



SLOVENSKI STANDARD
SIST EN 13445-2:2002
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Unfired pressure vessels - Part 2: Materials

Unbefeuerte Druckbehälter - Teil 2: Werkstoffe

Réipients sous pression non soumis a la flamme - Partie 2: Matériaux

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Ta slovenski standard je istoveten z: EN 13445-2:2002

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Unfired pressure vessels - Part 2: Materials

Réceptifs sous pression non soumis à la flamme - Partie
2: Matériaux

Unbefeuerte Druckbehälter - Teil 2: Werkstoffe

This European Standard was approved by CEN on 23 May 2002.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

Contents

Foreword.....	3
1 Scope	4
2 Normative references	4
3 Terms, definitions, symbols and units	7
3.1 Terms and definitions.....	7
3.2 Symbols and units	8
4 Requirements for materials to be used for pressure-bearing parts	10
4.1 General.....	10
4.2 Special provisions	12
4.3 Technical delivery conditions.....	13
4.4 Marking	14
5 Requirements for materials to be used for non-pressure parts	14
Annex A (normative) Metallic materials for pressure equipment — Grouping system and European standardised steels.....	15
A.1 Grouping system for metallic materials for pressure equipment.....	15
A.2 European standardised steels grouped according to product forms	17
Annex B (normative) Requirements for prevention of brittle fracture.....	31
B.1 General	31
B.2 Material selection and impact energy requirements	31
B.3 General test requirements	37
B.4 Welds.....	38
Annex C (informative) Technical delivery conditions for clad products for pressure purposes.....	49
C.1 Introductory note	49
C.2 Requirements for the material	49
C.3 Requirements for the deposited material.....	49
C.4 Qualification of the cladding procedure.....	50
C.5 Production tests.....	51
Annex D (informative) European Standards for steels and steel components for pressure vessels	53
Annex ZA (informative) Clauses of this European Standard addressing essential safety requirements or other provisions of EU directives	54
Bibliography	55

SIST EN 13445-2:2002

<https://standards.iteh.ai/catalog/standards/sist/7f623a33-fac6-4f51-91d7-77e3d9108083/sist-en-13445-2-2002>

Foreword

This document (EN 13445-2:2002) has been prepared by Technical Committee CEN/TC 54 "Unfired pressure vessels", the secretariat of which is held by BSI.

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 November 2002, and conflicting national standards shall be withdrawn at the latest by November 2002.

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

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

In this standard the Annexes A and B are normative and the Annexes C and D are informative.

This European Standard consists of the following Parts:

Part 1: General.

Part 2: Materials.

Part 3: Design.

Part 4: Fabrication.

Part 5: Inspection and testing.

Part 6: Requirements for the design and fabrication of pressure vessels and pressure parts constructed from spheroidal graphite cast iron.

CR 13445-7, *Unfired pressure vessels - Part 7: Guidance on the use of conformity assessment procedures.*

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, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

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1 Scope

This Part of this European Standard specifies the requirements for materials (including clad materials) for unfired pressure vessels and supports which are covered by EN 13445-1:2002 and manufactured from metallic materials; it is currently limited to steels with sufficient ductility. This document is not applicable in the creep range.

NOTE Other materials will be added later by amendments.

It specifies the requirements for the selection, inspection, testing and marking of metallic materials for the fabrication of unfired pressure vessels.

This Part of this European Standard does not give provisions for material requirements and material selection for vessels designed using Design by Analysis – Direct Route (DBA) of EN 13445-3:2002, Annex B.

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 (including amendments).

EN 288-3:1992, *Specification and approval of welding procedures for metallic material — Part 3: Welding procedure tests for the arc welding of steels.*

prEN 764-1:2001, *Pressure equipment — Terminology — Part 1: Pressure, temperature, volume, nominal size.*

EN 764-2:2002, *Pressure equipment — Part 2: Quantities, symbols and units.*

EN 764-3:2002, *Pressure equipment — Part 3: Definition of parties involved.*

EN 10028-1:2000, *Flat products made of steels for pressure purposes — Part 1: General requirements.*

EN 10028-2:1992, *Flat products made of steels for pressure purposes — Part 2: Non-alloy and alloy steels with specified elevated temperature properties.*

EN 10028-3:1992, *Flat products made of steels for pressure purposes — Part 3: Weldable fine grain steels, normalized.*

EN 10028-4:1994, *Flat products made of steels for pressure purposes — Part 4: Nickel alloy steels with specified low temperature properties.*

EN 10028-5:1996, *Flat products made of steels for pressure purposes — Part 5: Weldable fine grain steels, thermomechanically rolled.*

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EN 10028-6:1996, *Flat products made of steels for pressure purposes — Part 6: Weldable fine grain steels, quenched and tempered.*

EN 10028-7:2000, *Flat products made of steels for pressure purposes — Part 7: Stainless steels.*

EN 10045-1:1990, *Metallic materials — Charpy impact test — Part 1: Test method.*

EN 10164:1993, *Steel products with improved deformation properties perpendicular to the surface of the product — Technical delivery conditions.*

EN 10204:1991, *Metallic products — Types of inspection documents.*

EN 10213-1:1995, *Technical delivery conditions for steel castings for pressure purposes — Part 1: General.*

EN 10213-2:1995, *Technical delivery conditions for steel castings for pressure purposes — Part 2: Steel grades for use at room temperature and elevated temperatures.*

EN 10213-3:1995, *Technical delivery conditions for steel castings for pressure purposes — Part 3: Steel grades for use at low temperatures.*

EN 10213-4:1995, *Technical delivery conditions for steel castings for pressure purposes — Part 4: Austenitic and austenitic-ferritic steel grades.*

EN 10216-1/2002, *Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 1: Non-alloy steel tubes with specified room temperature properties.*

EN 10216-2:2002, *Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 2: Non-alloy and alloy steel tubes with specified elevated temperature properties.*

EN 10216-3:2002, *Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 3: Alloy fine grain steel tubes*

EN 10216-4:2002, *Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 4: Non-alloy and alloy steel tubes with specified low temperature properties.*

EN 10216-5:2002, *Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 5: Stainless steel tubes.* EN 10217-1:2002, *Welded steel tubes for pressure purposes — Technical delivery conditions — Part 1: Non-alloy steel tubes with specified room temperature properties.* EN 10217-2:2002, *Welded steel tubes for pressure purposes — Technical delivery conditions — Part 2: Electric welded non-alloy and alloy steel tubes with specified elevated temperature properties.*

EN 10217-3:2002, *Welded steel tubes for pressure purposes — Technical delivery conditions — Part 3: Alloy fine grain steel tubes.*

EN 10217-4:2002, *Welded steel tubes for pressure purposes — Technical delivery conditions — Part 4: Electric welded non-alloy steel tubes with specified low temperature properties.*

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EN 13445-2:2002 (E)
Issue 1 (2002-05)

EN 10217-5:2002, *Welded steel tubes for pressure purposes — Technical delivery conditions — Part 5: Submerged arc welded non-alloy and alloy steel tubes with specified elevated temperature properties.*

EN 10217-6:2002, *Welded steel tubes for pressure purposes — Technical delivery conditions — Part 6: Submerged arc welded non-alloy steel tubes with specified low temperature properties.*

EN 10217-7:2002, *Welded steel tubes for pressure purposes — Technical delivery conditions — Part 7: Stainless steel tubes.*

EN 10222-1:1998, *Steel forgings for pressure purposes — Part 1: General requirements for open die forgings.*

EN 10222-2:1999, *Steel forgings for pressure purposes — Part 2: Ferritic and martensitic steels with specified elevated temperature properties.*

EN 10222-3:1998, *Steel forgings for pressure purposes — Part 3: Nickel steels with specified low temperatures properties.*

EN 10222-4:1998, *Steel forgings for pressures purposes — Part 4: Weldable fine grain steels with high proof strength.*

EN 10222-5:1999, *Steel forgings for pressure purposes — Part 5: Martensitic, austenitic and austenitic-ferritic stainless steels.*

prEN 10253-2:1999, *Butt welding pipe fittings — Part 2: Wrought carbon and ferritic alloy steel with specific inspection requirements.*

EN 10269:1999, *Steels and nickel alloys for fasteners with specified elevated and/or low temperature properties.*

EN 10272:2000, *Stainless steel bars for pressure purposes.*

EN 10273:2000, *Hot rolled weldable steel bars for pressure purposes with specified elevated temperature properties.*

EN 12074:2000, *Welding consumables — Quality requirements for manufacture, supply and distribution of consumables for welding and allied processes.*

EN 13445-1:2002, *Unfired pressure vessels — Part 1: General.*

EN 13445-3:2002, *Unfired pressure vessels – Part 3: Design.*

EN 13445-4:2002, *Unfired pressure vessels – Part 4: Fabrication.*

EN 13445-5:2002, *Unfired pressure vessels — Part 5: Inspection and testing.*

prEN 13479-1:1999, *Welding consumables — Test methods and quality requirements for conformity evaluation of consumables — Part 1: Primary methods and evaluation.*

EN ISO 2566-1:1999, *Steel — Conversion of elongation values — Part 1: Carbon and low alloy steels (ISO 2566-1:1984).*

EN ISO 2566-2:1999, *Steel — Conversion of elongation values — Part 2: Austenitic steels (ISO 2566-2:1984).*

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

3 Terms, definitions, symbols and units

3.1 Terms and definitions

For the purposes of this European Standard the terms and definitions given in EN 13445-1:2002, prEN 764-1:2001, EN 764-3:2002 and the following terms and definitions shall apply.

3.1.1

minimum metal temperature T_M

the lowest temperature determined for any of the following conditions (also see 3.1.2, 3.1.3):

- normal operations;
- start up and shut down procedures;
- possible process upsets, such as flashings of fluid, which have an atmospheric boiling point below 0 °C;
- during pressure or leak testing.

3.1.2

temperature adjustment term T_S

relevant to the calculation of the design reference temperature T_R and is dependent on the calculated tensile membrane stress at the appropriate minimum metal temperature

NOTE 1 Values for T_S are given in Table B.2-1.

NOTE 2 For tensile membrane stress reference is made to EN 13445-3, Annex C:2002-05.

3.1.3

design reference temperature T_R

the temperature used for determining the impact energy requirements and is determined by adding the temperature adjustment T_S to the minimum metal temperature T_M :

$$T_R = T_M + T_S$$

3.1.4

impact test temperature T_{KV}

the temperature at which the required resistance to impact energy has to be achieved (see clause B.2).

3.1.5

impact rupture energy KV

the energy absorbed by a sample of material when subjected to a Charpy-V-notch test in accordance with EN 10045-1

3.1.6

reference thickness e_B

thickness of a component to be used to relate the design reference temperature T_R of the component with its required impact test temperature T_{KV} (see Table B.1-1 and Figures B.4-1 to B.4-5). For unwelded parts the reference thickness e_B is equal to the nominal wall thickness (including corrosion allowance). For welded parts the reference thickness is defined in Table B.4-1.

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3.2 Symbols and units

For the purpose of this part, the symbols and units of EN 764-2:2002 apply together with those given in Table 3.2-1 and Table 3.2-2.

Table 3.2-1 — Quantities for space and time

Quantity	Symbol	Unit
time	<i>t</i>	s, min, h, d, a
frequency	<i>f</i>	Hz
dimension	any Latin letter ^a	mm
length	<i>l</i>	mm
thickness	<i>e</i>	mm
corrosion allowance	<i>c</i>	mm
diameter	<i>d, D</i>	mm
radius	<i>r, R</i>	mm
area	<i>A, S</i>	mm ²
volume, capacity	<i>V</i>	mm ³ ^{b, c}
weight	<i>W</i>	N, kN
density	<i>ρ</i>	kg/mm ³ ^d
second moment of area	<i>I</i>	mm ⁴
section modulus	<i>Z</i>	mm ³
acceleration	<i>γ</i>	m/s ²
plane angle	any Greek letter ^a	rad, °

^a Symbols may use any lower-case letter, except for those defined elsewhere in this table.
^b Volume may also be given in m³ or L.
^c Litre "L" is a non-SI unit which may be used with SI units and their multiples.
^d Density may also be given in kg/m³.

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Table 3.2-2 — Mechanical quantities

Quantity ^a	Symbol ^b	Unit
force	F	N
moment	M	N·mm
pressure	p, P	bar ^c , MPa, N/mm ²
Celsius temperature	t	°C
thermodynamic temperature	T	K
linear expansion coefficient	α	µm/m°C
normal stress	σ	MPa, N/mm ²
shear stress	τ	MPa, N/mm ²
nominal design stress	f	MPa, N/mm ²
tensile strength	R_m	MPa, N/mm ²
ultimate tensile strength at temperature t	$R_{m/t}$	MPa, N/mm ²
yield strength	R_e	MPa, N/mm ²
yield strength at temperature t	$R_{e/t}$	MPa, N/mm ²
upper yield strength	R_{eH}	MPa, N/mm ²
1 % proof strength	$R_{p1,0}$	MPa, N/mm ²
0,2 % proof strength	$R_{p0,2}$	MPa, N/mm ²
0,2 % proof strength at temperature t	$R_{p0,2/t}$	MPa, N/mm ²
modulus of elasticity	E	MPa, N/mm ²
shear modulus	G	MPa, N/mm ²
Poisson's ratio	ν	—
strain	ϵ	%
elongation after rupture	A	%
impact rupture energy	KV	J
hardness	HB, HV	—
Joint coefficient	z	—
safety factor	S	—

^a Quantities without a temperature index normally refer to room temperature.

^b Some of these symbols, such as R, f , are not part of ISO 31.

^c "bar" is a non-SI unit which may be used with SI units and their multiples. The unit bar shall be used on nameplates, certificates, drawings, pressure gauges and instrumentation and is always used as a gauge pressure. This is in line with the requirements of the Pressure Equipment Directive 97/23/EC.

4 Requirements for materials to be used for pressure-bearing parts

4.1 General

4.1.1 Materials to be used for pressure-bearing parts shall meet the general requirements of 4.1 and the special provisions of 4.2, if applicable. Materials for pressure bearing parts shall be ordered complying with the technical delivery conditions in 4.3.

Marking of materials for pressure-bearing parts shall be performed in accordance with 4.4.

Materials shall be selected to be compatible with anticipated fabrication steps and to be suitable for the internal fluid and external environment. Both normal operating conditions and transient conditions occurring during fabrication, transport, testing and operation shall be taken into account when specifying the materials.

NOTE 1 The requirements of 4.1 and 4.2 should also be fulfilled when technical delivery conditions are developed for European material standards, European approval of materials or particular material appraisals.

NOTE 2 When technical delivery conditions for pressure-bearing parts are developed, the structure and requirements of EN 764-4:2002 should be met. Exceptions should be technically justified.

The materials shall be grouped in accordance with CR ISO 15608:2000 to relate manufacturing and inspection requirements to generic material types.

NOTE 3 Materials have been allocated into these groups in accordance with their chemical composition and properties in relation to manufacture and heat treatment after welding.

4.1.2 Materials for pressure-bearing parts compliant with the requirements of this European Standard shall be accompanied by inspection documents in accordance with EN 10204:1991.

NOTE The type of inspection document should be in accordance with EN 764-5:2002 and include a declaration of compliance to the material specification.

4.1.3 The materials shall be free from surface and internal defects which can impair their intended usability.

4.1.4 Steels shall have a specified minimum elongation after fracture measured on a gauge length

$$L_0 = 5,65 \sqrt{S_0} \quad (4.1-1)$$

where

S_0 is the original cross sectional area within the gauge length.

The minimum elongation after fracture in any direction shall be $\geq 14\%$;

However, lower elongation values may also be applied (e.g. for fasteners or castings), provided that appropriate measures are taken to compensate for these lower values and the specific requirements are verifiable.

NOTE Examples for compensation:

- application of higher safety factors in design;
- performance of burst tests to demonstrate ductile material behaviour.

4.1.5 When measured on a gauge length other than that stated in 4.1.4, the minimum elongation after fracture shall be determined by converting the elongation given in 4.1.4 in accordance with

- EN ISO 2566-1:1999 for carbon and low alloy steels;
- EN ISO 2566-2:1999 for austenitic steels.

4.1.6 Steels shall have a specified minimum impact energy measured on a Charpy-V-notch impact test specimen (EN 10045-1) as follows:

- ≥ 27 J for ferritic and 1,5 % to 5 % Ni alloy steels;
- ≥ 40 J for steels of material group 8, 9.3 and 10

at a test temperature in accordance with Annex B, but not higher than 20 °C. The other requirements of Annex B shall also apply.

4.1.7 The chemical composition of steels intended for welding or forming shall not exceed the values in Table 4.1-1. Exceptions shall be technically justified.

Table 4.1-1 — Maximum carbon-, phosphorus- and sulphur contents for steels intended for welding or forming

Steel group (according to Table A.1-1)	Maximum content of cast analysis		
	% C	% P	% S
Steels (1 to 6 and 9)	0,23 ^a	0,035	0,025
Ferritic stainless steels (7.1)	0,08	0,040	0,015
Martensitic stainless steels (7.2)	0,06	0,040	0,015
Austenitic stainless steels (8.1)	0,08	0,045	0,015 ^b
Austenitic stainless steels (8.2)	0,10	0,035	0,015
Austenitic-ferritic stainless steels (10)	0,030	0,035	0,015

^a Maximum content of product analysis 0,25 %.

^b For products to be machined a controlled sulphur content of 0,015 % to 0,030 % is permitted by agreement provided the resistance to corrosion is satisfied for the intended purpose.

4.2 Special provisions

4.2.1 Special properties

4.2.1.1 General

Where the behaviour of a material can be affected by manufacturing processes or operating conditions, to an extent that would adversely affect the safety or service life of the pressure vessel, this shall be taken into consideration when specifying material.

Adverse effects may arise from:

- manufacturing processes: e.g. degree of cold forming and heat treatment;
- operating conditions: e.g. hydrogen embrittlement, corrosion, scaling and ageing behaviour of the material after cold forming.

4.2.1.2 Lamellar tearing

Where lamellar tearing due to the joint design and loading needs to be addressed, steels shall be used which have improved deformation properties perpendicular to the surface and verified in accordance with EN 10164:1993.

NOTE For guidance see EN 1011-2.

4.2.2 Design temperature above 20 °C

4.2.2.1 A material shall only be used for pressure parts within the range of temperatures for which the material properties required by EN 13445-3 are defined in the technical specification for the material. If the technical delivery condition does not contain the specific material values required for the allowable temperature *TS* the values required in EN 13445-3 for the design shall be determined by linear interpolation between the two adjacent values. Values shall not be rounded up.

For other than austenitic and austenitic-ferritic stainless steels, the specified value of R_{eH} ($R_{p0,2}$) at room temperature (RT) may be used for temperatures less than or equal to 50 °C. Interpolation between 50 °C and 100 °C shall be performed with the values of RT and 100 °C and using 20 °C as the starting point for interpolation. Above 100 °C linear interpolation shall be performed between the tabulated values given in the table.

4.2.2.2 As the impact properties may be affected by long or frequent holding of the material at elevated temperatures, it is presupposed that the temperatures and periods of exposure to elevated temperatures be recorded for review during in-service inspection. The influence of such exposure upon the lifetime expectancy shall be estimated and recorded.

For operations such as drying and cleaning of pressure vessels, steels with specified low temperature properties but without elevated temperature 0,2 % proof strength values may however be used at elevated temperatures for drying and cleaning processes provided that the values of 0,2 % proof strength used in design calculations for elevated temperatures shall be obtained by multiplying the specified minimum yield strength values at 20 °C by the factor given in Table 4.2-1.

Table 4.2-1 — Yield strength reduction factors for low temperature steels

Steel	Temperature T			
	100 °C	200 °C	250 °C	300 °C
Quenched and tempered	0,75	0,68	0,64	0,60
Normalised or thermomechanically treated	0,70	0,58	0,53	0,48

Interpolation shall be carried out as in 4.2.2.1.

4.2.3 Prevention of brittle fracture

The requirements in Annex B shall apply.

4.2.4 Specific requirements for steels for fasteners

Fasteners include bolts, studs and nuts.

Free cutting steel shall not be used. Bolting made of carbon steel or Ni alloy ferritic steel with > 3,5 % nickel shall not be used above 300 °C.

The specified minimum tensile strength of bar material of ferritic and martensitic steel for bolts shall not exceed 1 000 N/mm². The minimum elongation of bar material after fracture shall be at least $A_5 = 14\%$.

Impact requirements for ferritic and martensitic steels are specified in B.2.2.3.

Bolt material with a design temperature below – 160 °C shall be impact tested at – 196 °C.

Hydrogen embrittlement, fatigue or relaxation properties shall be taken into account where appropriate.

NOTE 1 Detailed requirements on the surface condition and internal soundness of the bar can be necessary for some applications.

NOTE 2 Materials for fasteners compliant with the requirements of this standard should be certified on the basis of EN 10204:1991.

4.3 Technical delivery conditions

4.3.1 European Standards

The European Standards for plates, strip, bars, tubes, fittings, forgings, castings, flanges, valve bodies and other pressure accessories for pressure parts shall be used to the limitations specified in Table A.2-1 for the supply of materials for use in a pressure vessel.

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NOTE Table D.1-1 contains an informative summary of the European material standards referred to.

Special provisions due to fabrication and operation shall be taken into account, if appropriate.

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