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

Kälteanlagen und Wärmepumpen - Ventile - Anforderungen, Prüfung und Kennzeichnung

Systemes de réfrigération et pompes a chaleur - Robinetterie - Exigences, essais et marquage

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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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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Contents

Foreword

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

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of an identical text or by endorsement, at the latest by March 2004, and conflicting national standards shall be withdrawn at the latest by March 2004.

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

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

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

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

1 Scope

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

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

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

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

2 Normative references

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3 Terms and definitions

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

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

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

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

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

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

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

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

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

3.8

min $t_{0\ 100}$

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

3.9

min $t_{0\ 75}$

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

3.10

min $t_{0\ 25}$

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

4 List of Symbols

Symbols used in this Standard are given in Table 1:

Table 1 – List of symbols

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

Table 1 (*continued*)

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

5 General Requirements

5.1 Installation and operation

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

5.2 Components under pressure

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

5.3 Excessive mechanical stress

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

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

5.4 Leakage

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

5.5 Functioning of hand-operated valves

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

5.6 Functioning of actuator-operated valves

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

6 Materials

6.1 General

6.1.1 Using metalic materials

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

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

6.1.2 Using non-metallic materials

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

6.2 Requirements for materials to be used for pressurized parts

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

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

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

6.3 Compatibility of connections

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

6.4 Requirements to avoid brittle fracture

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

6.5 Requirements for documentation

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

6.6 Ductility

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

6.7 Ageing

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

6.8 Castings

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

6.9 Forged and welded components

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

6.10 Nuts, bolts and screws

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

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

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

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

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

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

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

6.11 Spindles

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

NOTE Some suitable materials are given in Annex E.

6.12 Seat, valve plate and seal materials

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

7 Design

7.1 General

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

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

7.2 Maximum allowable pressure

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

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

7.3 Design pressure

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

7.4 Bodies and bonnets

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

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

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

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

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

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

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

7.5 Final assessment

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

7.6 Pressure-sensitive components

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

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

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

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

8 Construction and workmanship

8.1 General

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

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

8.2 Body and bonnet

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

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

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

8.3 Valve seats

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

8.4 Spindle seals and back seating for valves

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

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

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

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

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

8.5 Screwed spindles

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

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

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

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

8.6 Design of glands

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

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

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

8.7 Locking of spindles and shafts

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

8.8 Caps

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

Screw threads on valve caps shall be right-handed.

8.9 Hand-operated valves

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

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

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

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

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

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

NOTE 3 1 MPa = 10 bar

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

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

8.10 Valves not to be operated by unauthorized persons

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

8.11 Opening characteristics

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

8.12 Finish

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

Welds do not generally need to be machined.

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

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