SLOVENSKI STANDARD
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Neogrevane tlačne posode - 10. del: Dodatne zahteve za tlačne posode iz niklja in nikljevih zlitin

Unfired pressure vessels - Part 10: Additional requirements for pressure vessels of nickel and nickel alloys

Unbefeuerte Druckbehälter - Teil 10: Zusätzliche Anforderungen an Druckbehälter aus Nickel und Nickellegierungen

Récipients sous pression non soumis à la flamme - Partie 10 : Exigences complémentaires pour les récipients sous pression en nickel et alliages de nickel

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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

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European foreword

This document (EN 13445-10:2015) 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of an identical text or by endorsement, at the latest by June 2016, and conflicting national standards shall be withdrawn at the latest by June 2016.

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1 Scope

This Part 10 of this European Standard specifies requirements for unfired pressure vessels and their parts made of nickel and nickel alloys (see 3.1) in addition to the general requirements for unfired pressure vessels under EN 13445-1:2014, EN 13445-2:2014, EN 13445-3:2014, EN 13445-4:2014 and EN 13445-5:2014.

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

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

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

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

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

EN ISO 9606-4:1999, *Approval testing of welders — Fusion welding — Part 4: Nickel and nickel alloys (ISO 9606-4:1999)*

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

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

3 Terms, definitions, symbols and units

For the purposes of this document, the terms, definitions, symbols and units given in EN 13445-1:2014, EN 13445-2:2014, EN 13445-3:2014, EN 13445-4:2014 and EN 13445-5:2014 and the following apply.

3.1
nickel alloys
those alloys which contain a minimum of 30 % nickel and contain more nickel than iron

4 General requirements

The general requirements of EN 13445-1:2014 shall apply.

5 Materials

5.1 General

The general requirements of EN 13445-2:2014 shall apply with the following additions/exclusions in 5.2 – 5.5.

NOTE There are presently no European Standards specifically for nickel or nickel alloys for pressure purposes. This part 10 of EN 13445 is therefore limited to European Approval of Materials (EAM) or the use of Particular Materials Appraisal (PMA). These may be used when they meet the requirements in 5.1 to 5.5 of this part 10 of EN 13445.

5.2 Material grouping system

Annex A of EN 13445-2:2014 is not applicable to pressure vessels of nickel and nickel alloys and is replaced by Annex A of this part 10 of EN 13445.

The grouping system for nickel and its alloys is shown in Table A.1 of this part 10 of EN 13445.

Only material having a minimum elongation after fracture greater than 25 % shall be used for construction of pressure vessels.

Materials which have mechanical properties enhanced by precipitation hardening are excluded from this part of EN 13445, unless they are to be used for bolting applications.

5.3 Material documentation

Materials for pressure bearing parts compliant with the requirements of this European Standard shall be accompanied by inspection documentation 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.

5.4 Prevention of brittle fracture

There are no general requirements for nickel and nickel alloys at temperatures down to −196 °C. However, the specific requirements of individual EAMs/PMAs shall be taken into account.

5.5 Lamellar tearing

Failure by lamellar tearing is not normally applicable to nickel and nickel alloys.

6 Design

6.1 General

All the design methods included in EN 13445-3:2014 shall apply, with the following amendments, given in 6.2 – 6.5.

Physical properties of nickel and nickel alloys are given in Annex B.

6.2 Time-independent nominal design stress

The design stress for nickel and nickel alloy materials entering service without any subsequent heat treatment shall be evaluated in accordance with Table 6.2-1.

If any material is subjected to subsequent heat treatment (for example, in the manufacture of dished ends) representative material test coupons shall be heat treated with the components and subjected to the same mechanical tests as used to certify the material at the manufacturer's works. The nominal design stress shall then be calculated in accordance with Table 6.2-1. If this design stress is lower than

that used in the original calculations, the design of that component and any other related components shall be repeated using the nominal design stress derived from the properties of the heat treated material.

For designs using nickel and nickel alloys attention is drawn to the effect of heat treatment on the materials, and care should therefore be taken when determining the thickness of the materials that will receive subsequent heat treatments during manufacture.

Table 6.2–1 — Maximum allowed values of the nominal design stress for nickel and nickel alloy materials for pressure parts

Minimum specified elongation after fracture (A) (%)	**Design stress for normal operating load cases (MPa)**	**Design stress for testing and exceptional load cases (MPa)**
$A > 35$	$f_d = \min\left(\frac{R_{p1,0/T}}{1,2}; \frac{R_{m/T}}{3}\right)$	$f_{test} = \left(\frac{R_{p1,0/T_{test}}}{1,05}\right)$
$30 < A \leq 35$	$f_d = \left(\frac{R_{p1,0/T}}{1,5}\right)$	$f_{test} = \left(\frac{R_{p1,0/T_{test}}}{1,05}\right)$
$A \leq 30$	$f_d = \min\left(\frac{R_{p0,2/T}}{1,5}; \frac{R_{m/20}}{2,4}\right)$	$f_{test} = \left(\frac{R_{p0,2/T_{test}}}{1,05}\right)$

6.3 Creep design

Where sufficient material data is available, creep design may be applied to nickel and nickel alloys using the formulae and approach in Clause 19 of EN 13445-3:2014.

6.4 Shells under external pressure

The requirements in Clause 8 of EN 13445-3:2014 shall apply with the following modifications:

In EN 13445-3:2014, 8.4, for shells made in nickel or nickel alloys, the nominal elastic limit shall be given by:

$$\sigma_e = \frac{R_{p0,2/T}}{1,25}$$

and for stiffeners in the same material by:

$$\sigma_{es} = \frac{R_{p0,2/T,s}}{1,25}$$

6.5 Fatigue design

For loads up to 500 equivalent full pressure cycles no fatigue analysis is required. Above 500 cycles the requirements of Clause 17 of EN 13445-3:2014 shall apply with the following modifications:

The application of Clause 17 of EN 13445-3:2014 (see 17.4.4 of EN 13445-3:2014) to nickel and nickel alloys shall be limited to temperatures not exceeding 450 °C.

The correction factor to account for the influence of temperature on fatigue resistance (see 17.6.2.2 of EN 13445-3: 2014) is:

For T* ≥ 100 °C:

$$C_t = 1{,}0164 - 1{,}4 \times 10^{-4} T^* - 2{,}4 \times 10^{-7} (T^*)^2$$

The requirements of Clause 18 of EN 13445-3:2014 shall apply with the following modifications:

The application of Clause 18 of EN 13445-3:2014 (see 18.4.3 of EN 13445-3:2014) to nickel and nickel alloys shall be limited to temperatures not exceeding 450 °C.

The correction factor to account for the influence of temperature on fatigue resistance, f_{T^*} (see 18.10.6.2 of EN 13445-3:2014) is given by:

$$f_{T^*} = 1{,}0164 - 1{,}4 \times 10^{-4} T^* - 2{,}4 \times 10^{-7} (T^*)^2$$

7 Manufacture

7.1 General

EN 13445-4:2014 shall apply, with the following amendments, given in 7.2 – 7.14.

NOTE 1 Not all welding processes are suitable for all nickel alloys.

NOTE 2 Welding consumables may be selected from EN ISO 14172:2015 and EN ISO 18274:2010.

7.2 Qualification of welding procedure specifications (WPQR)

The requirements of 7.3 of EN 13445-4:2014 shall apply with the following modifications:

a) Annex B of EN 13445-2:2014 shall not apply.

b) Impact testing is not normally required for pressure vessels of nickel and nickel alloys at temperatures down to −196 °C except for alloys in group 47.

c) For nickel alloys in group 47 when the design temperature is below −105 °C, impact testing shall be carried out at −196 °C on the weld metal and heat affected zone of the WPQR.

7.3 Qualification of welders and welding operators

The requirements in 7.4 of EN 13445-4:2014 shall apply with the following modifications:

Replace reference to EN 287-1 with EN ISO 9606-4:1999.

7.4 Joint preparation

In addition to the requirements of 7.6 in EN 13445-4:2014 the following shall apply for pressure vessels of nickel and its alloys:

a) the edges of plates that have been thermally cut shall be dressed back by machining or grinding for a minimum distance of 1,5 mm to remove damaged material;

NOTE Nickel and nickel alloys are not subject to hardening by thermal cutting.

b) for plates less than 20 mm thickness cold shearing is permissible, provided that the cut edges are dressed back mechanically by not less than 1,5 mm to permit a satisfactory examination of the edges prior to welding;

c) plates less than 10 mm thick, which are cold sheared, need not be dressed prior to welding.

d) coated parts shall be free of coating products for a minimum distance of 50 mm from the edge of the weld preparation, in order that the coating does not interfere with the welding process, and to safeguard the coating itself;

e) after welding, the welded areas shall be cleaned, and any residues, slag, spatter, etc. shall be removed.

7.5 Preheat

Preheating is not normally necessary for nickel and nickel alloys.

When the metal temperature is less than 5 °C, heat should be applied to a maximum temperature of 75 °C to remove condensation.

7.6 Production test, reference criteria

The requirements in 8.2 of EN 13445-4:2014 shall apply with the following modifications:

The requirements for impact testing of production control test plates are not applicable to nickel and its alloys; 8.2 a) of EN 13445-4:2014 is not applicable.

Production control test plates for nickel and nickel alloys vessels shall be carried out in accordance with 8.2 d) of EN 13445-4:2014.

7.7 Extent of testing

The requirements of 8.3 of EN 13445-4:2014 shall apply with the following modifications:

Table 8.3-1 shall be replaced by Table 7.7-1 below:

Table 7.7–1 — Testing of production test plates

Material Group	Thickness of test plate e[a] mm	Test specimens[b]
All	$e \leq 12$	1 FB, 1 RB, 1 TT, 1 Ma, 1 Mi
	$12 < e$	2 SB[c], 1 TT, 1Ma, 1Mi

a Thinner plate thickness.

b The symbols for Table 7.7–1 are given in Table 8.3–2 of EN 13445–4:2014.

c SB = side bends

7.8 Performance of test and acceptance criteria

The requirements in 8.4.1, 8.4.2, 8.4.3, 8.4.5, 8.4.6, 8.4.7, 8.4.9 and 8.4.10 of EN 13445-4:2014 shall apply.

7.9 Forming procedures

7.9.1 Cold forming

Cold forming of nickel and nickel alloy materials shall be carried out at temperatures below 300 °C. It is preferable that nickel and nickel alloys are cold formed whenever possible.

7.9.2 Hot forming

The requirements in 9.3.2 of EN 13445-4:2014 are not applicable for pressure vessels made of nickel and nickel alloys.