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Unfired pressure vessels - Part 8: Additional requirements for pressure vessels of aluminium and aluminium alloys

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Récipients sous pression non soumis à la flamme - Partie 8: Exigences complémentaires pour les récipients sous pression en aluminium et alliages d'aluminium

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Réceptifs sous pression non soumis à la flamme -
Partie 8: Exigences complémentaires pour les
réceptifs sous pression en aluminium et alliages
d'aluminium

Unbefeuerte Druckbehälter - Teil 8: Zusätzliche
Anforderungen an Druckbehälter aus Aluminium und
Aluminiumlegierungen

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

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

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EN 13445-8:2021 (E)
Issue 1 (2021-05)**European foreword**

This document (EN 13445-8:2021) 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of an identical text or by endorsement, at the latest by November 2021, and conflicting national standards shall be withdrawn at the latest by November 2021.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 13445-8:2014. 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 requirements for unfired pressure vessels and their parts made of aluminium and aluminium alloys in addition to the general requirements for unfired pressure vessels under EN 13445:2021 Parts 1 to 5. This document specifies unfired pressure vessels for loads up to 500 full cycles.

NOTE Cast materials are not included in this version. Details regarding cast materials will be subject to an amendment to or a revision 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 485-2:2013, *Aluminium and aluminium alloys — Sheet, strip and plate — Part 2: Mechanical properties*

EN 573-3:2013, *Aluminium and aluminium alloys — Chemical composition and form of wrought products — Part 3: Chemical composition and form of products*

EN 586-2:1994, *Aluminium and aluminium alloys — Forgings — Part 2: Mechanical properties and additional property requirements*

EN 754-2:2013, *Aluminium and aluminium alloys — Cold drawn rod/bar and tube — Part 2: Mechanical properties*

EN 755-1:2016, *Aluminium and aluminium alloys — Extruded rod/bar, tube and profiles — Part 1: Technical conditions for inspection and delivery*

EN 755-2:2016, *Aluminium and aluminium alloys — Extruded rod/bar, tube and profiles — Part 2: Mechanical properties*

EN 755-8:2016, *Aluminium and aluminium alloys — Extruded rod/bar, tube and profiles — Part 8: Porthole tubes, tolerances on dimensions and form*

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

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

EN 12392:2000, *Aluminium and aluminium alloys — Wrought products — Special requirements for products intended for the production of pressure equipment*

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

EN 13445-2:2021, *Unfired pressure vessels — Part 2: Materials*

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*

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EN ISO 3452-1:2013, *Non-destructive testing — Penetrant testing — Part 1: General principles* (ISO 3452-1:2013)

EN ISO 3834-2:2005, *Quality requirements for fusion welding of metallic materials — Part 2: Comprehensive quality requirements* (ISO 3834-2:2005)

EN ISO 3834-3:2005, *Quality requirements for fusion welding of metallic materials — Part 3: Standard quality requirements* (ISO 3834-3:2005)

EN ISO 4063:2010, *Welding and allied processes — Nomenclature of processes and reference numbers* (ISO 4063:2009, Corrected version 2010-03-01)

EN ISO 6520-1:2007, *Welding and allied processes — Classification of geometric imperfections in metallic materials — Part 1: Fusion welding* (ISO 6520-1:2007)

EN ISO 9606-2:2004, *Qualification test of welders — Fusion welding — Part 2: Aluminium and aluminium alloys* (ISO 9606-2:2004)

EN ISO 10042:2005, *Welding — Arc-welded joints in aluminium and its alloys — Quality levels for imperfections* (ISO 10042:2005)

EN ISO 11666:2010, *Non-destructive testing of welds — Ultrasonic testing — Acceptance levels* (ISO 11666:2010)

EN ISO 14732:2013, *Welding personnel — Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials* (ISO 14732:2013)

EN ISO 15614-2:2005, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 2: Arc welding of aluminium and its alloys* (ISO 15614-2:2005)

EN ISO 16826:2014, *Non-destructive testing — Ultrasonic testing — Examination for discontinuities perpendicular to the surface* (ISO 16826:2012)

EN ISO 17635:2016, *Non-destructive testing of welds — General rules for metallic materials* (ISO 17635:2016)

EN ISO 17636-1:2013, *Non-destructive testing of welds — Radiographic testing — Part 1: X- and gamma-ray techniques with film* (ISO 17636-1:2013)

EN ISO 17636-2:2013, *Non-destructive testing of welds — Radiographic testing — Part 2: X- and gamma-ray techniques with digital detectors* (ISO 17636-2:2013)

EN ISO 17637:2011, *Non-destructive testing of welds — Visual testing of fusion-welded joints* (ISO 17637:2003)

EN ISO 17640:2010, *Non-destructive testing of welds — Ultrasonic testing — Techniques, testing levels, and assessment* (ISO 17640:2010)

EN ISO 23277:2009, *Non-destructive testing of welds — Penetrant testing of welds — Acceptance levels* (ISO 23277:2006)

CR ISO/TR 15608:2013, *Welding — Guidelines for a metallic materials grouping system* (ISO/TR 15608:2013)

ISO 857-1:1998, *Welding and allied processes — Vocabulary — Part 1: Metal welding processes*

3 Terms, definitions, symbols and units

For the purposes of this document, the terms, definitions, symbols and units given in EN 13445:2021 Parts 1 to 5 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>

NOTE Further symbols are listed in 8.2.3.

4 General

EN 13445-1:2021 applies.

5 Materials

5.1 General

Materials for pressure-bearing parts compliant with the requirements of this document shall be accompanied by inspection documents in accordance with EN 10204:2004.

The type of inspection document shall be in accordance with EN 764-5:2014 and include a declaration of compliance to the material specification.

The requirements of EN 13445-2:2021 shall apply with the following additions/exclusions.

5.2 Elongation after fracture

NOTE Also see 4.1.4 of EN 13445-2:2021.

Aluminium and aluminium alloys used for welded parts of pressure vessels that are subjected to cold forming (e.g. rolled shells and heads) shall have a specified minimum elongation after fracture measured on a gauge length

$$L_o = 5,65\sqrt{S_o} \quad (5.2-1)$$

that is ≥ 14 % in the longitudinal or transverse direction as defined by the material specification.

Aluminium and aluminium alloys used for parts of pressure vessels that are not subject to cold forming (e.g. straight flanges and nozzles) shall have a specified minimum elongation after fracture of ≥ 10 % in the longitudinal or transverse direction as defined by the material specification, measured on a gauge length as defined in Formula (5.2-1).

5.3 Prevention of brittle fracture

EN 13445-2:2021, Annex B, is not applicable. All materials of Table 5.6-1 are suitable for any minimum metal temperature without impact testing.

NOTE See also EN 1252-1 and EN 12392:2000, 8.4.

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5.4 Lamellar tearing

NOTE Also see EN 13445-2:2021, 4.2.1.2.

Specific requirements of lamellar tearing for pressure vessels of aluminium and its alloys are not applicable.

5.5 Chemical composition

The chemical composition shall be in accordance with the material specification.

It is recommended that the material to be used for welded components be produced from rolling or extrusion ingots with hydrogen level no greater than 0,2 ml per 100 g aluminium, measured on liquid metal during casting (see EN 12392:2000, 5.1.3).

EN 12392:2000, 4.1, recommends a maximum lead content not exceeding 150 µg/g.

5.6 Material grouping system

Annex A of EN 13445-2:2021 is not applicable for pressure vessels of aluminium and its alloys. The allowable materials for the construction of aluminium alloy pressure vessels shall be according to Table 5.6-1 below.

Any product form available in EN 12392:2000 for a material in Table 5.6-1 at an acceptable temper is acceptable for construction to this document, as long as the requirements of 5.2 and 5.5 are fulfilled. Other materials not defined here may be used by agreement by the parties concerned (see EN 13445-2:2021, 4.1.4) if they meet the requirements of 5.2 and 5.5 and a particular material appraisal is produced (see EN 764-4:2002).

Table 5.6-1 — Grouping system based on CR ISO/TR 15608:2013 and allowable materials of construction based on EN 12392:2000 using the EN AW numbers according to EN 573-3:2013

Group	Sub group	Type of aluminium and aluminium alloys	Designation		
			EN AW number	Chemical symbol	Temper
21		Pure aluminium with ≤ 1 % impurities or alloy content	EN AW — 1050A	EN AW-Al 99,5	O, H111, H112
			EN AW — 1070A	EN AW-Al 99,7	O, H111, H112
			EN AW — 1080A	EN AW-Al 99,8(A)	O, H111, H112
22	Non heat treatable alloys				
	22.1	Aluminium-manganese alloys	EN AW — 3003	EN AW-Al Mn1Cu	O, H111, H112
			EN AW — 3103	EN AW-Al Mn1	O, H111, H112
			EN AW — 3105	EN AW-Al Mn0,5Mg0,5	O, H111
	22.2	Aluminium-magnesium alloys with Mg ≤ 1,5 %	EN AW — 5005	EN AW-Al Mg1(B)	O, H111, H112
			EN AW — 5005A	EN AW-Al Mg1(C)	O, H111, H112
			EN AW — 5050	EN AW-Al Mg1,5(C)	O, H111
	22.3	Aluminium-magnesium alloys with 1,5 % < Mg ≤ 3,5 %	EN AW — 5049	EN AW-Al Mg2Mn0,8	O, H111, H112
			EN AW — 5052	EN AW-Al Mg2,5	O, H111, H112
			EN AW — 5154A	EN AW-Al Mg3,5(A)	O, H111, H112
EN AW — 5251			EN AW-Al Mg2	O, H111, H112	
EN AW — 5454			EN AW-Al Mg3Mn(A)	O, H111, H112	
22.4	Aluminium-magnesium alloys with Mg > 3,5 %	EN AW — 5754	EN AW-Al Mg3	O, H111, H112	
		EN AW — 5083	EN AW-Al Mg4,5Mn0,7	O, H111, H112	
23	Heat treatable alloys				
	23.1	Aluminium-magnesium-silicon alloys	EN AW — 6060	EN AW-Al MgSi	T4 ^a
			EN AW — 6061	EN AW-Al Mg1SiCu	T4 ^b , T6 ^c
^a for profiles only ^b for seamless pipes and flanges only ^c for flanges only					

6 Design

6.1 General

The requirements of EN 13445-3:2021 shall apply with the following additions/exclusions.

6.2 Design temperature and properties

NOTE 1 Also see EN 13445-2:2021, 4.2.2.

EN 13445-2:2021, 4.2.2.1, 2nd paragraph, is not applicable for aluminium and its alloys.

Design strength values are given in Tables A.2 to A.5 in Annex A. Design temperatures that exceed the respective temperature limit in Annex A are not permitted.

For materials of group 22.4 temperatures above 80 °C may result in grain boundary precipitation of Al₃-Mg₂. These materials may be used at temperatures above 80 °C up to 200 °C only for non-corrosive service.

NOTE 2 For further material properties see EN 12392:2000.

For welded parts and heat-treated parts after forming only the values equivalent to the 0 temper shall be used for design when 6 000 series flanges, etc. are welded. These values are not quoted in EN 12392:2000 and so the tabulated values for f shown in Table 6.3-2 shall be used for design. The weld area shall be based on the 0 temper but the flange strength away from the weld ($2t$) may be based on the actual temper (T4 or T6).

For aluminium and aluminium alloys values of 0,2 % proof stress (or 1 % proof stress for material group 21-1 000 series aluminium) for temperatures above 20 °C shall be established by linear interpolation between two adjacent values in Annex A or in EN 12392:2000 except that for alloys 5083 and 5086 the respective value at 50 °C may be used for 65 °C.

For material of group 22.4: For short periods, higher temperatures (e.g. when defrosting refrigerating plant) up to 150 °C are permissible provided that the pressure is reduced to half the working pressure for a period up to 8 h and to atmospheric pressure for a period up to 24 h.

6.3 Time-independent nominal design stress

The design stress for aluminium and aluminium alloy materials shall be in accordance with the Table 6.3-1.

Table 6.3-1 — Design Stresses for aluminium and aluminium alloy material

Group according to Table 5.6-1	Design stresses at design condition	Design stresses at test condition
21	$f = [R_{p1,0,T} / 1,5]$	$f_{\text{test}} = [R_{p1,0,20} / 1,05]$
22	$f = \min ([R_{p0,2,T} / 1,5]; [R_{m,20} / 2,4])$	$f_{\text{test}} = [R_{p0,2,20} / 1,05]$
23	$f = \min ([R_{p0,2,T} / 1,5]; [R_{m,20} / 3])$	$f_{\text{test}} = [R_{p0,2,20} / 1,05]$

Table 6.3-2 — Allowable Design Stress values for 6000 series aluminium alloys in the welded condition (see 6.2)

Material designation to EN 12392:2000	Value of f for design temperature (°C) not exceeding						
	50	75	100	125	150	175	200
EN AW 6060	40	40	40	38	36	22	14
EN AW 6061	55	55	55	54	51	43	32

6.4 Thick walled, small bore piping for shells

Formulae (6.4-1) and (6.4-2) may be used as an alternative to Annex B and C in EN 13445-3:2021 for thick-walled piping of aluminium and aluminium alloy materials, i.e. for piping with $e/D_e > 0,16$ and $DN \leq 50$. The maximum allowable pressure shall be used for design.

Limit Load Procedure

$$p_d < PS \quad (6.4-1)$$

This maximum allowable pressure can be determined as follows:

$$PS = \left(\frac{2}{\sqrt{3}} \cdot R_{p0,2} \cdot \ln \left[\frac{D_o}{D_i} \right] \right) / 1,5 \quad (6.4-2)$$

NOTE The method proposed is the standard design method for vaporisers upstream a cryogenic pressure tank. These vaporisers are small bore piping ($DN \leq 50$) with comparable thick wall thickness (e/D_e typically ranges from 0,23 to 0,33 or D_e/D_i from 2,7 to 1,8).

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6.5 Fatigue design

Fatigue design for over 500 full equivalent pressure cycles is not covered by this Part 8 for aluminium and aluminium alloy pressure vessels. For the determination of 500 full equivalent pressure cycles see EN 13445-3:2021, 5.4.2

NOTE This will be subject to a future revision of or an amendment to this Part 8.

6.6 Lapped joints, joggle joints, permanent backing strips

6.6.1 General

The requirements of 5.7.4 in EN 13445-3:2021 are not applicable for pressure vessels of aluminium and aluminium alloys, and 5.7.4.1, 5.7.4.2, and 5.7.4.3.1 shall be replaced with the following 6.6.2, 6.6.3, and 6.6.4, respectively.

6.6.2 Lapped joints

Lapped joints with fillet welds shall be used only when all of the following conditions are fulfilled:

- only testing group 4 is permitted;
- the materials are limited to material groups 21, 22.1, 22.2, 22.3, 22.4;
- for circumferential joints of shell to head only;
- the nominal wall thickness of the thickest pressure part does not exceed 8 mm;