SLOVENSKI STANDARD

SIST EN 13445-6:2002/A1:2004

01-september-2004

Neogrevane tlaị ne posode - 6. del: Zahteve za konstruiranje in proizvodnjo tlaị nih posod in delov posode iz nodularne litine - Dodatek D: Ocena odpornosti proti utrujanju

Unfired pressure vessels - Part 6 :Requirements for design and fabrication of pressure vessel and vessel parts constructed of spheroidal graphite cast iron - Annex D Assessment of fatigue life

Unbefeuerte Druckbehälter - Teil 6: Anforderungen an die Konstruktion und Herstellung von Druckbehältern und Druckbehälterteilen aus Gusseisen mit Kugelgraphit

Récipients sous pression non soumis a la flamme - Partie 6: Exigences pour la conception et la fabrication des récipients sous pression et des parties sous pression moulés en fonte a graphite sphéroidal - Annexe D Evaluation de la durée de vie en fatigue

Ta slovenski standard je istoveten z: **EN 13445-6:2002/A1:2004**

ICS:

23.020.30	Tlaị ne posode, plinske jeklenke	Pressure vessels, gas cylinders

SIST EN 13445-6:2002/A1:2004 **en**

EUROPEAN STANDARD

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This amendment A1 modifies the European Standard EN 13445-6:2002; it was approved by CEN on 9 February 2004.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for inclusion of this amendment into the relevant national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This amendment 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 Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

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Foreword

This document (EN 13445-6:2002/A1:2004) has been prepared by Technical Committee CEN/TC 54 “Unfired pressure vessels”, the secretariat of which is held by BSI.

The document includes the text of the amendment itself. The corrected pages of EN 13445-6 will be delivered as issue 10 of the standard.

This Amendment to the European Standard EN 13445-6:2002/A1:2004 shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2004, and conflicting national standards shall be withdrawn at the latest by October 2004.

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, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Add Annex D as follows:

Annex D
(normative)

Assessment of fatigue life

D.1 Purpose

D.1.1 This annex gives rules for the simplified and detailed assessment of fatigue life of pressure equipment, due to pressure fluctuations, additional stress by rapid temperature changes in operation conditions or additional induced stresses due to external forces in the critical zones (for critical zone definition see 3.1.1). The design and manufacture of pressure equipment shall be according to Part 6, and materials of spheroidal graphite cast iron grades according to Table 5.1-1 and Table 5.1-2.

D.1.2 The rules for the simplified assessment may be applied in case of internal pressure fluctuations only. Other cyclic loads, e.g. due to changes in temperature during operation or to variation of external loads, shall be assessed according to the rules for the detailed assessment.

NOTE The rules for the simplified assessment are based on conservative assumptions. More accurate, less conservative results can be obtained with the rules for the detailed assessment.

D.1.3 It is assumed that the vessel has been designed in accordance with all of the requirements of EN 13445-6. This annex D on assessment of fatigue life only need to be performed if the service conditions require more than 200 000 full pressure cycles or equivalent number of cycles with smaller amplitude (see clause 4) or when the pressure equipment is considered as predominantly non – cyclic loaded .

D.1.4 Fatigue cracks can propagate from surface imperfections on the side opposite to pressure fluctuations, acceptance criteria for these imperfections are given in 7.1. The criterium to be used to fail under cyclic loading is a surface fatigue crack, which can be viewed by optical means or an appropriate non destructive method.

D.2 Specific definitions

See EN 13445-3 and clause 3.

D.3 Specific symbols and abbreviations

The following symbols and abbreviations are in addition to those given in 3.3 and in EN 13445-3:2002, clause 4, 17.3 and 18.3.

C_C factor in equation of fatigue design curve for spheroidal graphite cast iron components;

m_C exponent in equation of fatigue design curve for spheroidal graphite cast iron components.

D.4 Limitations

D.4.1 These rules apply to components designed by:

a) Formulae;

b) Finite Element Analysis

D.4.2 These rules apply only to components operating outside the creep range (i.e. when the nominal design stress is time-independent).

D.4.3 The data on which these rules are based are valid for fatigue in non corrosive environment. It is assumed that in the case of corrosive conditions precautions are taken i.e. corrosion allowance and / or surface protection.

D.5 General

D.5.1 ΔP shall be obtained by applying either the simplified cycle counting method described in EN 13445-3:2002, 18.9.2 or the reservoir cycle counting method in EN 13445 –3:2002, 18.9.3.

D.5.2 The calculations according to D.6 shall be performed for the various components of the vessels. The stress determination of castings is based on a stress analysis of notched parts. The lowest life obtained from each component is the fatigue life of the vessel.

D.6 Determination of allowable number of pressure cycles

D.6.1 Pseudo-elastic stress range $\Delta\sigma$

D.6.1.1 Design by the simplified method

$$\Delta\sigma_{simple} = \frac{\Delta P}{P_{max}} \times \eta \times f \qquad \text{(D.6.1.1)}$$

For simplification, either the maximum allowable pressure PS of the whole vessel may be used instead of that of the component (P_{max}), or the calculation pressure P may be used.

NOTE 1 These simplifications lead to more conservative results.

NOTE 2 Since f in equation (D.6.1-1) is taken at the calculation temperature, the ratio P_{max} /f is independent of temperature.

NOTE 3 P_{max} can be calculated in accordance with EN 13445-3. When no calculation is possible with a design by formulae for the main pressure bearing part, an experimental value according to this standard can be taken.

For each detail the value of η (stress concentration factor) is obtained from EN 13445-3:2002, Table 17-1, but in the formula giving the value of η the weld joint factor z shall be taken equal to 1. Values of $\eta > 3$ are not to be taken into account; they do not appear in castings manufactured according to Part 6.

For details, which are not described in EN 13445-3:2002, Table 17-1, a value for η of 3 shall be used, except if a lower value can be justified (i.e. by 3-D finite element modelling, etc.-a normal value being 2-2,4).

NOTE 4 Above ratio is written for the simple case of uniaxial stress state to understand the principle.

D.6.2 Corrections to stress range

D.6.2.1 Thickness

$$f_e = F_e^{(0{,}1 \ln N - 0{,}465)} \qquad \text{(D.6.2.1)}$$

where

$$F_e = \left(\frac{25}{e_{\max}} \right)^{0,182} \quad \text{(D.6.2.2)}$$

For $e_{max} \leq 25$ mm, $f_e = 1$.

For $e_{max} > 150$ mm, the value of f_e for $e_{max} = 150$ mm applies.

D.6.2.2 Temperature

For operating temperatures above 100 °C, f_{t*} is given by:

$$f_{t^*} = 1,03 - 1,5 \times 10^{-4} \times t^* - 1,5 \times 10^{-6} \times t^{*2} \quad \text{(D.6.2.3)}$$

where

$$t^* = 0,75 \times t_{\max} + 0,25 \times t_{\min} \quad \text{(D.6.2.4)}$$

D.6.2.3 Surface finish correction factor

No correction for surface finish is necessary. This factor is already taken into account in the fatigue design curves. It means that the surface conditions meet the requirements of 7.1. However a finer surface finish due to appropriate moulding techniques is advantageous on the side opposite to the fluctuating pressure to keep low local stresses.

D.6.2.4 Mean stress

The mean stress correction factor f_m is to be determined as a function of the mean stress sensitivity factor M from EN 13445-3:2002, equations (18.11-5) or (18.11-6),

where for spheroidal graphite cast iron:

$$M = 0,00035 \times R_m + 0,08 \quad \text{(D.6.2.5)}$$

D.6.2.5 Notch effect

As the fatigue design curves $\Delta\sigma_{R,simple}$ = f(N) and $\Delta\sigma_{R,struc}$ = f(N) according to Figure D.1 are based on maximum notch effect, the stress concentration factors K_t and K_{eff} can be ignored.

For the notch stress analysis see D.6.1.1.

D.6.2.6 Plasticity correction factor

Correction factors for mechanical (k_e) and thermal (k_v) loadings in the hyper plastic range can be ignored, as a result of the high safety factors used for the calculation of the nominal design stress in EN 13445-6 for spheroidal graphite cast iron.

D.6.3 Fictitious stress range

The fictitious stress ranges $\Delta\sigma^*_{simple}$, $\Delta\sigma^*_{eq,struc}$ and $\Delta\sigma^*_{eq,notch}$ shall be calculated (by omitting the required indexes for clarity), as follows:

$$\Delta\sigma^{*} = \frac{\Delta\sigma}{f_u} \qquad \text{(D.6.3.1)}$$

Where the overall correction factor f_u is:

a) for simplified assessment:

$$f_u = \frac{f_e \times f_{t^*}}{K_f} \qquad \text{(D.6.3.2)}$$

b) for structural stress analysis:

$$f_u = \frac{f_e \times f_{t^*} \times f_m}{K_f} \qquad \text{(D.6.3.3)}$$

c) for detailed stress analysis:

$$f_u = \frac{f_e \times f_{t^*} \times f_s \times f_m}{K_f} \qquad \text{(D.6.3.4)}$$

If the stresses are determined using finite element analysis, K_f can be ignored.

If the stresses are not determined using finite element analysis, use the values of K_f given in EN 13445-3:2002, equation 17.6-6 where $\Delta\sigma_R = \Delta\sigma_D$.

D.6.4 Fatigue design curves

The fatigue design curves given in Figure D.1 are described by the following equation:

$$\Delta\sigma_R = \frac{C_Q}{0{,}9} \times \frac{C_C}{N^{1/m_C}} \qquad \text{(D.6.4.1)}$$

Where $\Delta\sigma_R$ is $\Delta\sigma_{R,\,simple}$, $\Delta\sigma_{R,\,struc}$ or $\Delta\sigma_{R,\,notch}$.

C_C and m_C are constants whose values are given in Table D.1

Table D.1 - Coefficients of the fatigue design curves for spheroidal graphite cast iron grades

Fatigue analysis	**Constants of $\Delta\sigma_R - N$ curve** [a]				**Stress range at N cycles** N/mm^2			
	$10^3 < N < 2 \times 10^6$		$2 \times 10^6 < N < 10^8$		$C_Q = 0{,}9$		$C_Q = 0{,}8$	
	$1/m_C$	C_C	$1/m_C$	C_C	2×10^6	10^8	2×10^6	10^8
EN-GJS-400-18	0,116	786	0,1	623	146	99	130	88
EN-GJS-350-22	0,108	731	0,093	579	135	92	121	81
[a] For E = 165 000 N/mm^2								

NOTE The fatigue design curves have been derived from data (See reference [1]) obtained from notched and un-notched test pieces of spheroidal graphite cast iron grade EN-GJS-400-18 for axial and bending fatigue tests, tested under load control or, for applied strains exceeding yield (low cycle fatigue), under strain control. The allowable stresses have been