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Nekurjene tlačne posode - 2. del: Materiali

Unfired pressure vessels - Part 2: Materials

Unbefeuerte Druckbehälter - Teil 2: Werkstoffe

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

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Unfired pressure vessels - Part 2: Materials

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

Unbefeuerte Druckbehälter - Teil 2: Werkstoffe

This European Standard was approved by CEN on 24 February 2021.

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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 CEN-CENELEC 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

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European foreword

This document (EN 13445-2:2021) 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of an identical text or by endorsement, at the latest by November 2021, and conflicting national standards shall be withdrawn at the latest by November 2021.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a standardization request 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.

list of all parts in the EN 13445 series can be found on the CEN website.

Although these Parts may be obtained separately, it should be recognised that the Parts are inter-dependant. As such the manufacture of unfired pressure vessels requires the application of all the relevant Parts in order for the requirements of the Standard to be satisfactorily fulfilled.

Corrections to the standard interpretations where several options seem possible are conducted through the Migration Help Desk (MHD). Information related to the Help Desk can be found at http://www.unm.fr (en13445@unm.fr). A form for submitting questions can be downloaded from the link to the MHD website. After subject experts have agreed an answer, the answer will be communicated to the questioner. Corrected pages will be given specific issue number and issued by CEN according to CEN Rules. Interpretation sheets will be posted on the website of the MHD.

This document supersedes EN 13445-2:2014. This new edition incorporates the Amendments which have been approved previously by CEN members, and the corrected pages up to Issue 5 without any further technical change. Annex Y provides details of significant technical changes between this European Standard and the previous edition.

Amendments to this new edition may be issued from time to time and then used immediately as alternatives to rules contained herein. It is intended to deliver a new Issue of EN 13445:2021 each year, starting with the precedent as Issue 1, consolidating these Amendments and including other identified corrections.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This document specifies the requirements for steel products used for unfired pressure vessels.

For some metallic materials other than steel, such as spheroidal graphite cast iron, aluminium, nickel, copper, titanium, requirements are or will be formulated in separate parts of this document.

For metallic materials which are not covered by a harmonized material standard and are not likely to be in near future, specific rules are given in this part or the above cited parts of this document.

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.

EN 764-1:2015+A1:2016, *Pressure equipment — Terminology — Part 1: Pressure, temperature, volume, nominal size*

EN 764-2:2012, *Pressure equipment — Part 2: Quantities, symbols and units*

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

EN 764-4:2014, *Pressure equipment — Part 4: Establishment of technical delivery conditions for metallic materials*

EN 764-5:2014, *Pressure equipment — Part 5: Inspection documentation of metallic materials and compliance with the material specification*

EN 1092-1:2018, *Flanges and their joints — Circular flanges for pipes, valves, fittings and accessories, PN designated — Part 1: Steel flanges*

EN 10028-2:2009, *Flat products made of steels for pressure purposes — Part 2: Non-alloy and alloy steels with specified elevated temperature properties*

EN 10028-3:2009, *Flat products made of steels for pressure purposes — Part 3: Weldable fine grain steels, normalized*

EN 10028-4:2009, *Flat products made of steels for pressure purposes — Part 4: Nickel alloy steels with specified low temperature properties*

EN 10028-5:2009, *Flat products made of steels for pressure purposes — Part 5: Weldable fine grain steels, thermomechanically rolled*

EN 10028-6:2009, *Flat products made of steels for pressure purposes — Part 6: Weldable fine grain steels, quenched and tempered*

EN 10028-7:2007, *Flat products made of steels for pressure purposes — Part 7: Stainless steels*

EN 10204:2004, *Metallic products — Types of inspection documents*

EN 10216-3:2013, *Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 3: Alloy fine grain steel tubes*

EN 10216-4:2013, *Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 4: Non-alloy and alloy steel tubes with specified low temperature properties*

EN 10217-3:2002, EN10217-3:2002/A1:2005, *Welded steel tubes for pressure purposes — Technical delivery conditions — Part 3: Alloy fine grain steel tubes*

EN 10217-4:2002, EN 10217-4:2002/A1:2005, *Welded steel tubes for pressure purposes — Technical delivery conditions — Part 4: Electric welded non-alloy steel tubes with specified low temperature properties*

EN 10217-6:2002, EN 10217-6:2002/A1:2005, *Welded steel tubes for pressure purposes — Technical delivery conditions — Part 6: Submerged arc welded non-alloy steel tubes with specified low temperature properties*

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

EN 10222-4:1998, EN 10222-4:1998/A1:2001, *Steel forgings for pressures purposes — Part 4: Weldable fine grain steels with high proof strength*

EN 10269:2013, *Steels and nickel alloys for fasteners with specified elevated and/or low temperature properties*

EN 10273:2007, *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 13445-1:2021, *Unfired pressure vessels — Part 1: General*

EN 13445-3:2021, *Unfired pressure vessels — Part 3: Design*

EN 13445-4:2021, *Unfired pressure vessels — Part 4: Fabrication*

EN 13445-5:2021, *Unfired pressure vessels — Part 5: Inspection and testing*

EN 13479:2004, *Welding consumables — General product standard for filler metals and fluxes for fusion welding of metallic materials*

EN ISO 148-1:2010, *Metallic materials — Charpy pendulum impact test — Part 1: Test method* (ISO 148-1:2010)

EN ISO 204:2009, *Metallic materials — Uniaxial creep testing in tension — Method of test* (ISO 204:2009)

EN ISO 898-1:2013, *Mechanical properties of fasteners made of carbon steel and alloy steel — Part 1: Bolts, screws and studs with specified property classes — Coarse thread and fine pitch thread* (ISO 898-1:2013)

EN ISO 898-2:2012, *Mechanical properties of fasteners made of carbon steel and alloy steel — Part 2: Nuts with specified property classes — Coarse thread and fine pitch thread* (ISO 898-2:2012)

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)

EN ISO 3506-1:2009, *Mechanical properties of corrosion-resistant stainless-steel fasteners — Part 1: Bolts, screws and studs* (ISO 3506- 1:2009)

EN ISO 3506-2:2009, *Mechanical properties of corrosion-resistant stainless-steel fasteners — Part 2: Nuts* (ISO 3506-2:2009)

EN ISO 6892-1:2009, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature* (ISO 6892-1:2009)

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

3 Terms, definitions, symbols and units

3.1 Terms and définitions

For the purposes of this document, the terms and definitions given in EN 13445-1:2021, EN 764-1:2015+A1:2016, EN 764-3:2002 and the following apply.

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

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

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

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 to entry: Values for T_S are given in Table B.2-12.

Note 2 to entry: For tensile membrane stress reference is made to EN 13445-3:2021, Annex C.

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 impact energy has to be achieved (see B.2).

3.1.5
impact energy *KV*
the energy absorbed by a sample of material when subjected to a Charpy-V-notch test in accordance with EN ISO 148-1:2010

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 Tables B.2-2 to B.2-7 and Figures B.2-1 to B.2-11). 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.

3.1.7
weld creep strength reduction factor (WCSRF)
factor to account for creep strength reduction at the weldment

3.2 Symbols and units

For the purpose of this part, the symbols and units of EN 764-2:2012 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	t	s, min, h, d, a
frequency	f	Hz
dimension	any Latin letter [a]	mm
length	l	mm
thickness	e	mm
corrosion allowance	c	mm
diameter	d, D	mm
radius	r, R	mm
area	A, S	mm^2
volume, capacity	V	mm^3 [b, c]
weight	W	N, kN
density	ρ	kg/mm^3 [d]
second moment of area	I	mm^4
section modulus	Z	mm^3
acceleration	γ	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 m^3 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/m^3.

Table 3.2-2 — Mechanical quantities

Quantity [a]	Symbol [b]	Unit
force	F	N
moment	M	N·mm
pressure	p, P	bar [c], MPa
Temperature	T	°C
linear expansion coefficient	α	µm/m°C
normal stress	σ	MPa
shear stress	τ	MPa
nominal design stress	f	MPa
tensile strength	R_m	MPa
ultimate tensile strength at temperature T	$R_{m/T}$	MPa
yield strength	R_e	MPa
yield strength at temperature T	$R_{e/T}$	MPa
upper yield strength	R_{eH}	MPa
1 % proof strength	$R_{p1,0}$	MPa
0,2 % proof strength	$R_{p0,2}$	MPa
0,2 % proof strength at temperature T	$R_{p0,2/T}$	MPa
modulus of elasticity	E	MPa
shear modulus	G	MPa
Poisson's ratio	υ	–
strain	ε	%
elongation after fracture	A	%
impact energy	KV	J
hardness	HB, HV	–
Joint coefficient	z	–
safety factor	S	–
Mean 1 % creep strain limit at calculation temperature T and lifetime t	$R_{p1,0/T/t}$	MPa
Mean creep rupture strength at calculation temperature T and lifetime t	$R_{m/T/t}$	MPa
Weld creep strength reduction factor	z_c	-

[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 764-4:2014 should be met. Exceptions should be technically justified.

The materials shall be grouped in accordance with CEN ISO/CR 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 view of manufacture and heat treatment after welding.

4.1.2 Materials for pressure-bearing parts compliant with the requirements of this document shall be accompanied by inspection documents in accordance with EN 10204:2004. Certificate of specific control (3.1 or 3.2 certificate) shall be required for all steels if Design by Analysis – Direct Route according to Annex B of EN 13445-3:2021 is used.

The type of inspection document shall be in accordance with EN 764-5:2014 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

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

where

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

The minimum elongation after fracture in any direction shall be ≥ 14 %.

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

— EN ISO 2566-1:1999 for carbon and low alloy steels;

— EN ISO 2566-2:1999 for austenitic steels.

4.1.5 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.

4.1.6 Steels shall have a specified minimum impact energy measured on a Charpy-V-notch impact test specimen (EN ISO 148-1:2010) 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. Line 2 of the table refers to vessels or parts designed using Design by Analysis – Direct Route according to Annex B of EN 13445-3:2021. 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)	Maximum content of cast analysis		
	% C	% P	% S
Steels (1 to 6 and 9)	0,23[a]	0,035	0,025
Steels (1 to 6 and 9) when DBA – Direct Route is used [c]	0,20	0,025	0,015
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.

[c] In addition the ratio on thickness reduction (ratio of initial thickness of slab/ingot to the thickness of the final plate) shall be equal or greater than:

— 4 for NL2 steels and steels of material group 9;

— 3 for other materials.

4.2 Special provisions

4.2.1 Special properties

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.

4.2.2 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 13445-3:2021 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 13445-3:2021 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.