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Neogrevane tlaļ ne posode ï 3. del: Konstruiranje

Unfired pressure vessels - Part 3: Design

Unbefeuerte Druckbehälter - Teil 3: Konstruktion

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

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English Version

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This amendment A6 modifies the European Standard EN 13445-3:2002; it was approved by CEN on 24 June 2005.

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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.

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

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Foreword

This document (EN 13445-3:2002/A6:2006) 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 13445-3 will be delivered as Issue 18 of the standard

This amendment is based on EN 13445-3 up to issue 16 (2005-09).

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of an identical text or by endorsement, at the latest by August 2006, and conflicting national standards shall be withdrawn at the latest by August 2006.

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).

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, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Replace the whole of Clause 10 with the following text:

10 Flat ends

10.1 Purpose

10.1.1 This clause specifies methods for determining the thickness of circular and non-circular unstayed flat ends under pressure and for providing adequate reinforcement for openings fitted in such ends. Loads other than pressure are not considered.

NOTE 1 For welded flat ends, the method takes into account the stresses caused by the junction forces and moments. For bolted flat ends, the method takes into account the stresses caused by the forces and moments due to the flange and bolting.

NOTE 2 For the design of vessels of rectangular cross-section, refer to Clause 15.

10.1.2 Stayed plates, i.e. plates supported by braces, stay bars or stay tubes, are not considered in this clause.

NOTE Stayed plates may be calculated using the formulae and methods of the European Standard for Shell Boilers (see EN 12953) with the nominal design stresses of this standard.

These rules do not apply to heat exchanger tubesheets, which are covered by Clause 13.

10.1.3 These rules do not apply to self-sealing covers, i.e. to covers where compression of the gasket is obtained through the action of internal pressure and which are equipped with a bolting-up device.

10.2 Specific definitions

The following specific definitions apply in addition to those in Clauses 3 and 11.

10.2.1
flat end
unstayed flat plate of generally constant thickness, connected to a shell by either welding or bolting, not supported by stays or stay-tubes, not strengthened by beams, and supported only at its periphery so that it is subject predominantly to bending

10.2.2
hub
cylindrical or conical projection on a flat end provided so that the end may be butt welded to a cylindrical shell (see Figure 10.4-1)

10.2.3
relief groove
peripheral groove in a flat end to be butt welded to a cylindrical shell (see Figure 10.4-3)

10.2.4
annular plate
flat end of annular form, connected to one cylindrical shell at its outside diameter and another at its inside diameter, and subject predominantly to bending and not shear

10.3 Specific symbols and abbreviations

The following symbols apply in addition to those in Clauses 4 and 11.

A is the nozzle reinforcement area, see 10.6.2.2;

a' is the smaller width dimension in a rectangular, elliptical or obround end;

b' is the greater width dimension in a rectangular, elliptical or obround end;

C_1, C_2 are the shape factors for calculation of circular flat ends;

C_3, C_4 are the shape factors for calculation of flat ends of non-circular shape;

c is the mean distance between the gasket reaction and the bolt pitch circle diameter;

D_{eq} is the equivalent diameter of an end with a hub, see Figure 10.4-1;

D_F is the diameter of the flat part of an end with a tapered hub, see Figure 10.4-1;

D_i is the inside diameter of the cylindrical shell welded to a flat end. When the thickness of the cylindrical shell adjacent to the shell is not constant, see Figure 10.4-1b), D_i is the inside diameter to the equivalent cylinder of mean thickness e_s;

D_X is the inside diameter of an annular plate;

D_Y is the outside diameter of an annular plate;

d is the diameter of an opening, the equivalent diameter of a nozzle, the mean diameter of two openings or the mean equivalent diameter of two nozzles;

d_i is the nozzle inside diameter;

d_e is the nozzle outside diameter;

e_1 is the required thickness for the flange extension on a flat end;

e_{ab} is the analysis thickness of the external section of a nozzle, see Figure 10.6-3;

e'_{ab} is the analysis thickness of the internal protrusion of a nozzle, see Figure 10.6-4;

e_{af} is the analysis thickness of an end with a hub;

e_b is the required thickness of the nozzle cylinder for pressure loading;

e_o is the required thickness of an unpierced end, in the design of a pierced end;

e_r is the required thickness under a relief groove, see Figure 10.4-3;

e_s is the analysis thickness of a uniform cylindrical shell, or the equivalent thickness of a tapered cylindrical shell, adjacent to a flat end;

f_A is the material nominal design stress at ambient temperature;

f_b is the nominal design stress at calculation temperature of the nozzle;

f_{min} is the lower of the nominal design stresses *f* of the end and f_s of the shell;

f_s is the nominal design stress at calculation temperature of the shell;

h is the smallest distance between the centre of an opening and the inside of the shell, see Figure 10.6-1;

h_w is the distance between the external wall of an end with a relief groove and the weld on the shell (see Figure 10.4-3);

j is determined from the position of an opening, see 10.6.2.1;

k is the distance between the centres of two openings, see Figure 10.6-2;

l is the external length of a nozzle effective for reinforcement;

l' is the internal length on a protruding nozzle effective for reinforcement, see Figure 10.6-3;

l_{cyl} is the length of cylindrical shell, as shown in Figures 10.4-1 to 10.4-3, which contributes to the strength of the flat end (all types of flat ends) and of the end-to-shell junction (ends welded directly to the shell);

n is the number of bolts in a flat end of non circular shape

r is the inside radius of a hub, see Figure 10.4-1;

r_d is the inside radius of the relief groove, see Figure 10.4 -3;

t_B is the mean bolt pitch in a bolted flat end;

Y_1 is the calculation coefficient for opening reinforcement, see equation 10.6-3;

Y_2 is the calculation coefficient for opening reinforcement, see equation 10.6-4;

ν is the Poisson's ratio of the material for the end.

10.4 Unpierced circular flat ends welded to cylindrical shells

10.4.1 General

The requirements of 10.4.2 to 10.4.5 apply to the following types of unpierced, circular flat end:

— with a hub, see Figure 10.4-1;

— welded directly to the shell, see Figure 10.4-2;

— with a relief groove, see Figure 10.4-3.

10.4.2 Limitations

10.4.2.1 The length l_{cyl} (see Figures 10.4-1 to 10.4.-3) shall not contain another junction between the shell and an end, tubesheet, flange or other shell.

10.4.2.2 For an end with a hub, the following conditions shall apply:

a) the inside radius of the hub shall meet the following: $r \geq e_s$ and $r \geq 1{,}3\ e_{af}$;

b) the hub and adjacent cylinder may be offset, but their wall centre-lines shall not be offset by an amount which is greater than the difference between their nominal thicknesses;

c) a taper hub shall have a slope not exceeding 1:3;

d) where the thickness of the cylindrical shell adjacent to the flat end is uniform (see Figure 10.4-1(a)), l_{cyl} shall be calculated as follows:

$$l_{cyl} = 0{,}5\sqrt{(D_i + e_s)e_s} \qquad (10.4\text{-}1)$$

e) where the thickness of the cylindrical shell adjacent to the flat end is tapered (see Figure 10.4-1(b)), a value of l_{cyl} shall be assumed and the mean thickness over that length calculated. This thickness shall be inserted into equation (10.4.1) and the required value of l_{cyl} calculated. If l_{cyl} required is greater than the assumed value, the calculation shall be repeated using a larger assumed value.

Flat ends which do not meet these conditions shall be treated as ends welded directly to the shell.

10.4.2.3 For a flat end welded directly to the shell (see Figure 10.4-2), l_{cyl} is given by:

$$l_{cyl} = \sqrt{(D_i + e_s)e_s} \tag{10.4-2}$$

10.4.2.4 For a flat end with a relief groove (see Figure 10.4-3), the following conditions shall apply:

a) l_{cyl} is also given by equation (10.4-2);

b) radius r_d shall be at least equal to 0,25e_s or 5 mm, whichever is greater;

c) the centre of the radius shall lie within the thickness of the flat end and not outside it, and the distance h_w of the end-to-shell weld to the outside surface of the end shall be greater than (e - 2mm), see Figure 10.4-3.

10.4.3 Flat ends with a hub

The minimum required thickness for a flat end with a hub is given by:

$$e = C_1 \cdot D_{eq} \sqrt{\frac{P}{f}} \tag{10.4-3}$$

When the distance from the inside surface of the flat portion of the end to the end-to-shell weld is larger than $l_{cyl} + r$, the coefficient C_1 is given by Figure 10.4-4 or by :

$$C_1 = MAX\left\{\left[0{,}40825\ A_1 \frac{D_i + e_s}{D_i}\right], \left[0{,}299\left(1 + 1{,}7\frac{e_s}{D_i}\right)\right]\right\} \tag{10.4-4}$$

where :

$$A_1 = B_1\left[1 - B_1 \frac{e_s}{2(D_i + e_s)}\right] \tag{10.4-5}$$

$$B_1 = 1 - \frac{3f}{P}\left(\frac{e_s}{D_i + e_s}\right)^2 + \frac{3}{16}\left(\frac{D_i}{D_i + e_s}\right)^4 \frac{P}{f} - \frac{3}{4}\frac{(2D_i + e_s)e_s^2}{(D_i + e_s)^3} \tag{10.4-6}$$

When this distance is lower than $l_{cyl} + r$, then the coefficient C_1 is still given by Figure 10.4-4 but using P/f instead of P/f_{min} .

For a uniform thickness shell per Figure 10.4-1 a),

$$D_{eq} = D_i - r \tag{10.4-7}$$

For a tapered shell per Figure 10.4-1 b),

$$D_{eq} = \frac{(D_i + D_F)}{2} \tag{10.4-8}$$

The following condition shall be met:

$$e_{af} \geq e \tag{10.4-9}$$

10.4.4 Flat ends welded directly to the shell

10.4.4.1 The minimum required thickness for the end is given, for a normal operating case, by the greatest of the following:

$$e = \max\left\{\left(C_1 \cdot D_i \sqrt{\frac{P}{f}}\right) \; , \; \left(C_2 \cdot D_i \sqrt{\frac{P}{f_{min}}}\right)\right\} \qquad (10.4\text{-}10)$$

where

$$f_{min} = \min\left\{f\,;\, f_s\right\} \qquad (10.4\text{-}11)$$

C_1 is given:

– either by Figure 10.4-4

– or by equation (10.4-4) calculated with the A_1 value derived from equations (10.4-5) and (10.4-6) using f_{min} instead of f.

C_2 is given by Figure 10.4-5.

Instead of reading C_2 on Figure 10.4-5, the term $C_2 \cdot D_i \sqrt{\frac{P}{f_{min}}}$ may also be calculated directly by means of the method given in 10.4.6

NOTE This method is based on the resolution of a cubic equation

When C_2 is less than 0,30, only the first term of equation (10.4-10) shall be considered.

10.4.4.2 For an exceptional operating case and for a hydrostatic testing case the calculation of e shall take into account only the first term of equation (10.4-10):

$$e = C_1 \cdot D_i \sqrt{\frac{P}{f}} \qquad (10.4\text{-}12)$$

10.4.4.3 In equations (10.4-10) to (10.4-12), f, f_s and P shall be understood as generic symbols valid for all types of load cases (normal, exceptional, testing) and having the following meaning:

— for a normal operating case, f is f_d, f_s is $(f_d)_s$ and P is P_d;

— or an exceptional operating case, f is f_{exp}, f_s is $(f_{exp})_s$ and P is P_{exp};

— for an hydrostatic testing case, f is f_{test}, f_s is $(f_{test})_s$ and P is P_{test}.

10.4.4.4 For a normal operating case, the minimum required thickness of the end may alternatively be calculated using equation (10.4-12) instead of (10.4-10), provided a simplified assessment of the fatigue life of the flat end to shell junction is performed according to Clause 17. In performing this assessment:

— the following stress index value shall be used :

$$\eta = 3\left(\frac{P_{max,1}}{P_{max,2}}\right) \qquad (10.4\text{-}13)$$

where $P_{max,1}$ is the maximum permissible pressure derived from equation (10.4-12) for the analysis thickness e_a;

$P_{max,2}$ is the maximum permissible pressure derived from equation (10.4-10) for the same thickness e_a.

NOTE 1 The iterative calculations which are necessary to determine $P_{max,1}$ and $P_{max,2}$ may be avoided by replacing equation (10.4-10) with the following more conservative one:

$$\eta = 3\left(\frac{C_2}{C_1}\right)^2 \frac{f}{f_{min}} \qquad (10.4\text{-}14)$$

where C_1 and C_2 are the values determined for the calculation pressure P.

— for calculation of the pseudo elastic stress range $\Delta\sigma$ with equation (17.6-1), the value to be given to the maximum permissible pressure P_{max} shall be $P_{max,1}$.

NOTE 2 The iterative calculations which are necessary to determine $P_{max,1}$ may be avoided by replacing $P_{max,1}$ with the calculation pressure P, which will lead to a more conservative result.

— the relevant plasticity correction shall be applied to $\Delta\sigma$, as required by 17.6.1.3.

— the fatigue class corresponding to the weld detail actually used for the flat end to shell junction shall be considered, as provided by Clause 17 (see Table 17-4).

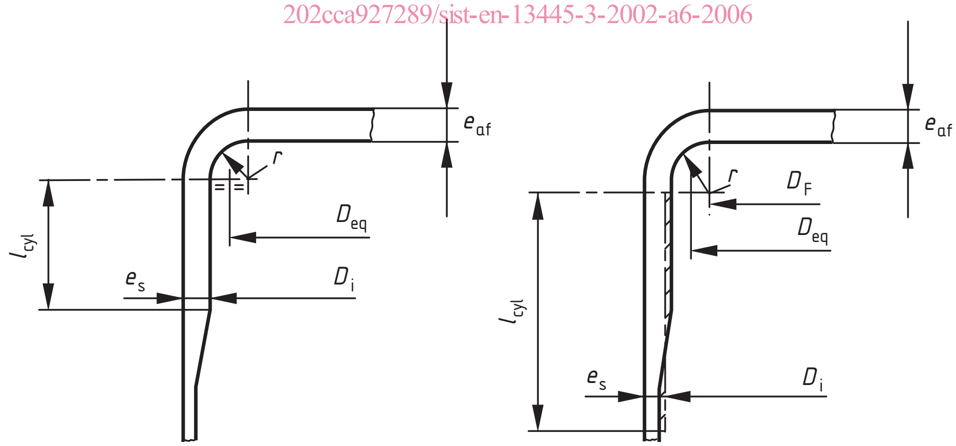
— for vessels of testing group 4, a NDE of the flat end to shell welded joint shall be performed according to the requirements of testing group 3a or 3b, as relevant (see Table 6.6.2-1 in EN13445-5).

10.4.5 Flat ends with a relief groove

The minimum required thickness for a flat end with a relief groove shall be determined using the same rules as given in 10.4.4 for flat ends without relief groove.

The minimum required thickness at the bottom of the groove is given by:

$$e_r = MAX\left\{e_s; e_s\left(\frac{f_s}{f}\right)\right\} \qquad (10.4\text{-}15)$$



a) Uniform thickness shell b) Tapered shell

Figure 10.4-1 — Circular flat ends with a hub

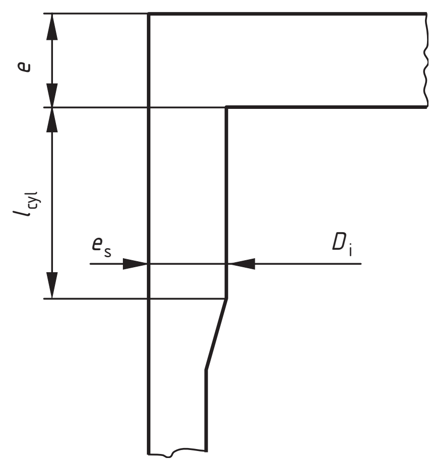


Figure 10.4-2 — Circular flat ends welded directly to the shell (refer to Annex A for acceptable weld details)

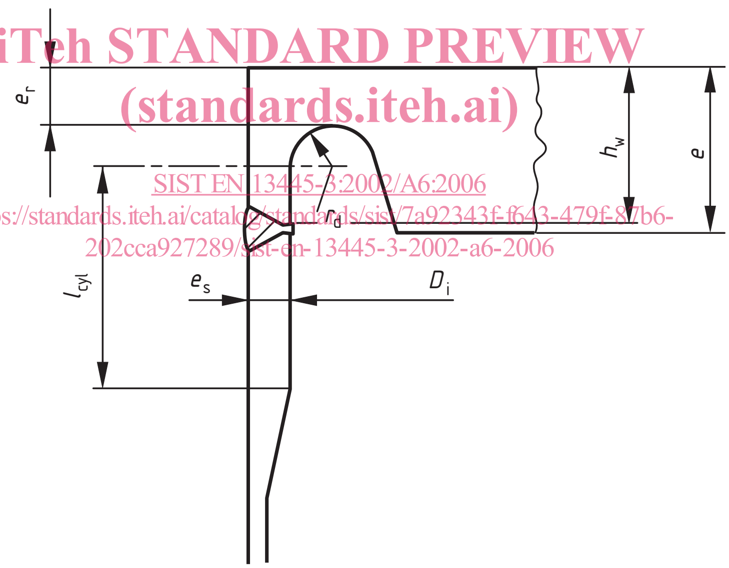


Figure 10.4-3 — Circular flat ends with a relief groove