



**SLOVENSKI STANDARD**  
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**Nadomešča:**  
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**Neogrevane tlačne posode - 9. del: Primerjava serije EN 13445 z ISO 16528**

Unfired pressure vessels - Part 9: Conformance of the EN 13445 series to ISO 16528

Unbefeuerte Druckbehälter - Gegenüberstellung der EN 13445 Normenreihe und ISO 16528

Réceptifs sous pression non soumis à la flamme - Partie 9 : Conformité de la série EN 13445 à l'ISO 16528

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**ICS:**

23.020.30	Tlačne posode, plinske jeklenke	Pressure vessels, gas cylinders
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TECHNICAL REPORT  
RAPPORT TECHNIQUE  
TECHNISCHER BERICHT

**CEN/TR 13445-9**

June 2011

ICS 23.020.30

Supersedes CEN/TR 13445-9:2007

English Version

**Unfired pressure vessels - Part 9: Conformance of the EN 13445  
series to ISO 16528**

Réceptifs sous pression non soumis à la flamme - Partie 9  
: Conformité de la série EN 13445 à l'ISO 16528

Unbefeuerte Druckbehälter - Gegenüberstellung der EN  
13445 Normenreihe und ISO 16528

This Technical Report was approved by CEN on 3 April 2011. It has been drawn up by the Technical Committee CEN/TC 54.

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## Foreword

This document (CEN/TR 13445-9:2011) has been prepared by Technical Committee CEN/TC 54 "Unfired pressure vessels", the secretariat of which is held by BSI.

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 supersedes CEN/TR 13445-9:2007.

The main differences between this edition and CEN/TR 13445-9:2007 are:

- a) updating on the basis of the 2009 edition of EN 13445;
- b) inclusion of full details for the following failure modes: creep rupture, creep - excessive deformations at mechanical joints or resulting in unacceptable transfer of load, creep instability

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**CEN/TR 13445-9:2011 (E)****1 Scope**

This CEN Technical Report details the conformance of the EN 13445 series for "Unfired pressure vessels" to ISO 16528-1 "Boilers and pressure vessels – Part 1: Performance requirements".

This Technical Report applies to vessels of steel construction.

It is envisaged that future editions will include spheroidal graphite cast iron and aluminium vessels.

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## 2 Failure mode summary

Table 1 — Failure mode summary

STANDARD <sup>a</sup> : Unfired pressure vessels EN 13445:2009 Parts 1 to 5 and CR 13445-7	
FAILURE MODE SUMMARY <sup>b</sup>	
Failure modes according to ISO 16528-1 clause 6.2	Addressed (Y / N / P) <sup>c</sup>
Brittle fracture	Y
Ductile rupture	Y
Leakage at joints	Y
Elastic or plastic instability	Y
Creep rupture	Y
Additional failure modes according to ISO 16528-1 clause 6.1	Addressed (Y / N / P) <sup>c</sup>
Crack formation or ductile tearing due to excessive local strains	Y
Creep – excessive deformations at mechanical joints, or resulting in unacceptable transfer of load	Y
Creep instability	Y
Erosion, corrosion	P
Environmentally assisted cracking, e.g. stress corrosion cracking, hydrogen induced cracking, etc.	P
Progressive plastic deformation	Y
Alternating plasticity	Y
Fatigue under elastic strains (medium and high cycle fatigue) or under elastic-plastic strains (low cycle fatigue)	Y
Environmentally assisted fatigue	P
<p><sup>a</sup> Provide full title of the standard and revision or addenda level.</p> <p><sup>b</sup> Failure modes addressed by this form (see ISO 16528-1).</p> <p><sup>c</sup> Y – failure mode addressed by standard N – failure mode not addressed by standard P – failure mode recognized but details not addressed.</p>	

## 3 Detailed failure mode checklists

Table 2 — Detailed failure mode checklists

<b>STANDARD : Unfired pressure vessels EN 13445:2009</b>
<b>FAILURE MODE <sup>a</sup> : Brittle fracture</b>
<b>EXPLICIT DESIGN <sup>d</sup></b>
<p><b>References <sup>b</sup> :</b></p> <p>EN 13445-2:2009 Unfired pressure vessels – Part 2: Materials Annex B "Requirements for prevention of brittle fracture" Method 1 and Method 2</p>
<p><b>Comments <sup>c</sup> :</b></p> <p><b>Method 1</b></p> <p>a) Technical requirements based on the choice of <math>T_R = T_{27J}</math> as specified in harmonised European Material Standards and on the assumption that it is possible to achieve these minimum properties after fabrication. Calculated from the principles of fracture mechanics used for method 2 for C and CMn steels with yield strength &lt; 460 MPa and</p> <p>b) based on operating experience for Ni-alloyed steels with Ni <math>\geq 3</math> % up to 9 %, for austenitic steels and for bolts and nuts.</p> <p><b>Method 2</b></p> <p>Method developed from the principles of fracture mechanics and from operating experiences.</p> <p>A more flexible approach than method 1 for derivation of technical requirements applicable to C, CMn and low alloy ferritic steels with a specified minimum yield strength <math>\leq 500</math> MPa and for austenitic-ferritic steels with a specified minimum yield strength <math>\leq 550</math> MPa. This method can be applied for these steels to a wider range of thicknesses and temperatures than method 1 because <math>T_R</math> shall not be equal to <math>T_{27J}</math> (see Figures B.2-1 to B.2-11). In addition, for ferritic steels with max 355 MPa in PWHT condition operation experience was considered for higher thicknesses.</p>
<b>IMPLICIT DESIGN</b>
<p><b>References:</b></p> <p>EN 13445-2:2009 Unfired pressure vessels – Part 2: Materials Annex B "Requirements for prevention of brittle fracture" Method 3.</p>
<p><b>Comments:</b></p> <p>Method 3 is the application of a fracture mechanics analysis.</p>



<b>FABRICATION DETAILS<sup>e</sup></b>
<p><b>References:</b></p> <p>Design requirements for construction details are given in:  <b>EN 13445-3:2009 Unfired pressure vessels – Part 3: Design</b>  and in Annex A "Design requirements for pressure bearing welds" of this Part.</p> <p>Manufacturing tolerances are given in:  <b>EN 13445-4:2009 Unfired pressure vessels – Part 4: Fabrication</b>  Clause 5: "Manufacturing tolerances"</p>
<p><b>Comments:</b></p> <p>Reference thickness is given in:  <b>EN 13445-2:2009 Unfired pressure vessels – Part 2: Materials</b>  Annex B "Requirements for prevention of brittle fracture"  Table B.4-1: "Reference thickness"</p>
<b>MATERIAL REQUIREMENTS<sup>f</sup></b>
<p><b>References:</b></p> <p><b>EN 13445-2:2009 Unfired pressure vessels – Part 2: Materials</b>  Clause 4.1.6: Specified minimum impact energy measured on a Charpy-V-notch specimen at a test temperature in accordance with Annex B.</p> <p><b>EN 13445-4:2009 Unfired pressure vessels – Part 4: Fabrication</b>  Clause 8: "Manufacture and testing of welds – Production test"  Testing of coupon plates with the same required impact energy as above.</p>
<p><b>Comments:</b></p> <p>Impact requirements are also specified for sub-sized Charpy-V-notch specimen if the base material is less than 10 mm thick.</p>
<b>EXAMINATION REQUIREMENTS<sup>g</sup></b>
<p><b>References:</b></p> <p><b>EN 13445-5:2009 Unfired pressure vessels – Part 5: Inspection and testing</b>  Clause 6: "Inspection and testing during fabrication", 6.6 "Non-destructive testing of welded joints".</p>
<p><b>Comments:</b></p> <p>There are four testing (examination) groups: 1 (full NDE), 2 (full NDE and reduction with successful experience, fully mechanised and/or automatic welding process), 3 (spot testing), 4 (visual examination only and higher test pressure).</p> <p>Acceptance criteria are based on EN ISO 5817:2007, level C (level B in critical areas when vessels are subjected to cyclic loads, see Annex G of EN 13445-5:2009).</p>

<b>TESTING REQUIREMENTS<sup>h</sup></b>
<p><b>References:</b></p> <p><b>EN 13445-5:2009 Unfired pressure vessels – Part 5: Inspection and testing Clause 10: "Final assessment", 10.2.3 "Proof test".</b></p>
<p><b>Comments:</b></p> <p><b>Higher pressure test for vessels with visual NDE only.</b></p>
<b>USE / FAILURE HISTORY<sup>i</sup></b>
<p><b>References:</b></p>
<p><b>Comments:</b></p> <p style="text-align: center; color: red; font-weight: bold; font-size: 1.2em;">iTeh STANDARD PREVIEW (standards.iteh.ai)</p>
<p>a Failure mode addressed by this form (See Table 1).</p> <p>b Provide specific clause or paragraph references (including the title, if any) indicating where relevant rules can be found. These references need not be exhaustive, but should be detailed enough to establish that the standard adequately addresses the selected failure mode.</p> <p>c Provide explanatory comments indicating the background for the approach employed or other material that might be useful. For example, brief description of failure theor(ies) used should be provided. References to academic papers and empirical testing methods used to establish rules are encouraged.</p> <p>d Reference(s) to rules or requirements that directly affect how the standard addresses the selected failure mode, e.g. formulas for sizing wall thickness of components for resisting ductile burst.</p> <p>e This section may be used to provide references and comments when design tables, empirically based rules or other approaches are employed whose derivation is not obvious. It may also be used to provide general information on design margins (safety factors) on material properties, etc. Many successful standards do not provide explicit design rules for certain failure modes yet do employ combinations of material control, temperature limits or other means to provide adequate protection against failure. This section may be used to provide information on how his standard indirectly addresses certain failure modes when explicit rules are not provided.</p> <p>f References for fabrication details relevant to the selected failure mode, e.g. control of cylinder ovality, weld profiling, control of tolerances, etc. For example, control of cylinder ovality is important for prevention of buckling of externally loaded vessels. This section should be used to describe such fabrication controls relevant for the designated failure mode.</p> <p>g Relevant requirements for base and welding materials, e.g. control of YS/UTS ratios, provisions for addressing strain hardening, applications of heat treatment, etc. Assuring that fabrication processes have not adversely affected material properties beyond acceptable limits can be important for preventing certain types of failures. This section should be used to describe such controls.</p> <p>h References for NDT or visual inspection relevant to the selected failure mode. (If NDT is correlated to design factors, this should be noted).</p> <p>i Provisions for final testing, i.e. hydrostatic or leak tests should be noted with specific information on normal test pressures and control of test lower and upper test pressures.</p> <p>j An explanation shall be provided defining the limitations in the standard's scope or application relative to ISO 16528-1:2007, Clause 6.2 failure mode(s) not addressed. References to data quantifying failure rates and other relevant experience may be provided. Likely sources include regulatory authorities, trade associations and insurers.</p>

<b>STANDARD</b> : Unfired pressure vessels EN 13445:2009
<b>FAILURE MODE</b> <sup>a</sup> : Ductile rupture
<b>EXPLICIT DESIGN</b> <sup>d</sup>
<b>References</b> <sup>b</sup> :  EN 13445-3:2009 Unfired pressure vessels – Part 3: Design Clause 6: "Maximum allowed values of the nominal design stress for pressure parts"
<b>Comments</b> <sup>c</sup> :
<b>IMPLICIT DESIGN</b> <sup>d</sup>
<b>References:</b>  EN 13445-3:2009 Unfired pressure vessels – Part 3: Design Annex B "Design by Analysis – Direct Route", Clause B.8.2: "Gross Plastic Deformation" Annex C "Design by Analysis – Method based on stress categories"
<b>Comments:</b>  In Annex B, limit analysis is used. For ferritic steels, this analysis allows the use of a reduced safety factor versus the tensile strength at 20 °C.
<b>FABRICATION DETAILS</b> <sup>e</sup>
<b>References:</b>  EN 13445-4:2009 Unfired pressure vessels – Part 4: Fabrication Clause 5: "Manufacturing tolerances"
<b>Comments:</b>

<b>MATERIAL REQUIREMENTS <sup>f</sup></b>
<p><b>References:</b></p> <p>EN 13445-2:2009 Unfired pressure vessels – Part 2: Materials            Clause 4: "Requirements for materials to be used for pressure-bearing parts"</p>
<p><b>Comments:</b></p> <p>Requirements on ductility.</p>
<b>EXAMINATION REQUIREMENTS <sup>g</sup></b>
<p><b>References:</b></p> <p>EN 13445-5:2009 Unfired pressure vessels – Part 5: Inspection and testing            Clause 6: "Inspection and testing during fabrication", 6.6 "Non-destructive testing of welded joints"</p>
<p><b>Comments:</b></p> <p>Acceptance criteria are based on EN ISO 5817: 2007, level C (level B in critical areas when vessels are subjected to cyclic loads, see Annex G).</p>
<b>TESTING REQUIREMENTS <sup>h11</sup></b>
<p><b>References:</b> <a href="https://standards.iteh.ai/catalog/standards/sist/07e43dab-3967-44dd-8178-b37f690fa0d1/sist-tp-cen-tr-13445-9-2011">https://standards.iteh.ai/catalog/standards/sist/07e43dab-3967-44dd-8178-b37f690fa0d1/sist-tp-cen-tr-13445-9-2011</a></p> <p>EN 13445-5:2009 Unfired pressure vessels – Part 5: Inspection and testing            Clause 10: "Final assessment", 10.2.3 "Proof test", 10.2.3.3 "Standard pressure test", 10.2.3.9 "Acceptance criteria"</p>
<p><b>Comments:</b></p> <p>During the proof test the vessel shall show no signs of general plastic yielding. No leaks from the pressure envelope.</p>
<b>USE / FAILURE HISTORY <sup>i</sup></b>
<p><b>References:</b></p>
<p><b>Comments:</b></p>

<b>STANDARD : Unfired pressure vessels EN 13445:2009</b>
<b>FAILURE MODE <sup>a</sup> : Leakage at joints</b>
<b>EXPLICIT DESIGN <sup>d</sup></b>
<b>References <sup>b</sup> :</b>  <b>EN 13445-3:2009 Unfired pressure vessels – Part 3: Design Clause 11: "Flanges"</b>
<b>Comments <sup>c</sup> :</b>  <b>Requirements for circular bolted flanged connections. The requirements are based on the Taylor Forge rules.</b>  <b>Suggested values of the gasket factors are given in Annex H: "Gasket factors m and y".</b>
<b>IMPLICIT DESIGN <sup>d</sup></b>
<b>References:</b> <b>iTeh STANDARD PREVIEW</b> <b>(standards.iteh.ai)</b> <b>EN 13445-3:2009 Unfired pressure vessels – Part 3: Design Annex G "Alternative design rules for flanges and gasketed flange connections"</b>  <a href="https://standards.iteh.ai/catalog/standards/sist/07e43dab-3967-44dd-8178-b37f690fa0d1/sist-tp-cen-tr-13445-9-2011">SIST-TP CEN/TR 13445-9:2011</a> <a href="https://standards.iteh.ai/catalog/standards/sist/07e43dab-3967-44dd-8178-b37f690fa0d1/sist-tp-cen-tr-13445-9-2011">https://standards.iteh.ai/catalog/standards/sist/07e43dab-3967-44dd-8178-b37f690fa0d1/sist-tp-cen-tr-13445-9-2011</a>
<b>Comments:</b>  <b>The purpose of these rules is to ensure structural integrity and leaktightness. They are most appropriate when a) thermal cycling is important b) bolt stress is controlled by the use of a defined tightening procedure c) there are significant additional loadings (forces or moments) d) leaktightness is a special importance (requirement of a specified leaktightness). Gasket factor values are provided for use with this annex.</b>
<b>FABRICATION DETAILS <sup>e</sup></b>
<b>References:</b>  <b>EN 13445-4:2009 Unfired pressure vessels – Part 4: Fabrication Clause 5: "Manufacture tolerances"</b>
<b>Comments:</b>