 S_{TS \min} &= 1,0 && \text{for } TS_{\min} \geq t_{\min 100}, \\
 &= 0,75 && \text{for } t_{\min 75} \leq TS_{\min} \leq t_{\min 100}, \\
 &= 0,25 && \text{for } t_{\min 25} < TS_{\min} \leq t_{\min 75}
 \end{aligned}$$

If the value for the intended low operating temperature  $TS_{\min}$  is below  $t_{\min 25}$ , a design of the component is not permitted by this method.

### D.3.5 Material test and documentation

An impact rupture energy test is to be carried out at  $t_{\min 100}$  in accordance with the conditions of the material standards, and the result shall be documented.

## D.4 Determination of the minimum operating temperature $TS_{min}$ based on reference thickness $e_B$

### D.4.1 General

This method can be applied to C, CMn, fine grain steels, Ni-alloyed steels with not more than 1,5 % of Ni with a specified minimum yield strength  $\leq 500$  MPa and austenitic-ferritic steels with a specified minimum yield strength  $\leq 550$  MPa.

This method, based on fracture mechanics, can be used to determine the requirements to avoid brittle fracture in these steels, and may be used for when the lowest operating temperature  $TS_{min}$  is not equal to the impact test temperature  $T_{KV}$ . The diagrams show the relationship between  $TS_{min}$  and  $T_{KV}$  depending on reference thickness and strength level. Distinction is made for as-welded (AW) and post weld heat treated (PWHT) condition.

This method does not apply to thermomechanically-rolled steels thicker than 35 mm.

Reference thickness  $e_B$  for constructional details is the minimum material thickness needed to give adequate strength to pressure bearing parts. The reference thickness  $e_B$  can be chosen to be a higher number if the minimum material thickness needed is unknown.

Parent material, welds and heat affected zone (HAZ) shall meet the required impact energy  $KV$  specified in Table D.3 or [D.4](#) at impact test temperature  $T_{KV}$ .

NOTE This method is based on EN 13445-2.

### D.4.2 Temperature adjustment

The design reference temperature  $T_R$ , The temperature used for determining the impact energy requirements is determined by adding the temperature adjustment  $T_S$  to the lowest operating temperature  $TS_{min}$ :

$$T_R = TS_{min} + T_S$$

Where  $T_S$  is either 0 K or according to [Table D.2](#).

**Table D.2 — Temperature adjustment  $T_S$**

Condition	Ratio of pressure induced principal membrane stress and maximum allowable design stress			Membrane stress <sup>b</sup>
	> 75 %	> 50 % ≤ 75 %	≤ 50 %	
Non-welded or post-weld heat treatment (PWHT) <sup>a</sup>	0 K	+10 K	+25 K	+50 K
As-welded and reference thickness ≤ 35 mm	0 K	0 K	0 K	+40 K

<sup>a</sup> Also applicable for equipment where all nozzles and non-temporary welded attachments are first welded to vessel components and these sub-assemblies are post-weld heat treated before being assembled into the equipment by butt-welding, but the main seams are not subsequently post-weld heat treated.

<sup>b</sup> The membrane stress should take account of internal and external pressure and dead weight. For walls and pipes of heat exchangers the restraint of free end displacement of the heat exchanger pipes should also be taken into account.

### D.4.3 Determining design reference temperature $T_R$

Table D.3 and D.4 show which figure shall be used to determine the impact test temperature  $T_{KV}$  or the design reference temperature  $T_R$ . The condition "non-welded" shall be treated as the condition PWHT.

If impact energy  $KV$  requirement of 40 J instead of 27 J is used, then the impact test temperature  $T_{KV}$  can be increased by 10 K or  $T_R$  can be reduced by 10 K.

Linear interpolation between strength and thickness levels given in the Figures D.1 to D.11 is allowed.

Alternatively the next higher strength class or wall thickness can be used. Lower test temperatures than  $T_{KV}$  are admissible for the same requirements.

The dashed lines in Figure D.1 and Figure D.3 apply to a wall thickness up to and including 110 mm when impact values  $KV$  of 40 J are obtained at  $T_{KV}$ .

Extrapolations for temperature ranges beyond the temperature ranges as given in the figures are not permissible.

For wall thicknesses < 10 mm the curve for 10 mm shall be used.

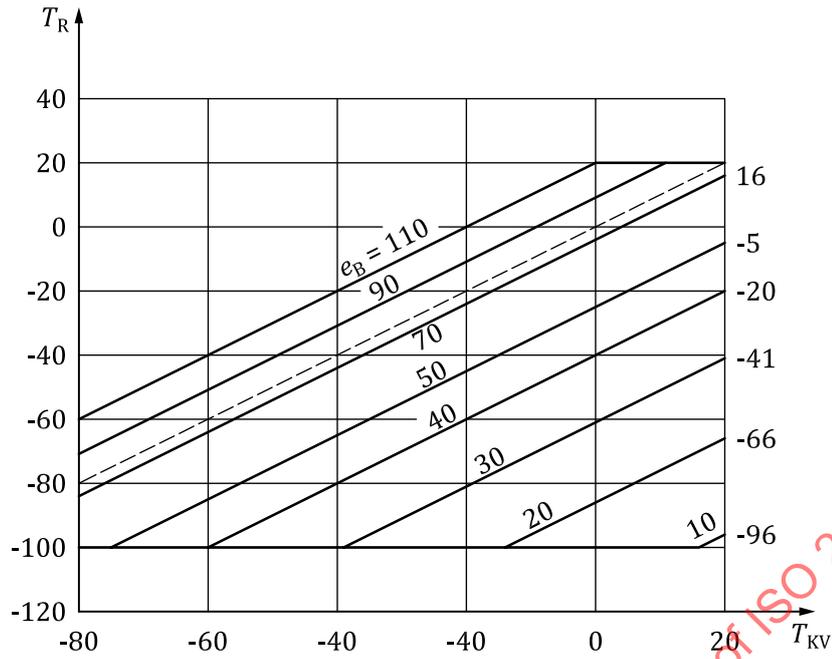
**Table D.3 — Impact energy requirements for C, CMn, fine grain steels, Ni-alloyed steels with not more than 1,5 % Ni**

Specified minimum yield strength of base material	Required impact energy $KV$ (on 10 mm × 10 mm test pieces)	Figure defining required $T_{KV}$	
		Non welded or post-weld heat treatment	As welded
MPa	J		
$R_e \leq 265$	27	Figure D.1	Figure D.2
$R_e \leq 355$	27	Figure D.3	Figure D.4
$R_e \leq 460$	40	Figure D.5	Figure D.6
$R_e \leq 500$	40	Figure D.7	Figure D.8

The dashed lines in Figures D.1 and D.3 shall only be used for  $KV \geq 40$  J.

**Table D.4 — Temperature adjustment  $T_S$**

Specified minimum yield strength of base material	Required impact energy $KV$ (on 10 mm × 10 mm test pieces)	Figure defining required $T_{KV}$
MPa	J	
$R_e \leq 385$	40	Figure D.9
$R_e \leq 465$	40	Figure D.10
$R_e \leq 550$	40	Figure D.11



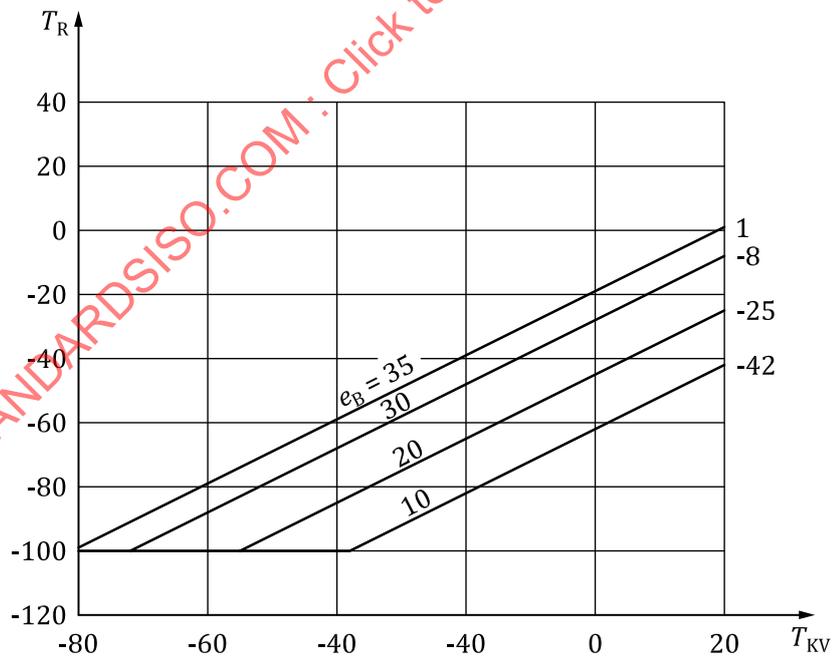
**Key**

$T_R$  design reference temperature

$e_B$  reference thickness

$T_{KV}$  material impact test temperature

**Figure D.1 — Design reference temperature and impact test temperature, post weld heat treated (PWHT) condition, for  $R_e \leq 265$  MPa and  $KV \geq 27$  J. Dashed line only to be used for  $KV \geq 40$  J and for thickness from 75 mm up to and including 110 mm**



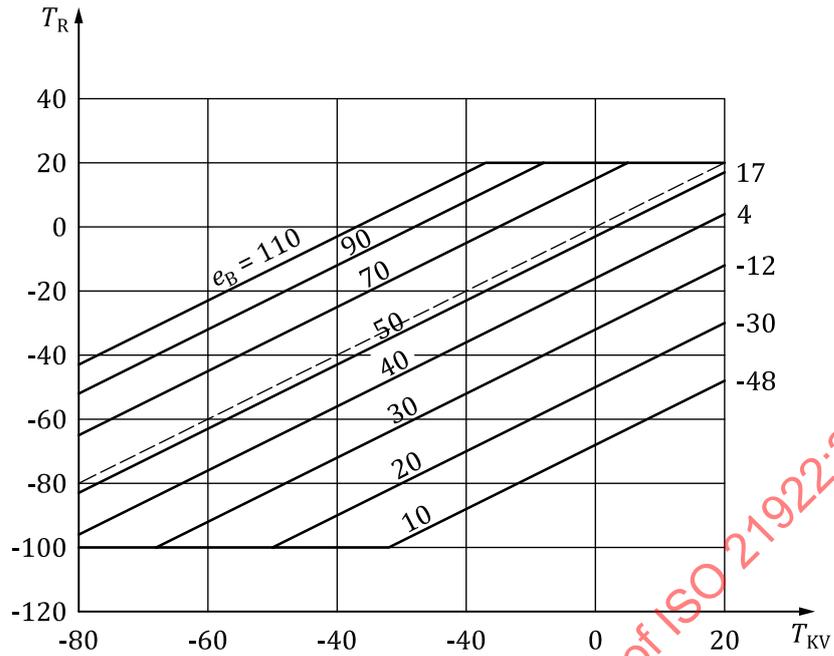
**Key**

$T_R$  design reference temperature

$e_B$  reference thickness

$T_{KV}$  material impact test temperature

**Figure D.2 — Design reference temperature and impact test temperature, as-welded (AW) condition, for  $R_e \leq 265$  MPa and  $KV \geq 27$  J**



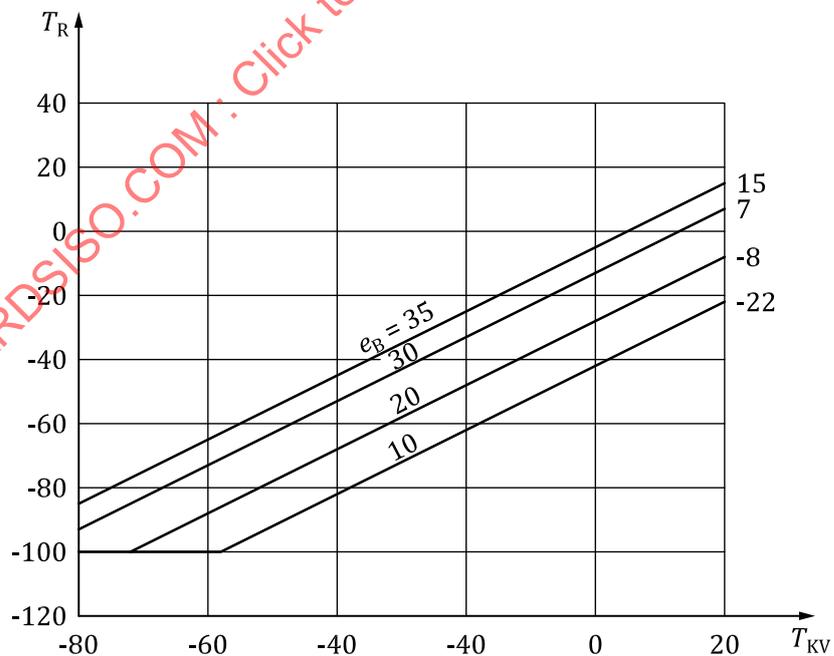
**Key**

$T_R$  design reference temperature

$e_B$  reference thickness

$T_{KV}$  material impact test temperature

**Figure D.3 — Design reference temperature and impact test temperature, post weld heat treated (PWHT) condition, for  $R_e \leq 355$  MPa and  $KV \geq 27$  J. Dashed line only to be used for  $KV \geq 40$  J and for thickness from 55 mm up to and including 110 mm**



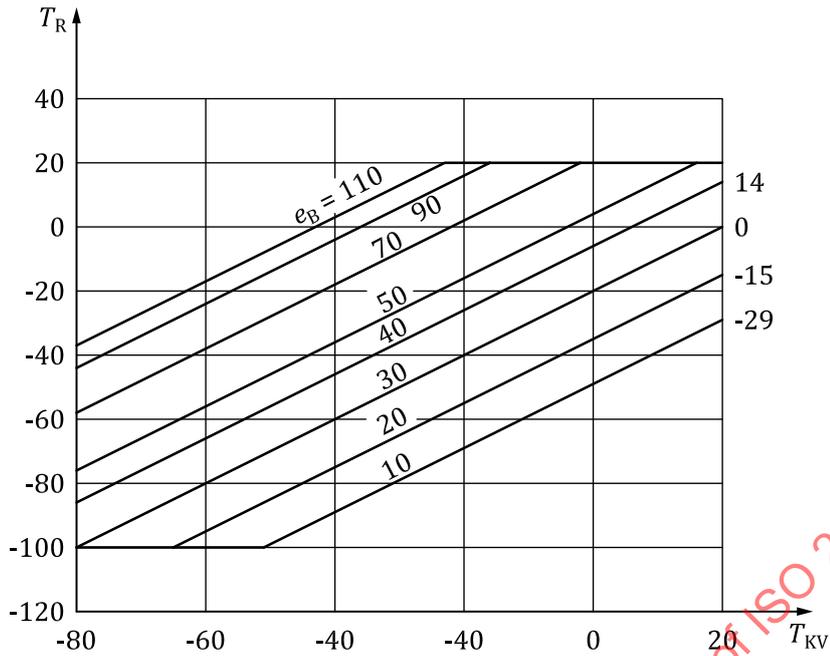
**Key**

$T_R$  design reference temperature

$e_B$  reference thickness

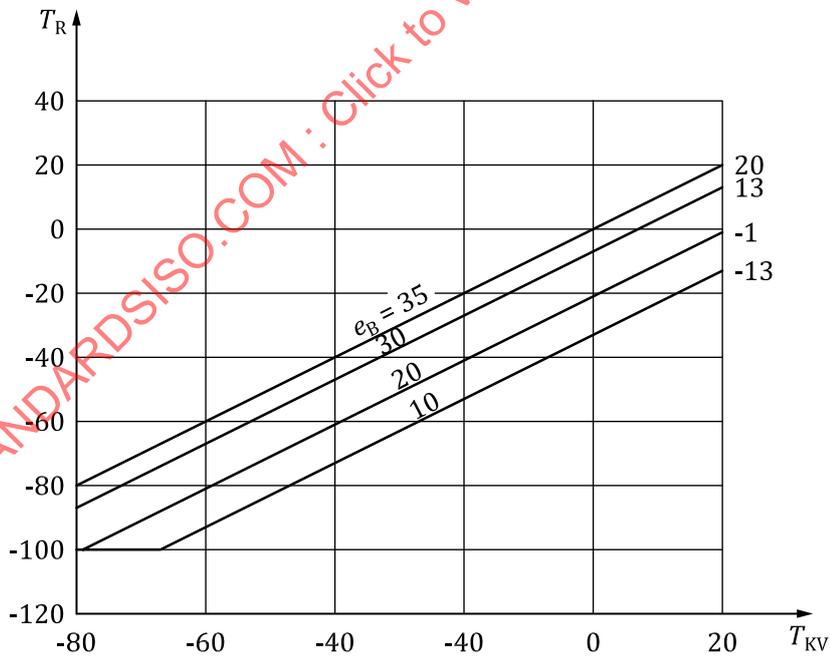
$T_{KV}$  material impact test temperature

**Figure D.4 — Design reference temperature and impact test temperature, as-welded (AW) condition, for  $R_e \leq 355$  MPa and  $KV \geq 27$  J**



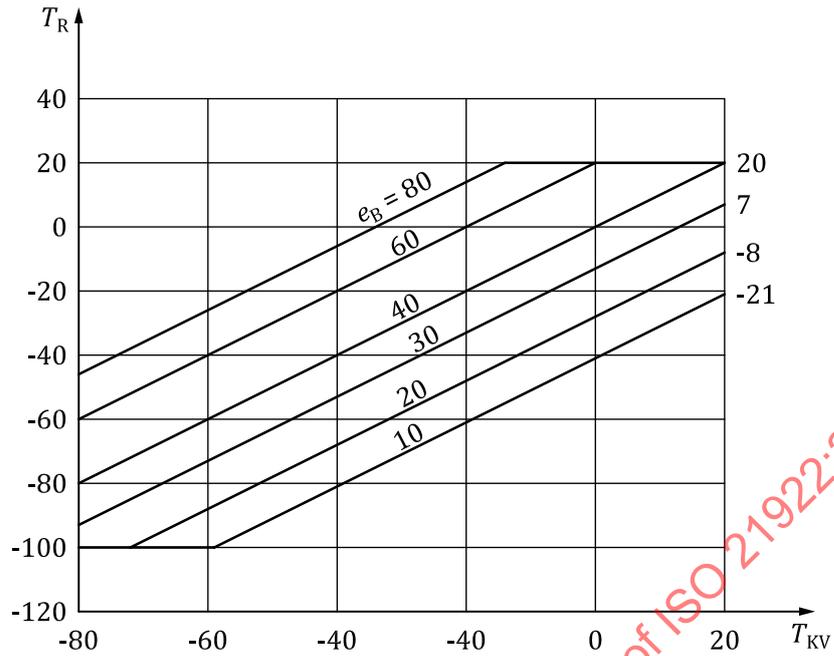
**Key**  
 $T_R$  design reference temperature  
 $T_{KV}$  material impact test temperature  
 $e_B$  reference thickness

**Figure D.5 — Design reference temperature and impact test temperature, post weld heat treated (PWHT) condition, for  $R_e \leq 460$  MPa and  $KV \geq 40$  J**



**Key**  
 $T_R$  design reference temperature  
 $T_{KV}$  material impact test temperature  
 $e_B$  reference thickness

**Figure D.6 — Design reference temperature and impact test temperature, as-welded (AW) condition, for  $R_e \leq 460$  MPa and  $KV \geq J$**



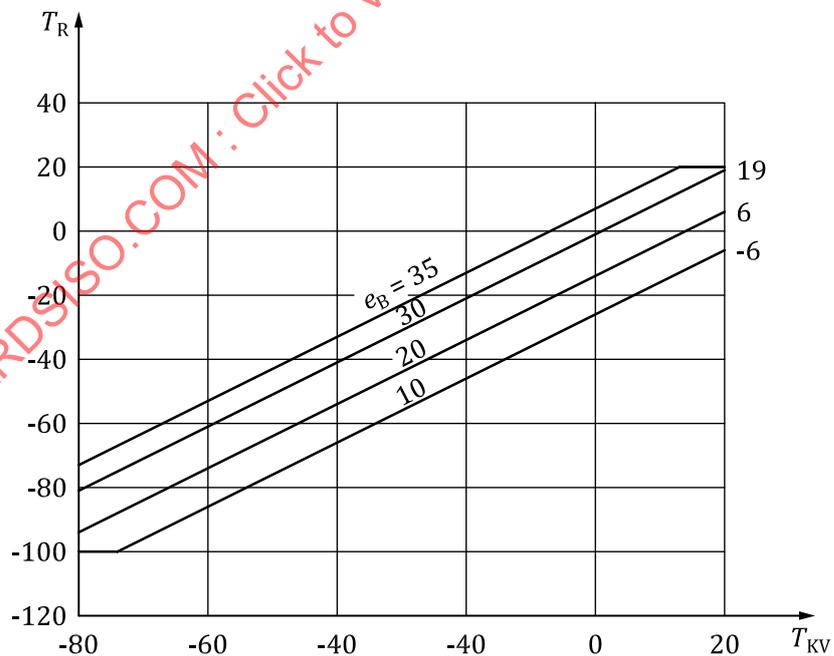
**Key**

$T_R$  design reference temperature

$e_B$  reference thickness

$T_{KV}$  material impact test temperature

**Figure D.7 — Design reference temperature and impact test temperature, post weld heat treated (PWHT) condition, for  $R_e \leq 500$  MPa and  $KV \geq 40$  J**



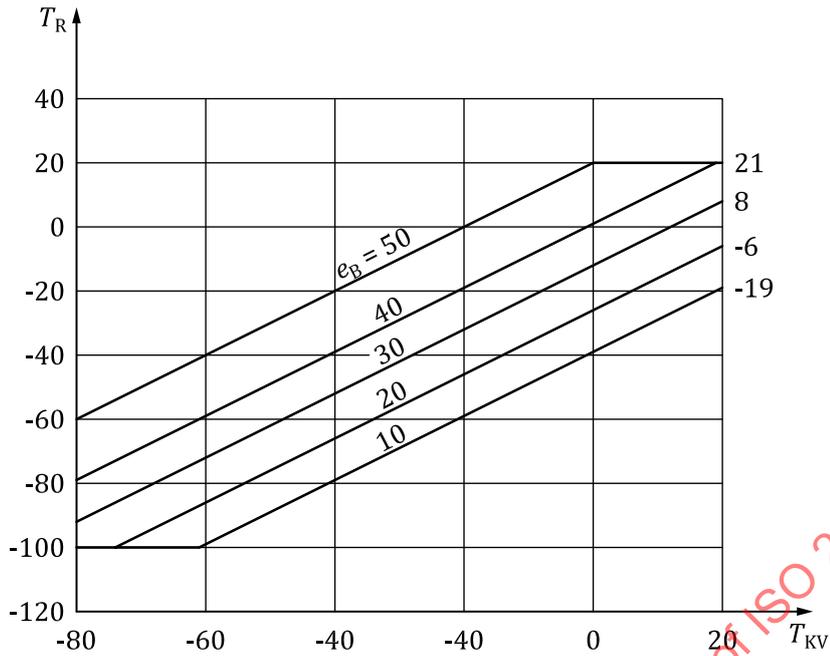
**Key**

$T_R$  design reference temperature

$e_B$  reference thickness

$T_{KV}$  material impact test temperature

**Figure D.8 — Design reference temperature and impact test temperature, as-welded (AW) condition, for  $R_e \leq 500$  MPa and  $KV \geq 40$  J**



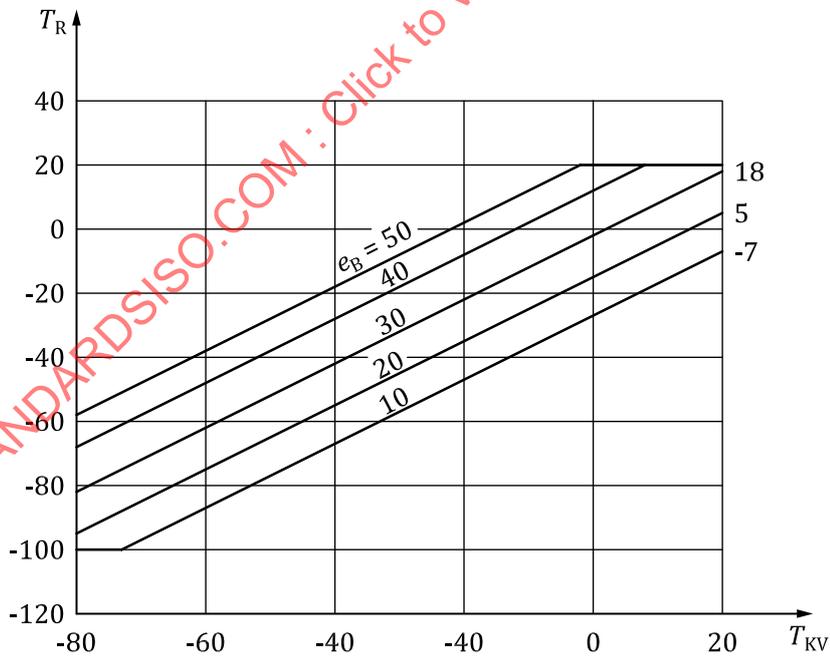
**Key**

$T_R$  design reference temperature

$e_B$  reference thickness

$T_{KV}$  material impact test temperature

**Figure D.9 — Design reference temperature and impact test temperature austenitic-ferritic steels, as-welded (AW) condition, for  $R_e \leq 385$  MPa and  $KV \geq 40$  J**



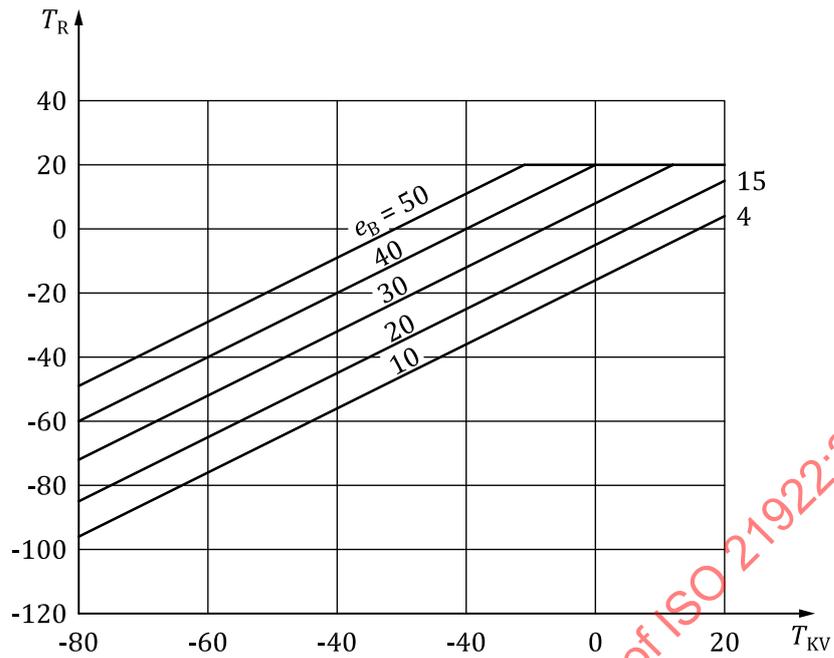
**Key**

$T_R$  design reference temperature

$e_B$  reference thickness

$T_{KV}$  material impact test temperature

**Figure D.10 — Design reference temperature and impact test temperature austenitic-ferritic steels, as-welded (AW) condition, for  $R_e \leq 465$  MPa and  $KV \geq 40$  J**



**Key**

$T_R$  design reference temperature

$e_B$  reference thickness

$T_{KV}$  material impact test temperature

**Figure D.11 — Design reference temperature and impact test temperature austenitic-ferritic steels, as-welded (AW) condition, for  $R_e \leq 550$  MPa and  $KV \geq 40$  J**

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## Annex E (informative)

### Compilation of material characteristics of frequently used materials

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

NOTE 1 For the design calculation the values of strength of bodies, bonnets, flanges, screws, bolts and nuts according the [Annexes A](#) to [D](#) of this document 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 takes precedence over the values of this Annex.

NOTE 2 Values from one standard are indicated as an example in case of more than one standard being applicable for a given row.

NOTE 3 Materials often used for seats, valve plates and seals are metals, soft metals and polymers.

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

Material			Standard	Strength Values		Elong. after fracture $A_5$ [%]	Impact rupture energy $KV_0$		Product form					Operating Temperature [°C]			US-nomenclature						
Symbol	Number	Group		Condition	$R_{p0,2}^a$ [MPa]		$R_m$ [MPa]	[J]	at [°C]	L/q	1	2	3	4	5	$t_{min 25}$	$t_{min 75}$	$t_{min 100}$	max	Standard	Grade		
P235GH	1.0345	1.1	N	EN 10028-2 EN 10273 EN 10216-2 EN 10217-2	235	360	27	0	L			X	X	X	-85	-60	-10	400	A.42/414/ 515/516	55/C/65			
					265	410	27	0	L		X	X	X										
					295	460	27	0	L		X												
					355	510	27	0	L		X												
P245GH	1.0352	1.1	NT QT	EN 10222-2	220	410	27	0	q		X												
					255	460	27	0	q		X												
P280GH	1.0426	1.2	N, NT, QT	EN 10222-2	235	360	28	-20	L		X	X	X	-100	-70	-20	300						
					480	480	28	-20	L		X												
P265S	1.0130	1.1	N	EN 10207	265	410	28	-20	L		X												
					530	530	28	-20	L		X												
P275SL	1.1100	1.1	N	EN 10207	275	390	28	-50	L		X												
					510	510	28	-50	L		X												
S235J2	1.0117	1.1	N	EN 10025	235	340	27	-20	L		X												
					470	470	27	-20	L		X												
S275J2	1.0145	1.1	N	EN 10025	275	410	27	-20	L		X												
					560	560	27	-20	L		X												

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

<sup>a</sup> Nominal value up to a determined thickness as noted in this document.

Table E.1 (continued)

Material			Standard	Strength Values		Elong. after fracture A <sub>5</sub> [%]	Impact rupture energy KV <sub>0</sub>		Product form					Operating Temperature [°C]			US-nomenclature					
Symbol	Number	Group		Condition	R <sub>p0,2</sub> <sup>a</sup> [MPa]		R <sub>m</sub> [MPa]	[J]	at [°C]	L/q	1	2	3	4	5	t <sub>min 25</sub>	t <sub>min 75</sub>	t <sub>min 100</sub>	max	Standard ASTM	Grade	
S355J2	1.0577	1.1	N	EN 10028-3	355	490	27	-20	L		X			X	-100	-70	-20					
P275NL1	1.0488	1.1	N	EN 10028-3	275	390	27	-20	q			X			-100	-70	-20	400	A662	A		
				EN 10216-3	510						X											
				EN 10217-3																		
P275NL2	1.1104	1.1	N	EN 10028-3	275	390	27	-50	q				X		-130	-100	-50	400				
				EN 10216-3	510						X											
				EN 10217-3																		
P355NL1	1.0566	1.2	N	EN 10028-3	355	490	27	-20	q				X		-100	-70	-20	400				
				EN 10216-3	630						X											
				EN 10217-3																		
P355NL2	1.1106	1.2	N	EN 10028-3	355	490	27	-50	q				X		-130	-100	-50	400				
				EN 10216-3	630						X											
				EN 10217-3																		
P255QL	1.0452	1.1	QT	EN 10216-4	255	360	27	-50	q				X		-130	-100	-50	400				
					490																	
P265NL	1.0453	1.1	N	EN 10216-4	265	410	27	-40	q				X		-120	-90	-40	400				
				EN 10217-4	570						X											
P285QH	1.0478	1.2	+ QT	EN 10222-4	245	370	34	-40	L					X		-120	-90	-40				
					510																	
P355QH1	1.0571	1.2	+ QT	EN 10222-4	315	470	34	-40	L					X		-120	-90	-40				
					630																	
P285NH	1.0477	1.2	N	EN 10222-4	285	390	28	-40	L				X		-120	-90	-40	400				

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

<sup>a</sup> Nominal value up to a determined thickness as noted in this document.

Table E.1 (continued)

Material			Standard	Strength Values		Elong. after fracture $A_5$ [%]	Impact rupture energy $KV_0$		Product form					Operating Temperature [°C]			US-nomenclature					
Symbol	Number	Group		Condition	$R_{p0,2}^a$ [MPa]		$R_m$ [MPa]	[J]	at [°C]	1	2	3	4	5	$t_{min 25}$	$t_{min 75}$	$t_{min 100}$	max	Standard	Grade		
P355NH	1.0565	1.2	N	EN 10222-4	355	490	28	L	X	X	X			-120	-90	-40	400					
				EN 10273	630																	
				EN 10216-3																		
				EN10217-3																		
DC04	1.0338	1.1	RR	EN 10130	140	270	—	—	—			X	-85	-60	-10							
				EN10028-3	210	350																

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

<sup>a</sup> Nominal value up to a determined thickness as noted in this document.

Table E.2 — Steel (group 8.1)

Material		Standard	Strength Values		Elong. after fracture	Impact rupture energy $KV_0$		Product form					Operating Temperature [°C]			US-nomenclature																	
			$R_{p0.2}$ [MPa]	$R_m$ [MPa]		$A_5$ [%]	[J]	at [°C]	L/q	1	2	3	4	5	$t_{min 25}$	$t_{min 75}$	$t_{min 100}$	max	Standard ASTM	Grade													
X5CrNi 18-10	1.4301	EN 10028-7 EN 10216-5 EN 10217-7 EN 10222-5 EN 10272	+AT	230	540	45	60	-196	q	X		X	X						A213/ A240/ A276/ A312/A403	TP304/304/ WP304													
X2CrNi 19-11	1.4306	EN 10028-7 EN 10216-5 EN 10217-7 EN 10222-5 EN 10272	+AT	220	520 670	45	60	-196	q			X	X						A213/ A240/ A276/ A312/A403	TP304L/ 304L/WP304L													
X2CrNi 18-9	1.4307	EN 10028-7 EN 10216-5 EN 10217-7 EN 10222-5 EN 10272	+AT	220	520 670	45	60	-196	q	X		X	X																				
X2CrNiN 18-10	1.4311	EN 10028-7 EN 10216-5 EN 10217-7 EN 10222-5 EN 10272	+AT	290	550 750	40	60	-196	q	X		X	X						A312	TP304NL													
X5CrNiN 19-9	1.4315	EN 10028-7	+AT	270	550 750	40																											

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

<sup>a</sup> Nominal value up to a determined thickness as noted in EN 13480-2, EN 13445-2.

Table E.2 (continued)

Material			Standard	Strength Values		Elong. after fracture $A_5$ [%]	Impact rupture energy $KV_0$		Product form					Operating Temperature [°C]				US-nomenclature			
Symbol	Num-ber	Group		Condition	$R_{p0,2}^a$ [MPa]		$R_m$ [MPa]	[J]	at [°C]	1	2	3	4	5	$t_{min 25}$	$t_{min 75}$	$t_{min 100}$	max	Standard ASTM	Grade	
X2CrNiMo 17-12-2	1.4401	8.1	+AT	EN 10028-7	220	530	60	-196	X									A276/A312/A403	316/WP316		
				EN 10222-5	680				X	X											
				EN 10216-5								X									
				EN 10217-7																	
			EN 10272																		
X2CrNiMo 17-12-2	1.4404	8.1	+AT	EN 10028-7	220	530	60	-196	X									A213/A276/A312/A403/A240	TP316L/TP316LN/316L/WP316L		
				EN 10216-5	680				X	X											
				EN 10217-7																	
				EN 10272																	
			EN 10222-5																		
X2CrNiMo 17-11-2	1.4406	8.1	+AT	EN 10028-7	300	580	60	-196	X									A276	316L		
				EN 10222-5	780				X												
				EN 10272																	
			EN 10222-5																		
X2CrNiMoN 17-13-3	1.4429	8.1	+AT	EN 10028-7	300	580	60	-196	X									A213/A240/A276	TP316LN/316L		
				EN 10216-5	780				X	X											
				EN 10217-7																	
				EN 10222-5																	
			EN 10272																		
X2CrNiMo 17-12-3	1.4432	8.1	+AT	EN 10028-7	240	550	60	-196	X												
				EN 10217-7	700																
				EN 10222-5																	
				EN 10272																	

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

<sup>a</sup> Nominal value up to a determined thickness as noted in EN 13480-2, EN 13445-2.

Table E.2 (continued)

Material		Standard	Strength Values		Elong. after fracture	Impact rupture energy $KV_0$		Product form					Operating Temperature [°C]			US-nomenclature											
			$R_{p0.2}^a$ [MPa]	$R_m$ [MPa]		$A_5$ [%]	[J]	at [°C]	1	2	3	4	5	$t_{min 25}$	$t_{min 75}$	$t_{min 100}$	max	Standard ASTM	Grade								
X2CrNiMo 18-14-3	8.1	EN 10028-7 EN 10216-5 EN 10217-7 EN 10222-5 EN 10272	240	550 700	40	60	-196	q	X			X	X														
												X	X														
X3CrNiMo 17-13-3	8.1	EN 10028-7 EN 10222-5 EN 10216-5 EN 10217-7 EN 10272	205	510 710	45	60	-196	q	X			X	X														
												X	X														
X2CrNiMo 17-13-5	8.1	EN 10028-7 EN 10216-5 EN 10217-7 EN 10272	290	580 780	35	60	-196	q				X	X														
												X	X														
X3CrNiMo 18-12-3	8.1	EN 10222-5	220	520 720	45	60	-196	q	X																		
X6CrNiTi 18-10	8.1	EN 10222-5 EN 10028-7 EN 10216-5 EN 10217-7 EN 10272	220	520 720	40	60	-196	q	X			X	X														
												X	X														

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

<sup>a</sup> Nominal value up to a determined thickness as noted in EN 13480-2, EN 13445-2.

Table E.2 (continued)

Material		Standard	Strength Values		Elong. after fracture $A_5$ [%]	Impact rupture energy $KV_0$		Product form					Operating Temperature [°C]			US-nomenclature									
			$R_{p0,2}^a$ [MPa]	$R_m$ [MPa]		[J]	at [°C]	1	2	3	4	5	$t_{min 25}$	$t_{min 75}$	$t_{min 100}$	max	Standard ASTM	Grade							
X6CrNiMoTi17-12-2	1.4571	8.1	+AT	EN 10222-5	240	540	60	-196	q	X						550	A213/ A240/ A276/ A312/ A403/A479	TP316L/ 316Ti/ TP316Ti/ WP316Ti							
					EN 10028-7					690	X	X	X												
					EN 10216-5																				
					EN 10217-7																				
X6CrNiMo Nb17-12-2	1.4580	8.1	+AT	EN 10028-7	215	510	60				X	X				A276	316CB								
					EN 10272			740																	
					EN10216-5																				
X6CrNi 18-10	1.4948	8.1	+AT	EN10028-7	185	500	60	+	20	X					-85	-60	-10								
					EN 10216-5					700															
					EN 10222-5																				
X8CrNiNb 16-13	1.4961	8.1	+AT	EN10028-7	205	510	60	+	20						-85	-60	-10	600							
					EN 10216-5					690															

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

<sup>a</sup> Nominal value up to a determined thickness as noted in EN 13480-2, EN 13445-2.

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

Material			Standard	Strength Values		Elong. after fracture A <sub>5</sub> [%]	Impact rupture energy KV <sub>0</sub>		Product form					Operating Temperature [°C]			US-nomenclature	
Symbol	Number	Group		Condition	R <sub>p0,2</sub> <sup>a</sup> [MPa]		R <sub>m</sub> [MPa]	[J]	at [°C]	1	2	3	4	5	t <sub>min 25</sub>	t <sub>min 75</sub>	t <sub>min 100</sub>	max
GP240GH	1.0619	1.1	N	EN 10213	240	420	27	20	X				-85	-60	-10	450	A216	WCA, WCB, WCC
GP240GH	1.0619	1.1	QT	EN 10213	240	420	40	20	X				-85	-60	-10	450	A216	WCA, WCB, WCC
GP280GH	1.0625	1.2	N	EN 10213	280	480	27	20	X				-85	-60	-10	450		
GP280GH	1.0625	1.2	QT	EN 10213	280	480	35	20	X				-85	-60	-10	450		
G20Mo5	1.5419	1.2	QT	EN 10213	245	440	27	20	X				-85	-60	-10	450	A217	WC1
G17Mn5	1.1131	1.1	QT	EN 10213	240	450	27	-40	X				-120	-90	-40	300		
G20Mn5	1.6220	1.2	N	EN 10213	300	480	27	-30	X				-110	-80	-30	300		
G20Mn5	1.6220	1.2	QT	EN 10213	300	500	27	-40	X				-120	-90	-40	300		
G18Mo5	1.5422	1.2	QT	EN 10213	240	440	27	-45	X				-125	-95	-45	300		
GX2CrNi19-11	1.4309	8.1	+AT	EN 10213	210	440	70	-196	X				-	-	-196	350		
GX5CrNi19-10	1.4308	8.1	+AT	EN 10213	200	440	60	-196	X				-	-	-196	300	A743/A744	CF8
GX2CrNiMo19-11-2	1.4409	8.1	+AT	EN 10213	220	440	70	-196	X				-	-	-196	300		

NOTE: Measuring condition: L is in direction of rolling direction, q is at right angles of rolling direction. Product forms: 1-forging; 2-casting; 3-rolled bars; 4-tube; 5-plate.  
<sup>a</sup> Nominal value up to a determined thickness as noted in this document.

Table E.3 (continued)

Material			Standard	Strength Values		Elong. after fracture $A_5$	Impact rupture energy $KV_0$		Product form					Operating Temperature [°C]			US-nomenclature		
Symbol	Number	Group		Condition	$R_{p0,2}^a$ [MPa]		$R_m$ [MPa]	[J]	at [°C]	1	2	3	4	5	$t_{min 25}$	$t_{min 75}$	$t_{min 100}$	max	Standard ASTM
GX5CrNiMo19-11-2	1.4408	8.1	+AT	EN 10213	210	440	60	-196	L	X				-	-	-196	300	A351/A744	CF8M
						640													

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

<sup>a</sup> Nominal value up to a determined thickness as noted in this document.

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

Material			Standard	Strength Values		Elong. after fracture A <sub>5</sub> [%]	Impact rupture energy KV <sub>0</sub>		Product form					Operating Temperature [°C]			US-nomenclature		
Symbol	Number	Group		Condition	R <sub>p0,2</sub> <sup>a</sup> [MPa]		R <sub>m</sub> [MPa]	[J]	at [°C]	1	2	3	4	5	t <sub>min</sub> 25	t <sub>min</sub> 75	t <sub>min</sub> 100	max	Standard ASTM
EN AW-A1 99,8 (A)	EN AW -1080A	21	H12	EN 573-3	55	80							X			-196	200		
EN AW-A1 99,7	EN AW -1070A	21	H12	EN 573-3	55	80							X			-196	200		
EN AW-A1 99,5	EN AW -1050A	21	H12	EN 573-3	65	85				X	X	X	X			-196	200		
EN AW-A1 Mn1Cu	EN AW -3003	22.1	H12	EN 573-3	90	120				X	X	X	X			-196	250		
EN AW-A1 Mn1	EN AW -3103	22.1	H12	EN 573-3	85	115				X	X	X	X			-196	250		
EN AW-A1 Mn0,5Mg0,5	EN AW -3105	22.1	H12	EN 573-3	105	130							X			-196	200		
EN AW-A1 Mg1(B)	EN AW -5005	22.1	H12	EN 573-3	95	125				X	X	X	X			-196	200		
EN AW-A1 Mg1,5(C)	EN AW -5050	22.1	H12	EN 573-3	130	155							X			-196	200		
EN AW-A1 Mg2	EN AW -5251	22.1	H12	EN 573-3	150	190				X	X	X	X			-196	200		
EN AW-A1 Mg2,5	EN AW -5052	22.1	H12	EN 573-3	160	210				X	X	X	X			-196	200		
EN AW-A1 Mg3Mn	EN AW-5454	22.3	H12	EN 573-3	190	250				X	X	X	X			-196	200		

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

<sup>a</sup> Nominal value up to a determined thickness as noted in this document.

<sup>b</sup> Sand casting.

<sup>c</sup> Permanent moulds casting.

<sup>d</sup> Pressure die casting.

Table E.4 (continued)

Material			Standard	Strength Values		Elong. after fracture	Impact rupture energy KV <sub>0</sub>		Product form					Operating Temperature [°C]			US-nomenclature			
Symbol	Number	Group		Condition	R <sub>p0,2</sub> <sup>a</sup> [MPa]		R <sub>m</sub> [MPa]	A <sub>5</sub> [%]	at [°C]	L/q	1	2	3	4	5	t <sub>min 25</sub>	t <sub>min 75</sub>	t <sub>min 100</sub>	max	Standard
EN AC-A1 Mg3(b)	EN AC-22.3	22.3	F	EN 1706	70	140					X <sup>b</sup>					-196				
EN AC-A1 Mg3(a)	EN AC-22.3	22.3	F	EN 1706	70	140					X <sup>b</sup>					-196				
EN AC-A1 Mg5	EN AC-22.3	22.3	F	EN 1706	90	160					X <sup>b</sup>					-196				
EN AC-A1 Mg3(b)	EN AC-22.3	22.3	F	EN 1706	70	150					X <sup>c</sup>					-196				
EN AC-A1 Mg3(a)	EN AC-22.3	22.3	F	EN 1706	70	150					X <sup>c</sup>					-196				
EN AC-A1 Mg5	EN AC-22.5	22.5	F	EN 1706	100	180					X <sup>c</sup>					-196				
EN AC-A1 Mg9	EN AC-22.5	22.5	F	EN 1706	130	200					X <sup>d</sup>					-196				
EN AW-A1 Mg3,5A	EN AW-22.3	22.3	H12 H32	EN 573-3 EN 12392	190	250					X	X	X	X		-196	100			
EN AW-A1 Mg3	EN AW-22.3	22.3	H12 H32	EN 573-3 EN 12392	170	220					X	X	X	X		-196	100			
EN AW-A1 Mg4,5Mn0,7	EN AW-22.5	22.5	H116	EN 573-3 EN 12392	215	305					X	X	X	X		-196	65			
EN AW-A1 Mg4	EN AW-22.5	22.5	H116	EN 573-3 EN 12392	195	275					X	X	X	X		-196	65			
EN AlSi7Mg	EN AC-23.1	23.1	T6	EN 1706	180	220					X <sup>b</sup>					-196				
EN AC-A1 Si7Mg0,3	EN AC-23.1	23.1	T6	EN 1706	190	230					X <sup>b</sup>					-196				

NOTE Measuring condition: L is in direction of rolling direction, q is 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 as noted in this document.
- b Sand casting.
- c Permanent moulds casting.
- d Pressure die casting.

Table E.4 (continued)

Material			Standard	Strength Values		Elong. after fracture	Impact rupture energy $KV_0$		Product form					Operating Temperature [°C]			US-nomenclature			
Symbol	Number	Group		Condition	$R_{p0,2}^a$ [MPa]		$R_m$ [MPa]	$A_5$ [%]	[J]	at [°C]	1	2	3	4	5	$t_{min 25}$	$t_{min 75}$	$t_{min 100}$	max	Standard
EN AC-A1 Si7Mg0,6	EN AC-42200	23.1	T6	EN 1706	210	250											-196			
EN AC-A1 Si10Mg(a)	EN AC-43000	23.1	T6	EN 1706	180	220											-196			
EN AC-A1 Si10Mg(b)	EN AC-43100	23.1	T6	EN 1706	180	220											-196			
EN AC-A1 Si9Mg	EN AC-43300	23.1	T6	EN 1706	190	230											-196			
EN AC-A1 Si7Mg	EN AC-42000	23.1	T64	EN 1706	200	240											-196			
EN AC-A1 Si7Mg0,3	EN AC-42100	23.1	T64	EN 1706	180	250											-196			
EN AC-A1 Si7Mg0,6	EN AC-42200	23.1	T64	EN 1706	210	290											-196			
EN AC-A1 Si10Mg(a)	EN AC-43000	23.1	T64	EN 1706	200	240											-196			
EN AC-A1 Si10Mg(b)	EN AC-43100	23.1	T64	EN 1706	200	240											-196			
EN AC-A1 Si9Mg	EN AC-43300	23.1	T64	EN 1706	180	250											-196			

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

<sup>a</sup> Nominal value up to a determined thickness as noted in this document.

<sup>b</sup> Sand casting.

<sup>c</sup> Permanent moulds casting.

<sup>d</sup> Pressure die casting.

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

Material			Standard	Strength Values		Elong. after fracture A <sub>5</sub> [%]	Impact rupture energy KV <sub>0</sub>		Product form					Operating Temperature [°C]			US-nomenclature					
Symbol	Number CW ...	Group		Condition	R <sub>p0,2</sub> <sup>a</sup> [MPa]		R <sub>m</sub> [MPa]	[J]	at [°C]	1	2	3	4	5	t <sub>min</sub> 25	t <sub>min</sub> 75	t <sub>min</sub> 100	max	Standard ASTM	Grade		
CuZn10	501L	32.1	R240	EN 12449	140	240																
			H050									X	X									
Cu-DHP	024A	31	R200	EN 12449	40 <sup>c</sup>	200			X													
			R250		-	-			X													
			R290		150	250	30			X												
			R240		-	-	-				X											
					250	290	3															
					-	-	-															
					120	240	-															
					-	-	-															
CuFe2P	107C	31	R300	EN12449	250	300																
			R420		320	420	5															
CuZn36Pb2As	602N	32.2	R280	EN 12164	200 <sup>c</sup>	280			X													
			R320	EN 12165	-	-				X												
			R400	EN 12420	200	320	20			X												
					-	-	-															
					250	400	8															
					-	-	-															
					-	-	-															
					120 <sup>d</sup>	280 <sup>d</sup>	20 <sup>d</sup>															

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

<sup>a</sup> Nominal value up to a determined thickness as noted in this document.

<sup>c</sup> Maximum value.

<sup>d</sup> For information only, actual values may differ.

Table E.5 (continued)

Material			Standard	Strength Values		Elong. after fracture $A_5$ [%]	Impact rupture energy $KV_0$		Product form					Operating Temperature [°C]			US-nomenclature				
Symbol	Number CW ...	Group		Condition	$R_{p0.2}^a$ [MPa]		$R_m$ [MPa]	[J]	at [°C]	1	2	3	4	5	$t_{min 25}$	$t_{min 75}$	$t_{min 100}$	max	Standard ASTM	Grade	
CuZn38Pb2	608N	32.2	R360	EN 12164	300 <sup>c</sup>	360		X		X											
			R410	EN 12165	-	-			X												
			R500	EN 12420	410	410			X												
			-	-	-	-			X												
CuZn39Pb2Sn	613N	32.2	-	EN 12165	140 <sup>d</sup>	350 <sup>d</sup>		X													
			-	EN 12420	140 <sup>d</sup>	350 <sup>d</sup>															
CuZn39Pb3/ CuZn40pb2	614N/ 617N	32.2	R360	EN 12164	320 <sup>c</sup>	360		X		X											
			R410	EN 12165	-	-			X												
			R500	EN 12420	220	430			X												
			-	-	350	500															
			-	-	-	-															
			-	-	140 <sup>d</sup>	350 <sup>d</sup>															

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

<sup>a</sup> Nominal value up to a determined thickness as noted in this document.

<sup>c</sup> Maximum value.

<sup>d</sup> For information only, actual values may differ.

Table E.6 — Cast iron (group 72.2)

Material			Standard	Strength Values		Elong. after fracture	Impact rupture energy $KV_0$		Product form					Operating Temperature [°C]			US-nomenclature				
Symbol	Number	Group		Condition	$R_{p0.2}^a$ [MPa]		$R_m$ [MPa]	$A_5$ [%]	[J]	at	L/q	1	2	3	4	5	$t_{min 25}$	$t_{min 75}$	$t_{min 100}$	max	Standard
EN-GJS-350-22-RT	EN-JS 1014			EN 1563	220	350	22	17	20		X					-	-	-10	300		
EN-GJS-400-18-RT	EN-JS 1024			EN 1563	250	400	18	14	20		X					-	-	-10	300		
EN-GJS-350-22U-RT	EN-JS 1029			EN 1563	220	350	22	17	20		X					-	-	-10	300		
EN-GJS-400-18U-RT	EN-JS 1059			EN 1563	250	400	18	14	20		X					-	-	-10	300		
EN-GJS-400-18-LT	EN-JS 1025			EN 1563	240	400	18	12	-20		X					-60	-60	-20	300		
EN-GJS-400-18U-LT	EN-JS 1049			EN 1563	240	400	18	12	-20		X					-60	-60	-20	300		
EN-GJS-350-22-LT	EN-JS 1015			EN 1563	220	350	22	12	-40		X					-70	-70	-40	300		
EN-GJS-350-22U-LT	EN-JS 1019			EN 1563	220	350	22	12	-40		X					-70	-70	-40	300		

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

<sup>a</sup> Nominal value up to a determined thickness as noted in the material standard.

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

Material <sup>b</sup>			Standard	Strength Values		Elong. after fracture A <sub>5</sub> [%]	Impact rupture energy KV <sub>0</sub>		Product form					Operating Temperature [°C]			US-nomenclature			
Symbol	Number	Group		Condition	R <sub>p0,2</sub> <sup>a</sup> [MPa]		R <sub>m</sub> [MPa]	[J]	at [°C]	L/q	1	2	3	4	5	t <sub>min 25</sub>	t <sub>min 75</sub>	t <sub>min 100</sub>	max	Standard
11SMn30	1.0715		a		380 570						X				-60	-40	-10	300		
11SMnPb30	1.0718		a		380 570						X				-60	-40	-10	300		
11SMn37	1.0736		a		370 570						X				-60	-40	-10	300		
11SMnPb37	1.0737		a		370 570						X				-60	-40	-10	300		

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

<sup>a</sup> Nominal value up to a determined thickness as noted in this document.

<sup>b</sup> Not qualified for welding.

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Table E.8 — Materials for spindles

Material			Standard	Strength Values		Elong. after fracture $A_5$ [%]	Impact rupture energy $KV_0$		Product form					Operating Temperature [°C]			US-nomenclature		
Symbol	Number	Group		Condition	$R_{p0,2}^a$ [MPa]		$R_m$ [MPa]	[J]	at [°C]	1	2	3	4	5	$t_{min 25}$	$t_{min 75}$	$t_{min 100}$	max	Standard ASTM
X20Cr13	1.4021			EN 10088-3															
X5CrNi18-10	1.4301	8.1		EN 10088-3	230	540	60	-196	q		X						300		
X8CrNiS18-9	1.4305			EN 10088-3	190	500 750	-	-	L		X						300		
X2CrNiMoN22-5-3	1.4462	10.1		EN 10088-3	460	660	40	-40	q		X						300		
X6CrNiTi18-10	1.4541	8.1		EN 10088-3	220	520	60	-196	q		X						300		
CuAl10Ni5Fe4	CW307G	35	R590 R620	EN 1653	230 250	590 620	-	-			X						250		
X12CrS13	1.4005	-		EN 10088-3	450	650	60	-			X						300		
X3CrNiMo13-4	1.4313	7.2		EN 10088-3	520	650	60	-60	q		X						300		

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

<sup>a</sup> Nominal value up to a determined thickness as noted in EN 13480-2, EN 13445-2.

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

bolts		Material				Elongation after fracture $A_5$ [%]	Impact rupture energy $KV_0$		Strength Values		Mat. Group	PN Class up to	Marking of product	Operating Temperature [°C]		
		Symbol	Number	EN Standard	Symbol		Number	Standard	$A_5$ [%]	[J]				at [°C]	$L/q$	$R_{p0.2}^a$ [MPa]
C-St-5.6		ISO 898-1 EN 1515-1		C-ST-5	EN 20898-2 EN 1515-1						40 300	5.6	-10		300	
C-St-8.8		ISO 898-1 EN 1515-1		C-St-8	EN 20898-2 EN 1515-1						40 300	8.8	-10		300	
25CrMo4	1.7218	10269 1515-1									all	8	-10		300	
42CrMo4	1.7225	10269 1515-1		C 35 E C-St elev. temp	EN 10269 EN 1515-1						all		-10		450	
25CrMo4	1.7218	10269 1515-1		C 45 E C-St elev. temp	EN 10269 EN 1515-1						all		-10		450	
42CrMo4	1.7225	10269 1515-1		A2-50 A2-70	EN 1515-1 ISO3506-2						all	A2-50 A2-70	-200		400	
42CrMo4	1.7225	10269 1515-1		42CrMo4	EN 10269 EN 1515-1						all		-100		450	

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

<sup>a</sup> Nominal value up to a determined thickness as noted in this document.



## 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 experimentally with two levels of test pressure, the maximum allowable design test pressure and the minimum burst test pressure.

Determination of the maximum allowable design test pressure  $P_F$  is such that the design stress of the valve body material is nearly achieved by the static pressure load. Testing with maximum allowable design test pressure verifies that the yield strength is not exceeded. 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 minimum burst test pressure  $P_{Test}$  is determined to ensure that the tensile strength is not exceeded with a sufficient safety margin (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.

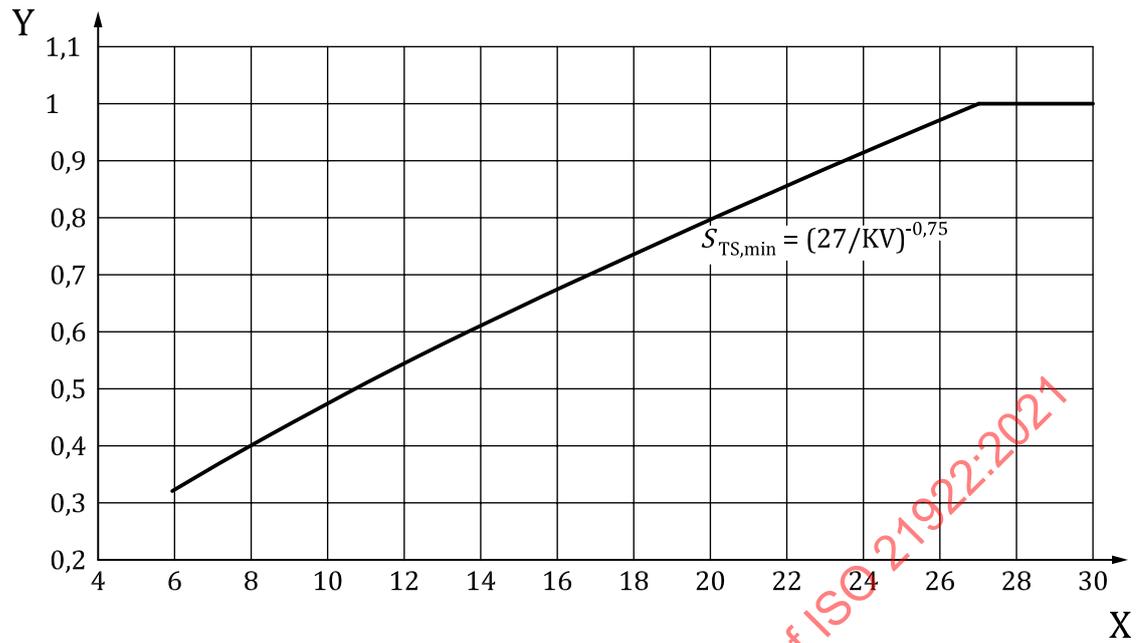
At a lower operating temperature, failure as the result of brittle fracture at reduced impact rupture energy is taken into consideration, either by a fracture mechanics theory (*KV*-Method) or by an empirical method gained from practical experience ( $t_{min}$ -Method). *KV*-Method is derived from a work of R. Sandström<sup>[29]</sup> (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.

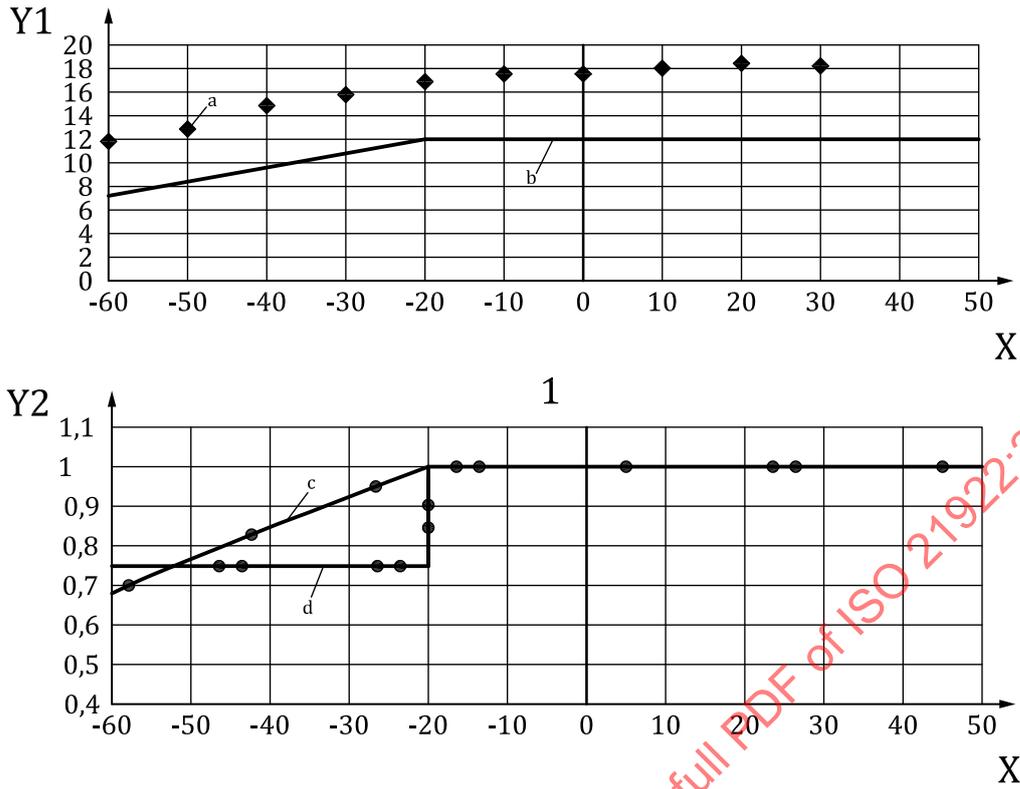
The *KV*-Method can be applied as a relative method where the safety factor is a function of the impact rupture energy (see [Figure F.1](#)). Dependencies of the notch impact rupture energy on the temperature of the design calculation which are specific to the material used can also be taken as a basis.

The results achieved by the *KV*-Method are, to a high degree, in accordance with those achieved by the  $t_{min}$ -Method. In the following, several examples are given, in which both procedures are compared with each other (see [Figures F.2](#) to [F.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 energy  $KV$  [J]Y Strength reduction factor  $S_{TS,min}$  [—]

**Figure F.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 ( $KV_0 = 27$  J)**

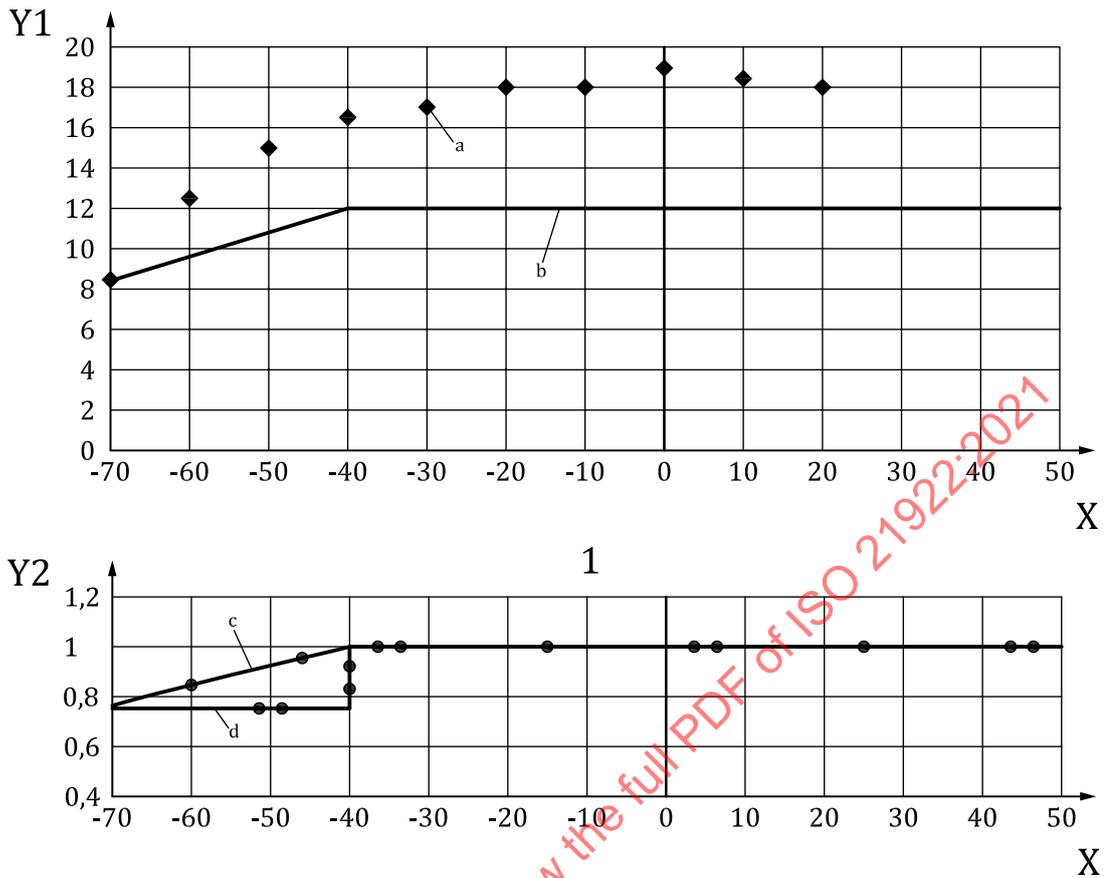


EN-GJS-400-18-LT (GGG 40.3)			
Temperature [°C]	Fracture mechanics method		$t_{min}$ Method
	KV [J]	for $KV < 12,0$ J $S_{TS\ min} = (12,0/KV)^{-0,75}$ $S_{TS\ min}$	$PS_{TS\ min} / PS$ $S_{TS\ min}$
50	12,0	1,00	1,0
30	12,0	1,00	1,0
10	12,0	1,00	1,0
-10	12,0	1,00	1,0
-20	<b>12,0</b>	<b>1,00</b>	1,0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

**Key**

- Y1 Impact rupture energy [J]
- Y2  $PS_{TS\ min}/PS$
- X Temperature [°C]
- 1 Reduction factor
- a Sandström [79]
- b Estimated KV-values from  $S_{TS\ min}$
- c Fracture mechanics method
- d  $t_{min}$  method

**Figure F.2 — Comparison of KV-method (here  $KV_0 = KV_0^t$ ) with  $t_{min}$ -method by means of material EN-GJS-400-18-LT (GGG 40.3)**



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

**Key**

Y1 Impact rupture energy [J]

Y2  $PS_{TS\ min} / PS$

X Temperature [°C]

1 Reduction factor

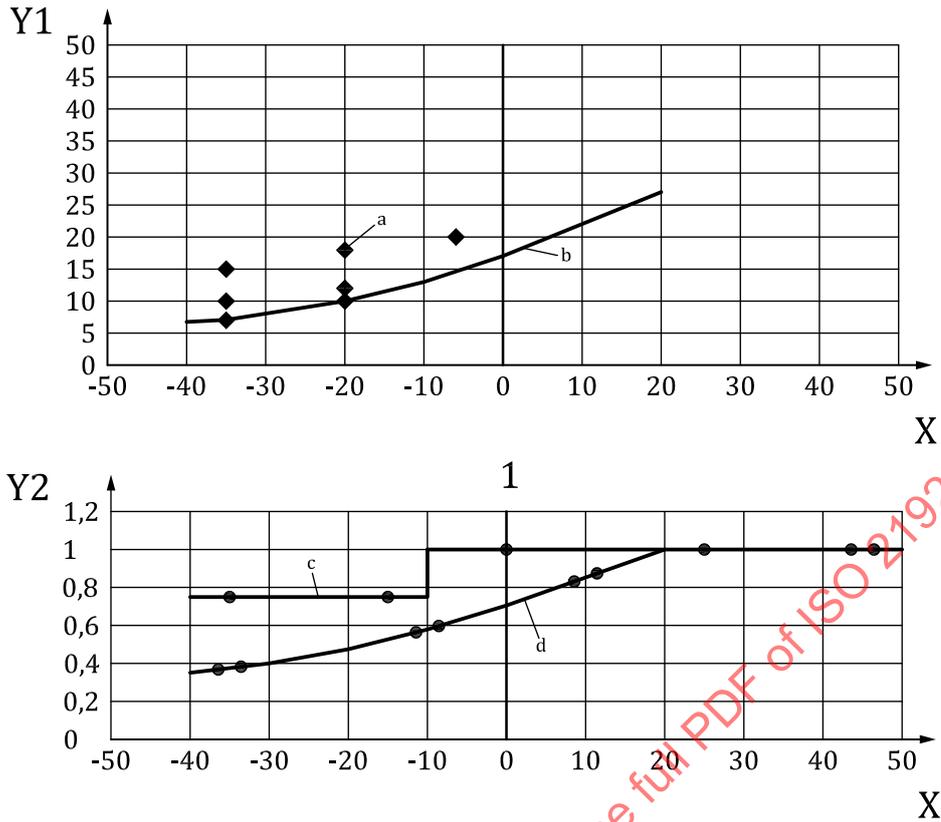
a Sandström [79]

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

c Fracture mechanics method

d  $t_{min}$  method

**Figure F.3 — Comparison of KV-method (here  $KV_0 = KV_0^t$ ) with  $t_{min}$ -method by means of material EN-GJS-350-22-LT (GGG 35.3)**

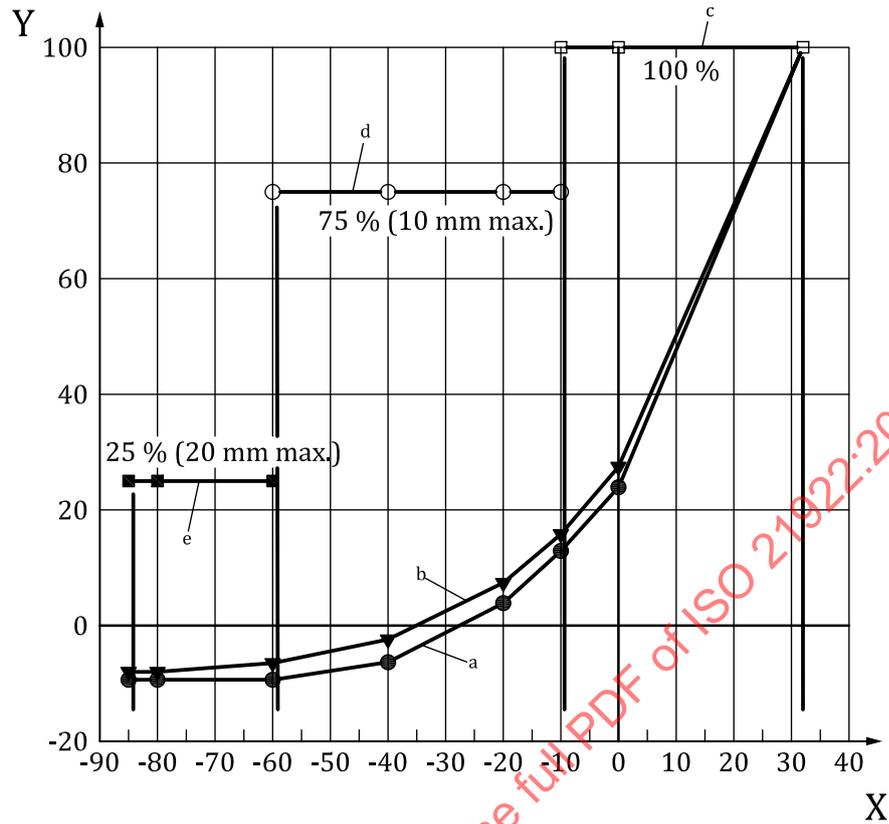


S235JRG2			
Temperature [°C]	Fracture mechanics method		$t_{min}$ Method
	KV [J]	for $KV < 27,0$ J $S_{TS\ min} = (27,0/KV)^{-0,75}$	$PS_{TS\ min} / PS$ $S_{TS\ min}$
50	>>27	1,00	1,0
30	>>27	1,00	1,0
20	27	1,00	1,0
10	22	0,86	1,0
0	17	0,71	1,0
-10	13	0,58	1,0
-20	13	0,58	0,75
-20	10	0,47	0,75
-30	8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

**Key**

- Y1 Impact rupture energy [J]
- Y2  $PS_{TS\ min} / PS$
- X Temperature [°C]
- 1 Reduction factor
- a Sandström [29]
- b Estimated KV-values from  $S_{TS\ min}$
- c Fracture mechanics method
- d  $t_{min}$  method

**Figure F.4 — Comparison of KV-method (here  $KV_0 = KV_0^t$ ) with  $t_{min}$ -method by means of material S235JRG2**

**Key**

- X Temperature [°C]
- Y Reduced pressure [%]
- a Vapour pressure of R-134a.
- b Vapour pressure of R-717 (NH<sub>3</sub>)
- c Stress case  $t_{\min 100}$
- d Stress case  $t_{\min 75}$
- e Stress case  $t_{\min 25}$

**Figure F.5 — Vapour pressure of common refrigerants (here R 134a and R 717) relative to design pressures (reduced pressure) at 32 °C and stress cases for steel and cast steel group 1.1 and 1.2**

## Annex G (normative)

### Pressure strength verification of valve assemblies

#### G.1 General

To verify the strength design of a valve assembly including the extension pipes and the joints between extension pipes and valve, the valve assembly (in complete) shall pass the test of [G.2](#).

Extension pipes of category II or more, as determined by [Annex H](#), shall comply with EN 14276-2.

Joints of category II or more, as determined by [Annex H](#), between extension pipes and valves shall also comply with EN 14276-2.

Extension pipes of materials other than the following (see also [Table A.1](#)) shall comply with EN 14276-2:

- steel groups 1.1, 1.2, and 8.1;
- aluminium groups 21 and 22;
- copper groups 31, 32, 33, 34, and 35.

#### G.2 Pressure test of valve assembly

The valve assembly is subject to a pressure not less than 3 times *PS* without rupture.

The test temperature is not less than 20 °C except if the design temperature exceeds 125 °C for copper or aluminium piping, in that case the test temperature shall be at least 200 °C.

NOTE This clause is based on EN 14276-2.

## Annex H (normative)

### Determination of category for valves

#### H.1 General

For determination of category for components and refrigerating system assemblies, the necessary steps shall be taken as indicated below.

NOTE The category in this annex corresponds to the category of ISO 5149-2:2014, Annex C.

#### H.2 Classification of the refrigerant

The refrigerant is classified into one of the following groups:

- a) Group 1: flammable and toxic fluids, classified as A2L, A2, A3, B1, B2L, B2, and B3 in ISO 817. With the exception of R-123, R-245fa, and R-1234ze(E);
- b) Group 2: Fluids not in group 1.

NOTE R-123, R-245fa, and R-1234ze(E) are in group 2 due to their lower hazard classification in the Globally Harmonized System of Classification and Labelling of Chemicals (GHS), and the lower hazard classification under the EU Pressure Equipment Directive 2014/68/EU.

#### H.3 Determine the state (liquid or gas) of the refrigerant

If the vapour pressure at the maximum allowable temperature (at bubble point) is greater than 0,5 bar (0,05 MPa) above normal atmospheric pressure, then this fluid is considered to be a gas, otherwise the fluid is to be considered a liquid.

#### H.4 Determination of category of valves

The category of the valve shall be at least the category given in [Table H.1](#) and [Table H.2](#).

The category is determined either based on the internal volume (as a pressure vessel) or the nominal connection size (as a pipe), whichever closest resembles the internal geometry of the valve:

- a) Category determination based on internal volume is given in [Table H.1](#).
- b) Category determination based on nominal connection size is given in [Table H.2](#).

The category of safety valves shall be determined to category IV. By way of exception, safety valves manufactured for specific pressure equipment may be classified in the same category as the pressure equipment they protect.

Table H.1 — Category determination for pressure vessels

Fluid	Nature	PS (bar) <sup>a</sup>	V (l)	PS × V (bar × l)	Category
If	and	and	and	and	then
GROUP 1	GAS	≤ 0,5	—	—	0a <sup>b</sup>
		> 0,5 and ≤ 200	≤ 1	—	0b <sup>b</sup>
			> 1	≤ 25	0b <sup>b</sup>
				> 25 and ≤ 50	I
				> 50 and ≤ 200	II
		> 200 and ≤ 1 000	≤ 1	—	III
		> 0,5 and ≤ 1 000	> 1	> 200 and ≤ 1 000	III
			> 1 000	IV	
	LIQUID <sup>c</sup>	≤ 0,5	—	—	0a <sup>b</sup>
		> 0,5 and ≤ 500	≤ 1	—	0b <sup>b</sup>
		> 0,5 and ≤ 200	> 1	≤ 200	0b <sup>b</sup>
		> 0,5 and ≤ 10		I	
		> 10 and ≤ 500	> 200	II	
		> 500	< 1	—	II
> 1	—		III		
GROUP 2	GAS	≤ 0,5	—	—	0a <sup>b</sup>
		> 0,5 and ≤ 1 000	≤ 1	—	0b <sup>b</sup>
		> 1 000 and ≤ 3 000		—	III
		> 0,5 and ≤ 1 000		> 1	≤ 50
			> 50 and ≤ 200	I	
			> 200 and ≤ 1 000	II	
		> 0,5 and ≤ 3 000	> 1	> 1 000 and ≤ 3 000	III
		> 0,5 and ≤ 4	> 750	> 3 000	III
	> 4	> 1	> 3 000	IV	
	> 3 000	—	—	IV	
	LIQUID <sup>c</sup>	≤ 0,5	—	—	0a <sup>b</sup>
		> 0,5 and ≤ 10	—	—	0b <sup>b</sup>
		> 10 and ≤ 1 000	—	≤ 10 000	0b <sup>b</sup>
		> 10 and ≤ 500	> 20	> 10 000	I
> 1 000		< 10	—	I	
> 500		> 10	> 10 000	II	

NOTE The categories in this table are equivalent to the categories in the Pressure Equipment Directive 2014/68/EU. For reference:

- 0a = not submitted to the Pressure Equipment Directive 2014/68/EU
- 0b = article 4.3 of the Pressure Equipment Directive 2014/68/EU

<sup>a</sup> 1 bar = 0,1 MPa

<sup>b</sup> For the purpose of this document this category is considered to be less than Category I

<sup>c</sup> Liquids are all fluids having a vapour pressure (at maximum allowable temperature) of not more than 0,5 bar above normal atmospheric pressure (1 013 mbar)

Table H.2 — Category determination for piping

Fluid	Nature	PS (bar) <sup>a</sup>	DN	PS × DN (bar) <sup>a</sup>	Category
If	and	and	and	and	then
GROUP 1	GAS	≤ 0,5	—	—	0a <sup>b</sup>
		> 0,5	≤ 25	—	0b <sup>b</sup>
			> 25 and ≤ 100	≤ 1 000	I
				> 1 000	II
			> 100 and ≤ 350	≤ 3 500	II
				> 3 500	III
	LIQUID <sup>c</sup>	≤ 0,5	—	—	0a <sup>b</sup>
		> 0,5	≤ 25	—	0b <sup>b</sup>
			> 25	≤ 2 000	0b <sup>b</sup>
		> 0,5 and ≤ 10	> 200	> 2 000	I
> 10 and ≤ 500		> 25	II		
> 500	> 25	—	III		
GROUP 2	GAS	≤ 0,5	—	—	0a <sup>b</sup>
		> 0,5	≤ 32	—	0b <sup>b</sup>
			> 32	≤ 1 000	0b <sup>b</sup>
			> 32 and ≤ 100	> 1 000	I
			> 100	> 1 000 and ≤ 3 500	I
			> 100 and ≤ 250	> 3 500	II
			> 250	> 3 500 and ≤ 5 000	II
				> 5 000	III
	LIQUID <sup>c</sup>	≤ 0,5	—	—	0a <sup>b</sup>
		> 0,5 and ≤ 10	—	—	0b <sup>b</sup>
		> 10	≤ 200	—	0b <sup>b</sup>
			> 200	≤ 5 000	0b <sup>b</sup>
		> 10 and ≤ 500	> 200	> 5 000	I
		> 500	> 200	—	II

NOTE The categories in this table are equivalent to the categories in the Pressure Equipment Directive 2014/68/EU. For reference:

- 0a = not submitted to the Pressure Equipment Directive 2014/68/EU
- 0b = article 4.3 of the Pressure Equipment Directive 2014/68/EU

<sup>a</sup> 1 bar = 0,1 MPa

<sup>b</sup> For the purpose of this document this category is considered to be less than Category I

<sup>c</sup> Liquids are all fluids having a vapour pressure (at maximum allowable temperature) of not more than 0,5 bar above normal atmospheric pressure (1 013 mbar)

## H.5 Determination of category of valve assemblies

Where an extension pipe is used, the DN for determining the category shall be the DN of the largest connection of the extension pipe.

The category of a valve assembly shall be the larger of the categories of the parts of the assembly.

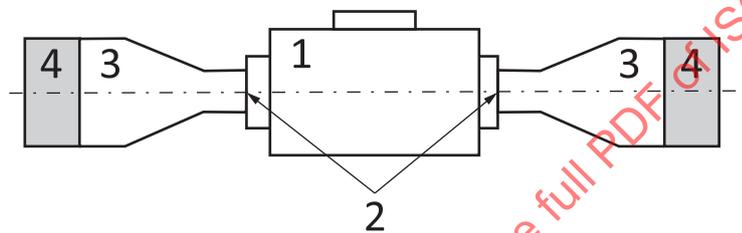
The category of the joint between a valve and an extension pipe shall be determined by the DN of the connection.

## H.6 Examples of category determination

This clause gives examples of category determination.

EXAMPLE 1 See [Figure H.1](#) for an example of a valve:

- The pipes are category II;
- The valve body is category 0b;
- The connections between the valve and the extension pipes are category 0b;
- The valve is category II due to the category of the pipes, and all pressure bearing parts requires certificate type 3.



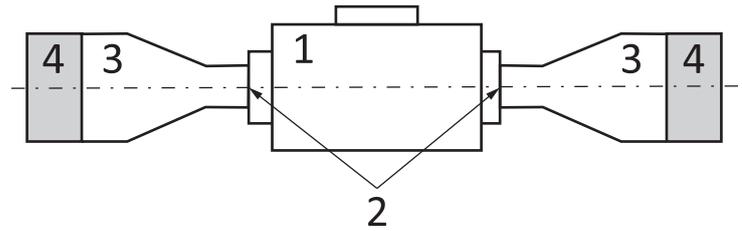
### Key

- 1 valve body, DN 22 and volume < 1l, category 0b according to both [Table H.1](#) and [Table H.2](#)
- 2 joint, DN 22, category 0b according to [Table H.2](#)
- 3 pipe, DN 22 to DN 40, category II according to [Table H.2](#) using DN 40
- 4 joint made by the end-user when connecting the valve to piping, DN 40

**Figure H.1 — Example of a valve for Group 1 refrigerants where *PS* is 30 bar (the valve is category II determined as the highest category of the parts)**

EXAMPLE 2 See [Figure H.2](#) for an example of a valve assembly. The physical structure is the same as in Figure H.1, but the manufacture has chosen to declare the pipes as extension pipes. This has the advantage that the burst pressure test of the extension pipes does not need to take the safety factors for joints on the valve body into account:

- The extension pipes are category II and needs certificate type 3;
- The valve is category 0b and needs certificate type 1 and documentation according to [11.1](#);
- The connections between the valve and the extension pipes are category 0b;
- The assembly of the valve combined with extension pipes is category II.

**Key**

- 1 valve, DN 22 and volume < 1l, category 0b according to both [Table H.1](#) and [Table H.2](#)
- 2 joint, DN 22, category 0b according to [Table H.2](#)
- 3 extension pipe, DN 22 to DN 40, category II according to [Table H.2](#) using DN 40
- 4 joint made by the end-user when connecting the valve assembly to piping, DN 40, not part of the valve assembly

**Figure H.2 — Example of a valve assembly for Group 1 refrigerants consisting of a valve and extension pipes, where  $PS$  is 30 bar (the valve assembly is category II determined as the highest category of the valve and the extension pipes)**

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## Annex I (informative)

### DN system

The purpose of this annex is to support finding the *DN* value as defined in ISO 6708 for pipe when the material standard does not give this value.

In absence of *DN* in the semi-finished product standard or in the below table, *DN* should be taken to correspond to the internal diameter in mm for circular products or to the equivalent flow section of the non-circular products.

Examples of finding *DN* values for imperial steel pipe, and imperial and metric copper tube, is given in [Table I.1](#), [I.2](#) and [I.3](#) respectively.

The relationship between the *DN* and the maximum external diameter of the pipe is given in [Table I.4](#).

**Table I.1 — Example: Imperial steel pipe, butt-weld**

<i>NPS</i> [inch]	<i>D<sub>out</sub></i> [mm]	<i>D<sub>in</sub></i> [mm]	Thickness [mm]	<i>DN</i>
¼	13,7	7,7	3,0	8
⅜	17,1	10,7	3,2	10
½	21,3	13,8	3,8	15
¾	26,7	18,9	3,9	20
1	33,4	24,3	4,6	25
1 ¼	42,2	32,5	4,9	32
1 ½	48,3	38,1	5,1	40
2	60,3	52,5	3,9	50
2 ½	73,0	62,7	5,2	65
3	88,9	77,9	5,5	80
4	114,3	102,3	6,0	100
5	141,3	128,2	6,6	125
6	168,3	154,1	7,1	150
8	219,1	202,7	8,2	200
10	273,0	254,4	9,3	250
12	323,8	303,2	10,3	300
14	355,6	333,3	11,2	350
16	406,4	381,0	12,7	400
NOTE 1 ¼ inch to 2 ½ inches are schedule 80 while 3 inches to 16 inches are schedule 40.				
NOTE 2 The dimensions are equivalent to ANSI B36.10.				