# SLOVENSKI STANDARD
# SIST EN 15776:2011+A1:2016

**01-januar-2016**

**Nadomešča:**
**SIST EN 15776:2011**

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**Neogrevane tlačne posode - Zahteve za konstruiranje in izdelavo tlačnih posod in njihovih delov iz litega železa z raztezkom ob porušitvi, enakim ali manjšim kot 15 %**

Unfired pressure vessels - Requirements for the design and fabrication of pressure vessels and pressure parts constructed from cast iron with an elongation after fracture equal or less than 15 %



Unbefeuerte Druckbehälter - Anforderungen an die Konstruktion und Herstellung von Druckbehältern und Druckbehälterteilen aus Gusseisen mit einer Bruchdehnung von 15 % oder weniger



Récipients sous pression non soumis à la flamme - Exigences supplémentaires pour la conception et la fabrication des récipients sous pression et des parties sous pression moulés en fonte à allongement, après rupture, inférieur ou égal à 15 %

**Ta slovenski standard je istoveten z:** **EN 15776:2011+A1:2015**

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**ICS:**

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| 23.020.30 | Tlačne posode, plinske jeklenke | Pressure vessels, gas cylinders |
| 77.140.80 | Železni in jekleni ulitki | Iron and steel castings |

**SIST EN 15776:2011+A1:2016** **en,fr,de**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

# EN 15776:2011+A1

October 2015

ICS 23.020.30

Supersedes EN 15776:2011

English Version

# Unfired pressure vessels - Requirements for the design and fabrication of pressure vessels and pressure parts constructed from cast iron with an elongation after fracture equal or less than 15 %

Récipients sous pression non soumis à la flamme - Exigences supplémentaires pour la conception et la fabrication des récipients sous pression et des parties sous pression moulés en fonte à allongement, après rupture, inférieur ou égal à 15 %

Unbefeuerte Druckbehälter - Anforderungen an die Konstruktion und Herstellung von Druckbehältern und Druckbehälterteilen aus Gusseisen mit einer Bruchdehnung von 15 % oder weniger

This European Standard was approved by CEN on 1 January 2011 and includes Amendment 1 approved by CEN on 24 August 2015.

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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

**CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels**



Ref. No. EN 15776:2011+A1:2015 E

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## European foreword

This document (EN 15776:2011+A1:2015) 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 April 2016, and conflicting national standards shall be withdrawn at the latest by April 2016.

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 supersede EN 15776:2011.

This document includes Amendment 1 approved by CEN on 2015-08-24.

The start and finish of text introduced or altered by amendment is indicated in the text by tags ▌A1〉 〈A1▐.

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.



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, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

## Introduction

〚A1〛 This standard is a stand-alone document and may be used for pressure equipment with certain restrictions and limitations.

NOTE For the design and fabrication of cast iron pressure equipment standards with higher elongations and ductility, see EN 13445-6:2014. 〈A1〛

Attention is drawn to the references to 〚A1〛 EN 13445-6:2014 〈A1〛for design and fabrication according to specific grades of material standards 〚A1〛 EN 1563:2011 〈A1〛and 〚A1〛 EN 13835:2012 〈A1〛which are found in some clauses of this standard, EN 15776. Requirements for the design, material, manufacturing and testing of pressure vessels and pressure vessel parts made from ferritic or austenitic spheroidal graphite cast iron grades with an elongation after fracture higher than 15 % are given in 〚A1〛 EN 13445-6:2014 〈A1〛.

Cast iron with elongation after fracture equal or less than 15 % may only be used for pressure equipment when operational and technical advantages are dictating its use instead of the cast iron grades given in 〚A1〛 EN 13445-6:2014 〈A1〛with elongation after fracture higher than 15 %.

## 1 Scope

This European Standard specifies requirements for the design, material, manufacturing and testing of pressure vessels and pressure vessel parts made from materials for which details are specified from the following material standards for specific grades which meet the criterion of an elongation after fracture less than or equal to 15 %:

— ⟨A1⟩ EN 1561:2011 ⟨A1⟩, *Founding — Grey cast irons*;

— ⟨A1⟩ EN 1563:2011 ⟨A1⟩, *Founding — Spheroidal graphite cast irons*;

— ⟨A1⟩ EN 13835:2012 ⟨A1⟩, *Founding — Austenitic cast irons*.

The allowed content of the vessel or pressure part is a fluid of group 2 only, according to the Directive 97/23/EC.

## 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.

⟨A1⟩ EN 764-5:2014, *Pressure equipment — Part 5: Inspection documentation of metallic materials and compliance with the material specification* ⟨A1⟩



⟨A1⟩ EN 1370:2011, *Founding — Examination of surface condition* ⟨A1⟩



⟨A1⟩ EN 1371-1:2011, *Founding — Liquid penetrant testing — Part 1: Sand, gravity die and low pressure die castings* ⟨A1⟩

⟨A1⟩ EN 1559-1:2011 ⟨A1⟩, *Founding — Technical conditions of delivery — Part 1: General*

⟨A1⟩ EN 1559-3:2011 ⟨A1⟩, *Founding — Technical conditions of delivery — Part 3: Additional requirements for iron castings*

⟨A1⟩ EN 1561:2011 ⟨A1⟩, *Founding — Grey cast irons*

⟨A1⟩ EN 1563:2011 ⟨A1⟩, *Founding — Spheroidal graphite cast irons*

⟨A1⟩ EN 12680-3:2011, *Founding — Ultrasonic testing — Part 3: Spheroidal graphite cast iron castings* ⟨A1⟩

⟨A1⟩ EN 13445-3:2014 ⟨A1⟩, *Unfired pressure vessels — Part 3: Design*

⟨A1⟩ EN 13445-5:2014 ⟨A1⟩, *Unfired pressure vessels — Part 5: Inspection and testing*

⟨A1⟩ EN 13445-6:2014 ⟨A1⟩, *Unfired pressure vessels — Part 6: Requirements for the design and fabrication of pressure vessels and pressure parts constructed from spheroidal graphite cast iron*

⟨A1⟩ EN 13835:2012 ⟨A1⟩, *Founding — Austenitic cast irons*

⟨A1⟩ EN ISO 8062-3:2007 ⟨A1⟩, *Geometrical Product Specifications (GPS) — Dimensional and geometrical tolerances for moulded parts — Part 3: General dimensional and geometrical tolerances and machining allowances for castings (ISO 8062-3:2007)*

# 3 Terms, definitions, units and symbols

## 3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

**3.1.1**
**grey cast iron**
cast material, mainly iron and carbon based, carbon being present mainly in the form of flake (lamellar) graphite particles (〈A1〉 EN 1561:2011 〈A1〉)

〈A1〉 Note 1 to entry: 〈A1〉 Grey cast iron is also known as flake graphite cast iron, and less commonly as lamellar graphite cast iron.

〈A1〉 Note 2 to entry: Grey cast irons contain 2,0 % - 4,5 % carbon and 1 % - 3 % silicon. The structure consists of branched and interconnected graphite flakes in a matrix which is pearlite, ferrite or a mixture 〈A1〉

**3.1.2**
**spheroidal graphite cast iron**
cast material, mainly iron and carbon-based, the carbon being present mainly in the form of spheroidal graphite particles (〈A1〉 EN 1563:2011 〈A1〉)

〈A1〉 Note 1 to entry: 〈A1〉 Spheroidal graphite cast iron is also known as ductile iron, and less commonly as nodular iron.



〈A1〉 Note 2 to entry: The mechanical properties of grey irons can be greatly improved if the graphite shape is modified if molten iron, having a composition in the range 3,2 % - 4,5 % carbon and 1,8 % - 2,8 % silicon, is treated with magnesium. This produces castings with graphite in spheroidal form instead of flakes, known as nodular, spheroidal graphite or ductile iron. Nodular irons are available with pearlite, ferrite or pearlite-ferrite matrices which offer a combination of greater ductility and higher tensile strength than grey cast irons. 〈A1〉



**3.1.3**
**austenitic cast iron**
〈A1〉 cast material with an austenitic matrix which is iron and carbon and silicon based and alloyed with nickel and manganese, copper and/or chromium in order to stabilize the austenitic structure at room temperature

Note 1 to entry: The graphite can be present in flake or spheroidal form (EN 13835:2012). 〈A1〉

**3.1.4**
**relevant wall thickness**
〈A1〉 wall thickness representative of the casting, defined for the determination of the size of the cast samples to which the guaranteed mechanical properties apply 〈A1〉

**3.1.5**
**critical zone**
highly stressed area where a fracture is expected to occur in a burst test

NOTE 1 It can be caused, for example, by any of the following:

— sudden change in cross section;

— sharp edges;

— sharp radii;

— peak stresses;

— bending stresses;

— stresses due to other than membrane stress;

— changes in curvature.

NOTE 2 A critical zone is analysed by any appropriate method, e.g. holographic, interferometric method, strain gauge methods, burst test, fatigue testing, FEM analysis, etc.

NOTE 3 Additionally, thermal gradients and thermal stresses due to different operating wall temperatures are to be considered in defining critical zones.

**3.1.6**
**purchaser**
individual or organisation that buys pressure equipment, including assemblies or parts, for its own use or on behalf of the user and/or operator

**3.1.7**
**manufacturer**
individual or organisation responsible for the design, fabrication, testing, inspection, installation of pressure equipment and assemblies where relevant

NOTE 1 The manufacturer may subcontract one or more of the above mentioned tasks under its responsibility.



**3.1.8**
**casting manufacturer**
subcontractor that produces the castings used in the manufacture of pressure equipment



**3.1.9**
**temperature factor**
reduction factor applied to the 0,2 % proof strength to take account of temperature influence

**3.1.10**
**wall thickness factor**
reduction factor applied to the nominal design stress to take account of reduced mechanical properties

**3.1.11**
**stress factor**
ratio of peak stress to total stress

**3.1.12**
**total stress**
total stress in a design model which includes all stress concentration effects, non-local and local

## 3.2 Symbols

〈A1〉 For the purposes of this document, symbols used in EN 13445-6:2014 are listed in Table 1. 〈A1〉

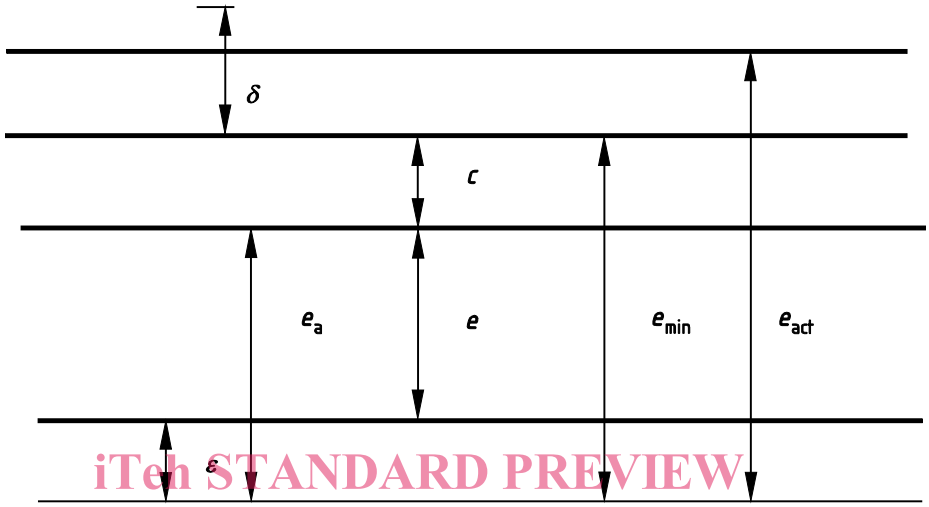
**Table 1 — Symbols**

| Symbol | Quantity | Unit |
|---|---|---|
| $c$ | corrosion allowance | mm |
| $e$ | required thickness | mm |
| $e_a$ | analysis thickness | mm |
| $e_{act}$ | actual thickness | mm |
| $e_{max}$ | maximum local thickness at the location of a possible fatigue crack initiation | mm |
| $e_{min}$ | minimum thickness as specified on drawing | mm |
| $f$ | nominal design stress | MPa |
| $f_e$ | thickness correction factor | |
| $f_m$ | mean stress correction factor | |
| $f_{test}$ | nominal design stress for testing condition | MPa |
| $f_T$ | temperature correction factor | |
| $f_s$ | surface finish correction factor | |
| $m_C$ | exponent in equation of fatigue design curve | |
| $n$ | shell shape factor | |
| $n_{eq}$ | number of equivalent full pressure cycles | |
| $T, T_c$ | calculation temperature | °C |
| $A, A_5$ | minimum elongation after fracture | % |
| $C_C$ | coefficient in equation of fatigue design curve | |
| $C_e$ | wall thickness reduction factor | |
| $C_T$ | temperature reduction factor | |
| $E$ | modulus of elasticity | MPa |
| $F$ | test factor used in experimental fatigue assessment | |
| $K_{eff}$ | effective stress concentration factor | |
| $K_t$ | theoretical elastic stress concentration factor | |
| $M$ | mean stress sensitivity factor | MPa |
| $m_c$ | value from appropriate Tables 10, 11, 13, 14 in the appropriate number of cycle number range used in fatigue calculations | |
| $N$ | total number of envisaged types of pressure cycles with different amplitude | |
| $N_{all}$ | allowable number of cycles obtained from the fatigue design curve | |

| Symbol | Quantity | Unit |
|---|---|---|
| $N_{min}$ | minimum number of cycles obtained in experimental fatigue assessment | |
| $n_i$ | number of cycles with amplitude $\Delta P_i$ | |
| $PC, p_c$ | calculation pressure | MPa [a] |
| $P_b$ | burst test pressure | MPa [a] |
| $P_{b,act}$ | actual burst test pressure | MPa [a] |
| $PD, p_d$ | design pressure | MPa [a] |
| $P_{max}$ | maximum permissible pressure [b] | MPa [a] |
| $PS, p_s$ | maximum allowable pressure [b] | bar [a] |
| $PT, p_t$ | test pressure [b] | MPa |
| $R_m$ | minimum tensile strength | MPa |
| 〚A1〛 *deleted text* 〚A1〛 | | |
| $R_{p0,2}$ | minimum 0,2 % - proof strength | MPa |
| $R_{p0,2/T}$ | minimum 0,2 % - proof strength at temperature $T$ in degrees Celsius | MPa |
| $R_z$ | surface roughness parameter – peak – to - valley height | µm |
| $RM$ | material strength parameter | MPa |
| 〚A1〛 $RM3$ | average strength from 3 tensile test samples | MPa 〚A1〛 |
| $S$ | safety factor | |
| $TS_{max}$, $TS_{min}$ | maximum / minimum allowable temperature | °C |
| $V$ | volume | L |
| $\Delta P$ | pressure range | MPa [a] |
| $\Delta P_i$ | pressure cycle amplitude | |
| $\Delta\sigma$ | allowable stress range | MPa |
| $\Delta\sigma^*$ | pseudo elastic stress range | MPa |
| $\Delta\sigma_{Cut}$ | cut-off limit | MPa |
| $\Delta\sigma_D$ | endurance limit | MPa |
| $\Delta\sigma_{eq,struc}$ | structural stress range | MPa |
| $\Delta\sigma_R$ | stress range in fatigue design curve | MPa |
| $\delta$ | casting tolerance | mm |
| $\varepsilon$ | extra thickness due to casting process | mm |
| $\gamma_R$ | partial safety factor | |
| $\eta$ | Stress factor | |
| $\nu$ | Poisson's ratio | |

| Symbol | Quantity | Unit |
|---|---|---|
| $\sigma_e$ | nominal design stress for external pressure | MPa |
| [a] MPa for calculation purposes only, otherwise the unit shall be bar (1 MPa = 10 bar). | | |
| [b] See also A1 EN 13445-3:2014 A1, Table 4-1. | | |

### 3.3 Inter relation of thicknesses definitions (A1 EN 13445-6:2014 A1)






**Key**

$e$ required thickness

$e_a$ analysis thickness

$e_{min}$ minimum thickness including corrosion allowance as indicated on drawings

$e_{act}$ actual thickness

$c$ corrosion allowance

$\varepsilon$ extra thickness due to casting process

$\delta$ casting tolerance



**Figure 1**

## 4 Materials, limitations and service conditions

### 4.1 Materials and limitations on temperature, maximum allowable pressure and energy content

A1 All material grades subject to internal or external pressure shall comply with EN 1561:2011 for grey cast iron, EN 1563:2011 for spheroidal graphite cast iron and EN 13835:2012 for austenitic cast iron. The material grades and corresponding limitations are given in Table 2 and Table 3.