SLOVENSKI STANDARD
SIST EN 13445-3:2002/A4:2005
01-november-2005

Neogrevane tlaļ ne posode ï 3. del: Konstruiranje

Unfired pressure vessels - Part 3: Design

Unbefeuerte Druckbehälter - Teil 3: Konstruction

Récipients sous pression non soumis a la flamme - Partie 3: Conception

Ta slovenski standard je istoveten z: EN 13445-3:2002/A4:2005

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23.020.30

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 13445-3:2002/A4

July 2005

ICS 23.020.30

English Version

Unfired pressure vessels - Part 3: Design

Récipients sous pression non soumis à la flamme - Partie 3: Conception

Unbefeuerte Druckbehälter - Teil 3: Konstruktion

This amendment A4 modifies the European Standard EN 13445-3:2002; it was approved by CEN on 14 April 2005.

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.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

Ref. No. EN 13445-3:2002/A4:2005: E

Foreword

This document (EN 13445-3:2002/A4:2005) has been prepared by Technical Committee CEN/TC 54 “Unfired pressure vessels”, the secretariat of which is held by BSI.

This Amendment to the European Standard EN 13445-3:2002 shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by January 2006, and conflicting national standards shall be withdrawn at the latest by January 2006.

This amendment, relative to Clause 14, is based on EN 13445-3:2002 up to Issue 11 (May 2004).

The document includes the text of the amendment itself. The corrected pages of EN 13445-3 will be delivered as issue xx of the standard.

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.

14 Expansion bellows

14.1 Purpose

Add at the end of the first sentence (after c):

subject to internal or external pressure and cyclic displacement.

Delete Note 1.

Rename Note 2 as Note.

Add the following paragraph at the end of the subclause:

If erosion or vibration is considered to be a concern due to the velocity of the medium conveyed, the use of an internal sleeve should be considered.

14.2.5 Squirm

Replace the complete subclause by the following:

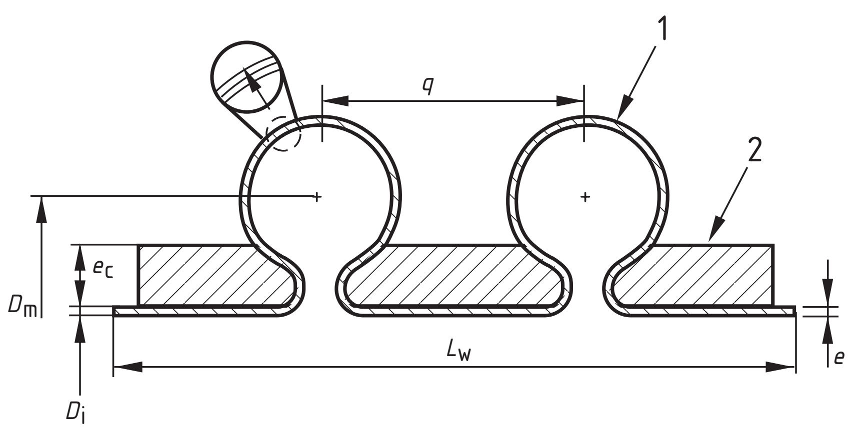
14.2.5 Reinforcing and equalizing rings

Devices that are tightly fitted into the roots of the convolutions in order to reinforce the bellows against internal pressure.

Reinforcing rings are fabricated from tubing or round bars. Equalizing rings are approximately "T" shaped in cross section and their primary purpose is to limit the total equivalent axial displacement range.

Figure 14.1-1c)

Replace by the following:



Key
(1) convolution
(2) reinforcing collar

c) Toroidal bellows
Figure 14.1-1 — Three types of expansion bellows

14.3 Specific symbols and abbreviations

Replace the description of E_o by the following:

E_o is the modulus of elasticity of bellows material at room temperature;

Replace the description of K_b by the following:

K_b is the bellows axial rigidity, given by equations (14.5.7-1, 14.6.8-1 or 14.7.8-1);

Add the following symbols in alphabetical order:

s_d is the strain caused by deformation during manufacturing, see 14.5.2.2;

α . is the in-plane instability stress interaction factor, given by equation (14.5.2-12);

δ is the in-plane stress instability stress ratio, given by equation (14.5.2-11);

Add in the list of main subscripts:

r for reinforced

14.4.1 Geometry

Add a new subclause 14.4.1.4:

14.4.1.4 The number of plies shall be such that:

$$n_p \leq 5$$

14.4.4 Materials

Replace the text of the subclause by the following:

These rules apply to ferritic steel, austenitic steel and nickel-chromium-iron, nickel-iron-chromium alloys.

14.4.5 Manufacture

Delete the whole subclause.

14.4.6 Welding seams

Replace the whole subclause by the following:

14.4.5 Welding seams

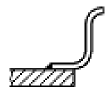
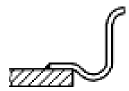
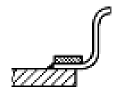
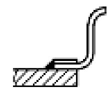
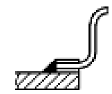
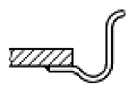
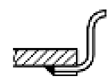
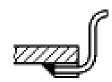
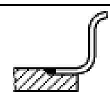
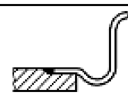
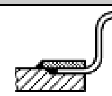
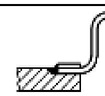
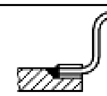
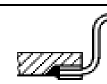
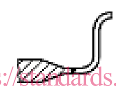
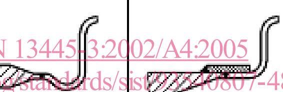
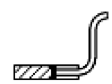
Expansion bellows may include one or several longitudinal welds. U-shaped unreinforced bellows may also have circumferential welds (see 14.5.9).

The circumferential attachment welds of single and multi-ply expansion bellows shall be designed according to the sketches given in Table 14.4.5-1.

Table 14.4.6-1

Replace Table 14.4.6-1 by the following:

Table 14.4.5-1 — Typical bellows attachment welds

Weld type		Variants (Combinations of A to D are permitted)			
No	General design	A increased neck	B reinforcing collar	C	D
				assisting collar	
				single	double
1.1	1)  outside lap joint/filled weld		2), 3) 		
1.2	1)  inside lap joints/fillet weld				
2.1	 outs. lap joint/groove weld				
2.2	 inside lap joint/groove weld				
3.0	4)  butt weld	4) 			
4.1	5)  radial edge weld (inside or outside)				
4.2	 axial edge weld (inside or outside)				

1) In the case of fillet welds, the weld thickness "*a*" shall fulfil following equation:

$$a \geq 0,7 e_s$$

where e_s is the nominal thickness of the connecting shell.

2) A reinforcing collar is advisable, if the cylindrical end tangent of bellows L_t exceeds:

$$L_t \geq 0,5 \sqrt{e_s D_i}$$

3) The reinforcing collar shall be fixed axially by welding or mechanical devices.

4) In the case of butt welds, special tools are necessary for welding of multi-ply bellows.

5) The diameter of the weld shall not exceed the mean diameter of bellows D_m by more than 20 % of the convolution height *w*.

6) Fittings and reinforcing collars opposite to the pressure bearing side of the bellows shall have a radius or a bevel at the edge in contact with the bellows and tangent.

NOTE These sketches are not exhaustive. Other configurations can be used, provided they lead to an equivalent level of safety.

14.4.7 Installation

Renumber as 14.4.6.

14.5.1.1 Scope

Replace the first sentence by the following:

This subclause applies to two types of unreinforced bellows having nominally U-shaped convolutions:

Add the following sentence before Figure 14.5.1-1:

Each convolution consists of a sidewall and two tori of nearly the same radius (at the crest and root of the convolution), in the neutral position, so that the convolution profile presents a smooth geometrical shape as shown in Figure 14.5.1-1.

14.5.1.2 Conditions of applicability

Replace the text of the subclause by the following:

The following conditions of applicability apply in addition to those listed in 14.4.

a) A variation of 10 % between the crest convolution radius r_{ic} and the root convolution radius r_{ir} is permitted (see Figure 14.5.1-2 for definitions of r_{ic} and r_{ir}).

b) The torus radius shall be such that:

$$r_i \geq 3\, e_p\,,$$

where

$$r_i = \frac{r_{ic} + r_{ir}}{2}\,.$$

c) The off-set angle of the sidewalls, α, in the neutral position shall be such that:

$-15 \leq \alpha \leq +15$ degrees (see Figure 14.5.1-2).

d) The convolution height shall be such that: $w \leq \frac{D_i}{3}$.

14.5.2 Determination of intermediate quantities

Transfer the whole of the text of 14.5.2 into a new subclause, 14.5.2.1 General. Add an introductory sentence to 14.5.2.1, as follows.

14.5.2.1 General

The following formulae are used in the determination of the intermediate factors.

….

Add the following equations to 14.5.2.1, after equation 14.5.2-10.

$$\delta = \frac{\sigma_{\mathrm{m,b}}}{3\sigma_{\theta,\mathrm{I}}} \tag{14.5.2-11}$$

$$\alpha = 1 + 2\delta^2 + \sqrt{\left(1 - 2\delta^2 + 4\delta^4\right)} \tag{14.5.2-12}$$

Add the following new subclause 14.5.2.2.

14.5.2.2 Determination of strain caused by deformation

The maximum true strain caused by deformation for bellows is given by:

$$s_\mathrm{d} = 1{,}04\sqrt{s_\theta{}^2 + s_\mathrm{b}{}^2} \tag{14.5.2-13}$$

The circumferential true strain caused by deformation s_c depends on the forming process. For the common forming processes the following formulas shall be used:

— for hydraulic or similar processes where the forming is performed 100 % to the outside of the initial cylinder:

$$s_\theta = \ln\left(1 + 2\frac{w}{D_\mathrm{i}}\right) \tag{14.5.2-14}$$

— for roll forming processes with 50 % forming to the inside and 50 % to the outside of the initial cylinder:

$$s_\theta = \ln\left(1 + \frac{w}{D_\mathrm{i}}\right) \tag{14.5.2-15}$$

— for half-convolutions manufactured from ring plates by roller bending or other methods, where the maximum strain occurs at the inner crest:

$$s_\theta = -\ln\left[1 - \frac{\left(\frac{\pi}{2} - 1\right)\left(2r_\mathrm{i} + e_\mathrm{p}\right)}{D_\mathrm{i} + e_\mathrm{p}}\right] \tag{14.5.2-16}$$

The bending component of the true strain caused by deformation s_b is independent of the forming process and given by:

$$s_b = \ln\left[1 + \frac{e_p}{2r_i + e_p}\right] \tag{14.5.2-17}$$

14.5.3.3 Bellows convolutions

Replace the 2 last lines of list item d) by:

where

$K_f = 3{,}0$ for as-formed bellows (with cold work) (14.5.3-8)

$K_f = 1{,}5$ for annealed bellows (without cold work) (14.5.3-9)

14.5.4 Squirm due to internal pressure

Replace the whole subclause by the following

14.5.4 Instability due to internal pressure

14.5.4.1 Column instability

The allowable internal design pressure to avoid column instability, $P_{s,c}$, is given by:

$$P_{s,c} = 0{,}34 \frac{\pi K_b}{Nq} \qquad (14.5.4\text{-}1)$$

The internal pressure P shall not exceed $P_{s,c}$:

$P \leq P_{s,c}$

14.5.4.2 In-plane instability

The allowable internal design pressure to avoid in-plane instability, $P_{s,i}$, is given by:

$$P_{s,i} = (\pi - 2) \frac{A R_e^*}{D_m q \sqrt{\alpha}} \qquad (14.5.4\text{-}2)$$

where R_e^* is the effective proof stress at design temperature of bellows material in the as-formed or annealed condition.

In absence of values for R_e^* in material standards, the following values shall be used for austenitic steel:

a) $R_e^* = K_d R_{p1,0/t}$ for as-formed bellows (with cold work) (14.5.4-3)

b) $R_e^* = 0{,}75\ R_{p1,0/t}$ for annealed bellows (without cold work) (14.5.4-4)

where

$R_{p1,0/t}$ is the yield stress at 1 % at design temperature, as defined in clause 4;

K_d is the bellows cold-work factor, given by:

$$K_d = \begin{cases} 1 + 5 \times s_d & if\ \ s_d \leq 0.2 \\ 2{,}0 & if\ \ s_d > 0{,}2 \end{cases} \qquad (14.5.4\text{-}5)$$

For non-austenitic steel: $R_e^* = R_{p\,0,2/t}$

The internal pressure P shall not exceed $P_{s,i}$:

$$P \leq P_{s,i}$$

14.5.6.3.1 General

Replace the second paragraph by:

The allowable number of cycles given by the following formulae includes a reasonable safety margin (factor 3 on cycles and 1,25 on stresses) and represents the maximum number of cycles for the operating condition considered.

In the third paragraph, replace squirm *by* instability.

In the fourth paragraph, replace cycles of pressure or displacement *by* cycles of displacement.

Replace the fifth paragraph by:

Use of specific fatigue curves established by a manufacturer will be covered later and specific requirements to be applied will be set-up in Annex K.3 (in course of consideration by CEN/TC 54/WG C).

14.5.6.3.2 Austenitic steels and other similar materials

Replace the text of the subclause by the following:

This following formula applies to as-formed bellows made of austenitic steel, nickel-chromium-iron and nickel-iron-chromium alloys.

The allowable number of cycles is given by (see Figure 14.5.6-1):

— If $\frac{E_0}{E_b}\sigma_{eq} \geq 1080$ N/mm^2:

$$N_{alw} = \left[\frac{9283,3}{\frac{E_0}{E_b}\sigma_{eq} - 372,3}\right]^{3,4} \qquad (14.5.6\text{-}4)$$

where σ_{eq} is expressed in N/mm^2.

— If $\frac{E_0}{E_b}\sigma_{eq} < 1080$ N/mm^2:

$$N_{alw} = \left[\frac{10259,4}{\frac{E_0}{E_b}\sigma_{eq} - 297,9}\right]^{3,4} \qquad (14.5.6\text{-}5)$$

where σ_{eq} is expressed in N/mm^2.

— If $\frac{E_0}{E_b}\sigma_{eq} \leq 297{,}9$ N/mm^2: $N_{alw} = 10^6$ cycles shall be used.

The curve and the equations are only valid for: $370 \leq N_{alw} \leq 10^6$

Figure 14.5.6-1

Replace figure 14.5.6-1 by the following