

# SLOVENSKI STANDARD

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### Neogrevane tlačne posode - 8. del: Dodatne zahteve za tlačne posode iz aluminija in aluminijevih zlitin

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

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

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

**Ta slovenski standard je istoveten z: EN 13445-8:2009**

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

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 30 June 2009.

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## Contents

Page

Foreword.....	4
1 Scope .....	5
2 Normative references .....	5
3 Terms, definitions, symbols and units .....	6
4 General requirements.....	6
5 Materials .....	6
5.1 General.....	6
5.2 Elongation after fracture .....	6
5.3 Prevention of brittle fracture .....	6
5.4 Lamellar tearing .....	7
5.5 Chemical composition .....	7
5.6 Material grouping system .....	7
6 Design .....	8
6.1 General.....	8
6.2 Design temperature and properties .....	8
6.3 Time-independent nominal design stress.....	8
6.4 Thick walled, small bore piping for shells.....	8
6.5 Fatigue design.....	9
6.6 Lapped joints, joggle joints, permanent backing strips .....	9
6.6.1 General.....	9
6.6.2 Lapped joints.....	9
6.6.3 Joggle joints.....	9
6.6.4 Joints with permanent backing strips .....	10
7 Manufacture.....	10
7.1 General.....	10
7.2 Materials .....	10
7.3 Welding procedure specification (WPS) .....	10
7.4 Qualification of welding procedure specifications (WPQR).....	10
7.5 Qualification of welders and welding operators.....	11
7.6 Joint preparation.....	11
7.7 Preheat.....	11
7.8 Production test, reference criteria .....	11
7.9 Extent of testing.....	11
7.10 Performance of test and acceptance criteria.....	12
7.11 Forming procedures.....	12
7.12 Heat treatment after forming .....	12
7.13 Sampling of formed products.....	14
7.14 Tests.....	14
7.14.1 Base material.....	14
7.14.2 Butt welds.....	15
7.15 Post weld heat treatment (PWHT) .....	15
8 Inspection and testing.....	15
8.1 General.....	15
8.2 Non-destructive testing of welded joints .....	15
8.2.1 General.....	15
8.2.2 Demonstration of satisfactory experience for testing group 2.....	16
8.2.3 Symbols .....	17
8.3 Determination of extent of non destructive testing .....	17
8.4 Applicable non destructive testing techniques.....	20
8.4.1 NDT methods.....	20
8.4.2 Acceptance criteria for radiographic testing (RT).....	21

8.4.3	Acceptance criteria for visual and surface penetrant testing.....	21
8.4.4	Acceptance criteria for penetrant testing (PT) .....	22
8.5	Selection of non-destructive testing methods for internal imperfections.....	22
8.6	Standard hydrostatic test .....	23
8.7	Pneumatic testing.....	23
9	Inspection and testing of serially produced pressure vessels — Model approval.....	23
9.1	General.....	23
9.2	Inspection and testing of pressure vessels subject to cyclic loads .....	23
	Annex Y (informative) Differences between EN 13445-8:2006 and EN 13445-8:2009.....	24
	Annex ZA (informative) Relationship between this European Standard and the Essential Requirements of the EU Pressure Equipment Directive 97/23/EC .....	25
	Bibliography.....	26

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**EN 13445-8:2009 (E)**  
**Issue 1 (2009-07)**

## Foreword

This document (EN 13445-8:2009) 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 *December 2009*, and conflicting national standards shall be withdrawn at the latest by *December 2009*.

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

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 EC Directive(s).

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

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.*
- Part 8: *Additional requirements for pressure vessels of aluminium and aluminium alloys.*
- CEN/TR 13445-9, *Unfired pressure vessels* — Part 9: *Conformance of EN 13445 series to ISO 16528*

This document supersedes EN 13445-8:2006. This new edition incorporates the Amendments which have been approved previously by CEN members, and the corrected pages up to Issue 36 without any further technical change. Annex Y to EN 13445-1:2009 and Annex Y to this Part 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 13445:2009 each year, 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, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

## 1 Scope

This Part 8 of this European Standard 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 13445:2009 Parts 1 to 5. This European Standard 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 European Standard.

## 2 Normative references

The following referenced documents are indispensable for the application 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 571-1:1997, *Non-destructive testing — Penetrant testing — Part 1: General principles*

EN 573-3:2007, *Aluminium and aluminium alloys — Chemical composition and form of wrought products — Part 3: Chemical composition*

EN 583-4:2002, *Non-destructive testing — Ultrasonic examination — Part 4: Examination for discontinuities perpendicular to the surface*

EN 970:1997, *Non-destructive examination of fusion welds — Visual examination*

EN 1289:1998, EN 1289:1998/A1:2002, EN 1289:1998/A2:2003, *Non-destructive examination of welds — Penetrant testing of welds — Acceptance levels*

EN 1435:1997, EN 1435:1997/A1:2002, EN 1435:1997/A2:2003, *Non-destructive examination of welds — Radiographic examination of welded joints*

EN 1712:1997, EN 1712:1997/A1:2002, EN 1712:1997/A2:2003, *Non-destructive examination of welds — Ultrasonic examination of welded joints — Acceptance levels*

EN 1714:1997, EN 1714:1997/A1:2002, EN 1714:1997/A2:2003, *Non-destructive examination of welds — Ultrasonic examination of welded joints*

EN 12062:1997, EN 12062:1997/A1:2002, EN 12062:1997/A2:2003, *Non-destructive examination of welds — General rules for metallic materials*

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

EN 13445-1:2009, *Unfired pressure vessels — Part 1: General*

EN 13445-2:2009, *Unfired pressure vessels — Part 2: Materials*

EN 13445-3:2009, *Unfired pressure vessels — Part 3: Design*

EN 13445-4:2009, *Unfired pressure vessels — Part 4: Fabrication*

EN 13445-5:2009, *Unfired pressure vessels — Part 5: Inspection and testing*

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 13445-8:2009 (E) Issue 1 (2009-07)

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

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)*

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

### 3 Terms, definitions, symbols and units

For the purposes of this document, the terms, definitions, symbols and units given in EN 13445:2009 Parts 1 to 5 apply.

NOTE Further symbols are listed in 8.2.3.

### 4 General requirements

The general requirements of EN 13445-1:2009 shall apply.

### 5 Materials

#### 5.1 General

The requirements of EN 13445-2:2009 shall apply with the following additions/exclusions.

#### 5.2 Elongation after fracture

NOTE Also see 4.1.4 of EN 13445-2:2009.

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  $\geq 14$  % 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 subjected to cold forming (e.g. straight flanges and nozzles) shall have a specified minimum elongation after fracture measured on a gauge length

$$L_o = 5,65\sqrt{S_o} \quad (5.2-2)$$

that is  $\geq 10$  % in the longitudinal or transverse direction as defined by the material specification.

#### 5.3 Prevention of brittle fracture

NOTE 1 Also see 4.1.6 of EN 13445-2:2009.

Annex B of EN 13445-2:2009 is not applicable.

NOTE 2 The requirements of 4.3 of EN 1252-1:1998 should be used for determining the minimum design and temperature and the requirements to prevent brittle fracture.



## 5.4 Lamellar tearing

NOTE Also see 4.2.1.2 of EN 13445-2:2009.

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 their material specification, except that all materials shall have a maximum lead content of 150 µg/g.

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.

## 5.6 Material grouping system

Annex A of EN 13445-2:2009 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.

**Table 5.6-1 — Grouping system based on CR ISO/TR 15608:2000 and allowable materials of construction based on EN 12392:2000 using the EN AW numbers according to EN 573-3:2007**

NOTE Any product form available in EN 12392:2000 for a material in this table at an indicated temper is acceptable for construction to this European Standard, 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 4.1.4 of EN 13445-2:2009) if they meet the requirements of 5.2 and 5.5 and a particular material appraisal is produced (see EN 764-4:2002).

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 — 1070A EN AW — 1080A	EN AW-AI 99,5 EN AW-AI 99,7 EN AW-AI 99,8(A)	O, H111, H112 O, H111, H112 O, H111, H112
22	Non heat treatable alloys				
	22.1	Aluminium-manganese alloys	EN AW — 3003	EN AW-AI Mn1Cu	O, H111, H112
			EN AW — 3103	EN AW-AI Mn1	O, H111, H112
			EN AW — 3105	EN AW-AI Mn0,5Mg0,5	O, H111
	22.2	Aluminium-magnesium alloys with Mg ≤ 1,5 %	EN AW — 5005	EN AW-AI Mg1(B)	O, H111, H112
			EN AW — 5005A	EN AW-AI Mg1(C)	O, H111, H112
			EN AW — 5050	EN AW-AI Mg1,5(C)	O, H111
			EN AW — 5049	EN AW-AI Mg2Mn0,8	O, H111, H112
	22.3	Aluminium-magnesium alloys with 1,5 % < Mg ≤ 3,5 %	EN AW — 5052	EN AW-AI Mg2,5	O, H111, H112
			EN AW — 5154A	EN AW-AI Mg3,5(A)	O, H111, H112
			EN AW — 5251	EN AW-AI Mg2	O, H111, H112
			EN AW — 5454	EN AW-AI Mg3Mn(A)	O, H111, H112
			EN AW — 5754	EN AW-AI Mg3	O, H111, H112
			EN AW — 5083	EN AW-AI Mg4,5Mn0,7	O, H111, H112
	22.4	Aluminium-magnesium alloys with Mg > 3,5 %	EN AW — 5086	EN AW-AI Mg4	O, H111
23	Heat treatable alloys				
	23.1	Aluminium-magnesium-silicon alloys	EN AW — 6060 EN AW — 6061	EN AW-AI MgSi EN AW-AI Mg1SiCu	T4 <sup>a</sup> T4 <sup>b</sup> , T6 <sup>c</sup>
<sup>a</sup> for profiles only <sup>b</sup> for seamless pipes and flanges only <sup>c</sup> for flanges only					

## 6 Design

### 6.1 General

The requirements of EN 13445-3:2009 shall apply with the following additions/exclusions.

### 6.2 Design temperature and properties

NOTE Also see 4.2.2 of EN 13445-2:2009.

The 2<sup>nd</sup> paragraph of 4.2.2.1 of EN 13445-2:2009 is not applicable for aluminium and its alloys.

The maximum design temperature shall not exceed that defined in Table 1 of EN 12392:2000 as the maximum working temperature.

The mechanical properties used for design shall be taken from the tabulated values in EN 12392:2000 at room temperature for  $R_{m/20}$  and at the highest design temperature for  $R_{e/T}$ .

For welded parts and heat treated parts after forming only the values equivalent to the O temper shall be used for design when 6000 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 O 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 strength (or 1 % proof strength for material group 21-1000 series aluminium) for temperatures above 20 °C shall be established by linear interpolation between two adjacent values in EN 12392:2000 except that for alloys 5083 and 5086 the respective value at 50 °C may be used for 65 °C.

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### 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

Equation 6.4-1 and 6.4-2 may be used as an alternative to Annex B and C in EN 13445-3:2009 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 ≤ 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).

## 6.5 Fatigue design

Fatigue design for over 500 cycles is not covered by this Part 8 for aluminium and aluminium alloy pressure vessels.

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 13445-3:2009 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:

- a) only testing group 4 is permitted;
- b) the materials are limited to material groups 21, 22.1, 22.2, 22.3, 22.4;
- c) for circumferential joints of shell to head only;
- d) the nominal wall thickness of the thickest pressure part does not exceed 8 mm;
- e) the overlap shall be minimum  $4e$ , where  $e$  represents the nominal thickness of the thickest pressure part;
- f) both sides of the lap are welded;
- g) the maximum vessel diameter does not exceed 1 600 mm;
- h) non-corrosive conditions only are permitted.

### 6.6.3 Joggle joints

Joggle joints shall be used only when all of the following conditions are fulfilled:

- a) the materials are limited to material groups 21, 22.1, 22.2, 22.3, and 22.4 (except 5454);
- b) for circumferential joints of shell to head only;