

# SVENSK STANDARD

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**Tryckkärl (ej eldberörda) –  
Del 3: Konstruktion**

**Unfired pressure vessels –  
Part 3: Design**



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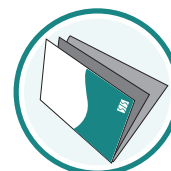
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Europastandarden EN 13445-3:2014 Issue 5 (2018-07) gäller som svensk standard. Detta dokument innehåller den officiella engelska versionen av EN 13445-3:2014 Issue 5 (2018-07).

Denna standard ersätter SS-EN 13445-3:2014+C4:2017 utgåva 1, SS-EN 13445-3:2014/A3:2018 utgåva 1 och SS-EN 13445-3:2014/A4:2018 utgåva 1.

The European Standard EN 13445-3:2014 Issue 5 (2018-07) has the status of a Swedish Standard. This document contains the official version of EN 13445-3:2014 Issue 5 (2018-07).

This standard supersedes the Swedish Standard SS-EN 13445-3:2014+C4:2017 edition 1, SS-EN 13445-3:2014/A3:2018 edition 1 and SS-EN 13445-3:2014/A4:2018 edition 1.

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EUROPEAN STANDARD

**EN 13445-3**

NORME EUROPÉENNE

EUROPÄISCHE NORM

September 2014

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English Version

**Unfired pressure vessels - Part 3: Design**

Récipients sous pression - Partie 3: Conception

Unbefeuerte Druckbehälter - Teil 3: Konstruktion

This European Standard was approved by CEN on 19 August 2014.

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## Foreword

This document (EN 13445-3:2014) 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of an identical text or by endorsement, at the latest by December 2014, and conflicting national standards shall be withdrawn at the latest by December 2014.

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 EU Directive(s).

For relationship with EU 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*
- Part 10: *Additional requirements for pressure vessels of nickel and nickel alloys*

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 13445-3:2009. 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 13445:2014 each year, consolidating these Amendments and including other identified corrections. . Issue 5 (2018-07) includes the corrected pages listed in Annex Y.

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.

**EN 13445-3:2014 (E)**  
**Issue 5 (2018-07)****1 Scope**

This Part of this European Standard specifies requirements for the design of unfired pressure vessels covered by EN 13445-1:2014 and constructed of steels in accordance with EN 13445-2:2014.

EN 13445-5:2014, Annex C specifies requirements for the design of access and inspection openings, closing mechanisms and special locking elements.

NOTE This Part applies to design of vessels before putting into service. It may be used for in service calculation or analysis subject to appropriate adjustment.

**2 Normative references**

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 286-2:1992, *Simple unfired pressure vessels designed to contain air or nitrogen — Part 2: Pressure vessels for air braking and auxiliary systems for motor vehicles and their trailers*

EN 764-1:2004, *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 837-1:1996, *Pressure gauges — Part 1: Bourdon tube pressure gauges — Dimensions, metrology, requirements and testing*

EN 837-3:1996, *Pressure gauges — Part 3: Diaphragm and capsule pressure gauges — Dimensions, metrology, requirements and testing*

EN 1092-1:2007, *Flanges and their joints — Circular flanges for pipes, valves, fittings and accessories, PN-designated — Part 1: Steel flanges*

EN 1591-1:2011, *Flanges and their joints — Design rules for gasketed circular flange connections — Calculation method*

EN 1708-1:2010, *Welding — Basic weld joint details in steel — Part 1: Pressurized components*

EN 1990, *Eurocode — Basis of structural design*

EN 1992-1-1:2005, *Eurocode 2 — Design of concrete structures — Part 1-1: General rules and rules for buildings*

EN 1991-1-4:2005, *Eurocode 1: Actions on structures — Part 1-4: General actions — Wind actions*

EN 1991-1-6, *Eurocode 1 — Actions on structures — Part 1-6: General actions — Actions during execution*

EN 1998-1:2004, *Design of structures for earthquake resistance — Part 1: General rules, seismic actions and rules for buildings*

EN 10222-1:1998, EN 10222-1:1998/A1:2002, *Steel forgings for pressure purposes — Part 1: General requirements for open die forgings*

EN 13445-1:2014, *Unfired pressure vessels — Part 1: General*

EN 13445-2:2014, *Unfired pressure vessels — Part 2: Materials*

EN 13445-4:2014, *Unfired pressure vessels — Part 4: Fabrication*

EN 13445-5:2014, *Unfired pressure vessels — Part 5: Inspection and testing*

EN 13445-8:2014, *Unfired pressure vessels — Part 8: Additional requirements for pressure vessels of aluminium and aluminium alloys*

EN ISO 4014:2011, *Hexagon head bolts — Product grades A and B (ISO 4014:2011)*

EN ISO 4016:2011, *Hexagon head bolts — Product grade C (ISO 4016:2011)*

EN ISO 15613:2004, *Specification and qualification of welding procedures for metallic materials — Qualification based on pre-production welding test*

ISO 261:1998, *ISO general purpose metric threads — General plan*

### 3 Terms and definitions

For the purposes of this Part of this European Standard, the terms and definitions given in EN 13445-1:2014, EN 13445-2:2014 and the following apply:

NOTE EN 13445-1:2014 and EN 13445-2:2014 have adopted terminology, symbols and definitions of EN 764-1:2004, EN 764-2:2012 and EN 764-3:2002.

#### 3.1 action

imposed thermo-mechanical influence which causes stress and/or strain in a structure, e.g. an imposed pressure, force, temperature

#### 3.2 analysis thickness

effective thickness available to resist the loading depending on the load case, see 5.3.2

#### 3.3 assumed thickness

thickness assumed by the designer between the minimum required shell thickness  $e$  and the shell analysis thickness  $e_a$

#### 3.4 calculation pressure

differential pressure used for the purpose of the design calculations for a component  
[EN 764-1:2004]

#### 3.5 calculation temperature

temperature used for the purpose of the design calculations for a component  
[EN 764-1:2004]

#### 3.6 chamber

fluid space within a unit of pressure equipment  
[EN 764-1:2004]

#### 3.7 component

part of pressure equipment which can be considered as an individual item for the calculation  
[EN 764-1:2004]

**EN 13445-3:2014 (E)**  
**Issue 5 (2018-07)****3.8****creep range**

temperature range in which material characteristics used in design are time dependent

NOTE See also 5.1.

**3.9****cryogenic applications**

applications involving liquefied gases at low temperature

**3.10****design pressure**

pressure at the top of each chamber of the pressure equipment chosen for the derivation of the calculation

pressure of each component

[EN 764-1:2004]

NOTE Any other location may be specified.

**3.11****design temperature**

temperature chosen for the derivation of the calculation temperature of each component

[EN 764-1:2004]

**3.12****differential pressure**

pressure which algebraic value is equal to the pressure difference on either side of a separation wall

[EN 764-1:2004]

**3.13****governing weld joint**

main full penetration butt joint the design of which, as a result of membrane stresses, governs the thickness of the component

**3.14****load case**

combination of coincident actions

**3.15****main joint**

weld joint assembling main pressure bearing parts

**3.16****maximum permissible pressure**

maximum pressure obtained from the design by formulae or relevant procedures of EN 13445-3:2014 for a given component in a given load case, or for the whole pressure vessel the minimum of these maximum permissible pressures of all components

NOTE 1 The differences of the nominal design stress  $f$ , the analysis thickness  $e_a$  and the joint coefficient  $z$  for the calculation of the maximum permissible pressure in different load cases are specified in 5.3.2.

NOTE 2 If no explicit formula is given for the maximum permissible pressure  $P_{max}$  then  $P_{max}$  may be calculated as pressure which gives the required thickness equal to the analysis thickness.

NOTE 3 The maximum permissible pressure  $P_{max}$  used for the simplified assessment of fatigue life in Clause 17 and for the calculation of the equivalent full pressure in 5.4.2 is calculated for normal operating load cases.

**3.17****minimum possible fabrication thickness**

minimum possible thickness after fabrication

**3.18****nominal design stress**

stress value to be used in the formulae for the calculation of pressure components

**3.19****nominal thickness**

thickness as specified on the drawings

**3.20****test pressure**

pressure to which the equipment is subjected for test purposes

[EN 764-1:2004]

**3.21****test temperature**

temperature at which the pressure test of the pressure equipment is carried out

[EN 764-1:2004]

**3.22****volume**

internal volume of a chamber, including the volume of nozzles to the first connection (flange, coupling, weld) and excluding the volume of internal permanent parts (e.g. baffles, agitators)

[EN 764-1:2004]

**3.23****weld throat thickness of a fillet weld**

height of the inscribed isosceles triangle measured from the theoretical root point

## 4 Symbols and abbreviations

For the purposes of this Part of this European Standard, the general symbols and abbreviations shall be in accordance with EN 13445-1:2014, EN 13445-2:2014 and Table 4-1:

Table 4-1 — Symbols, quantities and units <sup>c</sup>

Symbol	Quantity	Unit
$a$	weld throat thickness	mm
$e$	required thickness	mm
$e_n$	nominal thickness	mm
$e_{min}$	minimum possible fabrication thickness	mm
$e_a$	analysis thickness	mm
$c$	corrosion allowance	mm
$f$	nominal design stress	MPa
$f_d$	maximum value of the nominal design stress for normal operating load cases	MPa
$f_{exp}$	maximum value of the nominal design stress for exceptional load cases	MPa
$f_{test}$	maximum value of the nominal design stress for testing load cases	MPa
$n_{eq}$	number of equivalent full pressure cycles (see 5.4.2)	-
$P$	calculation pressure	MPa <sup>a</sup>
$P_d$	design pressure	MPa <sup>a</sup>
$P_{max}$	maximum permissible pressure	MPa <sup>a</sup>
$PS, P_s$	maximum allowable pressure	MPa <sup>a</sup>
$P_{test}$	test pressure	MPa <sup>a</sup>
$R_{eH}$	upper yield strength	MPa
$R_m$	tensile strength	MPa
$R_{m/T}$	tensile strength at temperature $T$	MPa
$R_{p0,2}$	0,2 % proof strength	MPa
$R_{p0,2/T}$	0,2 % proof strength at temperature $T$	MPa
$R_{p1,0}$	1,0 % proof strength	MPa
$R_{p1,0/T}$	1,0 % proof strength at temperature $T$	MPa
$T$	calculation temperature	°C
$T_d$	design temperature	°C
$T_{test}$	test temperature	°C
$TS_{max}, TS_{min}$	maximum/minimum allowable temperatures	°C
$V$	volume	mm <sup>3</sup> <sup>b</sup>
$Z$	joint coefficient	—
$\nu$	Poisson's ratio	—

<sup>a</sup> MPa for calculation purpose only, otherwise the unit may be bar (1 MPa = 10 bar).

<sup>b</sup> mm<sup>3</sup> for calculation purpose only, otherwise the unit should be litre.

<sup>c</sup> Formulae used in this standard are dimensional.



## 5 Basic design criteria

### 5.1 General

EN 13445-3:2014 is applicable only when:

- a) materials and welds are not subject to localized corrosion in the presence of products which the vessel is to contain or which can be present in the vessel under reasonably foreseeable conditions.
- b) either all calculation temperatures are below the creep range **or** a calculation temperature is in the creep range and time dependent material characteristics are available in the materials standard.

NOTE See definition 3.8 of creep range.

For the purpose of design, the creep range is the temperature range in which time independent material characteristics are no more governing in the determination of the nominal design stress.

The material strength characteristics used shall be related to the specified lifetimes in the various creep load cases

### 5.2 Corrosion, erosion and protection

#### 5.2.1 General

Whenever the word "corrosion" is used in this standard it shall be taken to mean corrosion, oxidation, scaling, abrasion, erosion and all other forms of wastage.

NOTE 1 Stress corrosion cracking may occur under certain conditions of temperature and environment. A corrosion allowance is not an appropriate way of dealing with stress corrosion. Under such conditions, consideration shall be given to the materials used and the residual stresses in the fabricated vessel.

NOTE 2 It is impossible to lay down definite precautionary guidelines to safeguard against the effects of corrosion owing to the complex nature of corrosion itself, which may occur in many forms, including but not limited to the following:

- chemical attack where the metal is dissolved by the reagents. It may be general over the whole surface or localized (causing pitting) or a combination of the two;
- rusting caused by the combined action of moisture and air;
- erosion corrosion where a reagent otherwise innocuous flows over the surface at velocity greater than some critical value;
- high temperature oxidation (scaling).

Consideration should be given to the effect which corrosion (both internal and external) may have upon the useful life of the vessel. When in doubt, corrosion tests should be undertaken. These should be carried out on the actual metal (including welds or combination of metals) under exposure to the actual chemicals used in service. Corrosion tests should be continued for a sufficiently long period to determine the trend of any change in the rate of corrosion with respect to time.

NOTE 3 It is very dangerous to assume that the major constituent of a mixture of chemicals is the active agent, as in many cases small traces of a substance can exert an accelerating or inhibiting effect out of all proportion to the amount present. Fluid temperatures and velocities from corrosion test data should be equivalent to those met in operation.

**5.2.2 Additional thickness to allow for corrosion**

In all cases where reduction of the wall thickness is possible as a result of surface corrosion or erosion, of one or other of the surfaces, caused by the products contained in the vessel or by the atmosphere, a corresponding additional thickness sufficient for the design life of the vessel components shall be provided. The value shall be stated on the design drawing of the vessel. The amounts adopted shall be adequate to cover the total amount of corrosion expected on either or both surfaces of the vessel.

A corrosion allowance is not required when corrosion can be excluded, either because the materials, including the welds, used for the pressure vessel walls are corrosion resistant relative to the contents and the loading or are reliably protected (see 5.2.4).

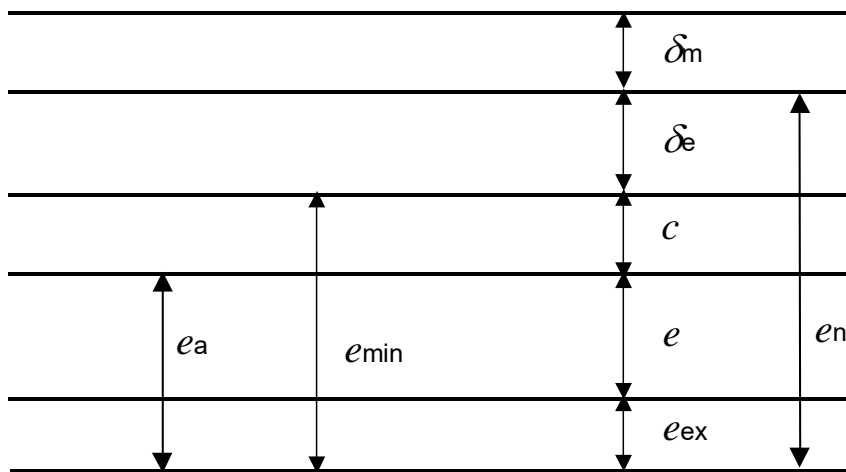
No corrosion allowance is required for heat exchanger tubes and other parts in similar heat exchanger duty, unless a specific corrosive environment requires one.

This corrosion allowance does not ensure safety against the risk of deep corrosion or stress corrosion cracking, in these cases a change of material, cladding, etc. is the appropriate means.

Where deep pitting may occur, suitably resistant materials shall be selected, or protection applied to the surfaces.

**5.2.3 Inter-relation of thickness definitions**

The inter-relation of the various definitions of thickness is shown in Figure 5-1.



**Key**

- $e$  is the required thickness;
- $e_n$  is the nominal thickness;
- $e_{min}$  is the minimum possible fabrication thickness ( $e_{min} = e_n - \delta_e$ );
- $e_a$  is the analysis thickness ( $e_a = e_{min} - c$ );
- $c$  is the corrosion allowance;
- $\delta_e$  is the absolute value of the possible negative tolerance on the nominal thickness (e.g. taken from the material standards);
- $\delta_m$  is the allowance for possible thinning during manufacturing process;
- $e_{ex}$  is the extra thickness to make up to the nominal thickness.

**Figure 5-1 — Relationship of thickness definitions**

#### 5.2.4 Linings and coatings

Only completely impervious, sufficiently thick and chemically stable layers with an average life not less than that of the pressure vessel shall be considered to be reliable protection against corrosion, but thin layers (like painting, electroplating, tinning, etc.) and coatings which are known to have to be renewed during the lifetime of the pressure vessel components shall not be used. For plastic coatings the suitability shall be justified, taking into account, among other factors, the risk of diffusion. The test of corrosion protection outlined in EN 286-2:1992 is not considered to be adequate for the pressure vessels covered by this standard.

Vessels may be fully or partially lined (or coated) with corrosion-resistant material. Linings should be integrally bonded to the vessel base metal. Loose or intermittently attached linings may be used taking the following into consideration:

- sufficient ductility of the lining to accommodate any strain likely to be imposed on it during service and testing conditions, differential thermal expansion being taken into consideration;
- for non-metallic coatings, the surface finish of the base material.

Provided contact between the corrosive agent and the vessel base material is excluded, no corrosion allowance needs be provided against internal wastage of the base material.

#### 5.2.5 Wear plates

Where severe conditions of erosion and abrasion arise, local protective or wear plates shall be fitted directly in the path of the impinging material.

### 5.3 Load cases

#### 5.3.1 Actions

In the design of a vessel the following actions shall be taken into account, where relevant:

- a) internal and/or external pressure;
- b) maximum static head of contained fluid under operating conditions;
- c) weight of the vessel;
- d) maximum weight of contents under operating conditions;
- e) weight of water under hydraulic pressure test conditions;
- f) wind, snow and ice loading;
- g) earthquake loading;
- h) other loads supported by or reacting on the vessel, including loads during transport and installation.

When necessary, consideration shall be given to the effect of the following loads in cases where it is not possible to demonstrate the adequacy of the proposed design e.g. by comparison with the behaviour of other vessels:

- i) stresses caused by supporting lugs, ring, girders, saddles, internal structures or connecting piping or intentional offsets of median lines on adjacent components;