SLOVENSKI STANDARD
SIST EN 13445-3:2014/A3:2018

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Neogrevane (nekurjene) tlačne posode - 3. del: Konstruiranje - Dopolnilo A3

Unfired pressure vessels - Part 3: Design

Unbefeuerte Druckbehälter - Teil 3: Konstruktion

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

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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 A3 modifies the European Standard EN 13445-3:2014; it was approved by CEN on 2 July 2017.

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

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European foreword

This document (EN 13445-3:2014/A3:2017) 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of an identical text or by endorsement, at the latest by February 2018, and conflicting national standards shall be withdrawn at the latest by February 2018.

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1 Modification to Clause 15

Replace Clause 15 by the following:

15 Pressure vessels of rectangular section

15.1 Purpose

This clause specifies requirements for the design of unreinforced and reinforced pressure vessels of rectangular cross-section. For fatigue, designs shall be checked against Clause 18. Thermal loads or effects are not considered in this clause.

15.2 Specific definitions

The following terms and definitions apply in addition to those in Clause 3. The governing stresses in this clause are not structural stress within the meaning of Clause 18.

15.2.1
membrane stress
equivalent uniform stress through the wall of the vessel, see also C.4.4.2

15.2.2
bending stress
equivalent linear distributed stress through the wall of the vessel, see also C.4.4.3

15.3 Specific symbols and abbreviations

The following symbols and abbreviations apply in addition to those in Clause 4:

a is the inside corner radius;

A is the area in vessel's longitudinal direction without hole between stiffeners or between stiffener walls;

A_h is the area A reduced by hole;

A_{rf} is the required reinforcing area;

A_1 is the cross-sectional area of a reinforcing member which is attached to the short side of a vessel;

A_2 is the cross-sectional area of a reinforcing member which is attached to the long side of the vessel;

A_{w1} is cross sectional area of short side stiffener webs at corner;

A_{w2} is cross sectional area of long side stiffener webs at corner;

A' is the area of that part of the composite section above or below the calculation point;

A'_{web} is the area of the reinforcement web;

b is the unsupported width of a flat plate between reinforcing elements, see Figure 15.6–1;

b_{cw} is the weld throat dimension of the continuous weld;

b_e is the effective width of a plate in combination with a reinforcing member, see Figure 15.6–1;

b_R is the pitch between centrelines of reinforcing members on a vessel;

b_v is the length of side wall (either h or H);

b_w is the weld throat dimension of the intermittent weld;

C is a shape factor determined from the long and short sides of an unsupported plate between stiffeners, see Table 15.6–2;

c is the distance from the neutral axis of a section to the outer fibre of a section and is positive when inwards;

d is either the diameter of an opening or the inside diameter of a welded connection if attached by a full penetration weld;

G is the shear modulus (by steel appr. E/2.6);

g is the length of an unsupported span;

g_w is the gap between intermittent welds;

h is the inside length of the long side;

h_1 is the distance between the neutral axes of reinforcing members on the long side;

H is the inside length of the short side;

H_1 is the distance between the neutral axes of reinforcing members on the short side;

I is the applicable second moment of area;

I_1, I_2, I_3 is the second moment of area per unit width of a plate strip;

I_{11} is the second moment of area of the combined reinforcing member and plate on the short side of the vessel;

I_{21} is the second moment of area of the combined reinforcing member and plate on the long side of the vessel;

J_1, J_2 is the stress correction factors of short vessels;

j is the distance from the neutral axis of the centroid of A';

j_{web} is the distance from the neutral axis of the centroid of $A`_{web}$;

k is a factor, see Formula (15.5.2–4) or (15.6.5–5);

k_1 is factor, see Formula (15.5.3–13);

k_2 is factor, see Formula (15.5.3–14);

K_3 is a factor for unreinforced vessel to Figure 15.5–1, see Formula (15.5.1.2–12);

Lv is the length of vessel;

L_1 is the half length of the shorter side of vessel (see Figure 15.5–1);

L_2 is the half length of the longer side of vessel;

L_x is the distance from centreline of shorter side plate to calculation point (mid of ligament or weld seam) in perpendicular direction to vessel axis;

L_y is the distance from centreline of longer side plate to calculation point (mid of ligament or weld seam) in perpendicular direction to vessel axis;

l_w is the length of the intermittent weld;

M_A is the bending moment at the middle of the long side in transversal direction of vessel, it is positive when the outside surface of the vessel (or reinforcement) has compressive stress. It is expressed as bending moment per unit length (in N·mm/mm);

M_{BC} is the bending moment in the corner of the vessel;

M_D is the bending moment at the middle of the short side of the vessel;

M_X is the bending moment at distance L_x;

M_y is the bending moment at distance L_y;

N is factor, see Formula (15.5.3–10);

p is the hole pitch along the plate length, see Figure 15.5–2;

p_s is the diagonal hole pitch in triangular hole pattern, see Figure 15.5–2;

Q is the shear force;

S_1 is the first moment of area of short side reinforcement cross section at corner in respect to outside surface of shell plate;

S_2 is the first moment of area of long side reinforcement cross section at corner in respect to outside surface of shell plate;

t_w is the thickness of web;

W is the elastic section modulus of combined cross section;

W_p is the plastic section modulus of combined (shell wall +stiffener) cross section:

α is H / h;

α_1 is H_1 / h_1;

α_2 is L_2 / L_1;

β is the angle between the line of the holes and the long axis, see Figure 15.5–2;

θ is an angle indicating position at the corner of a vessel, see Figure 15.5–2;

μ is ligament efficiency;

σ_b is bending stress;

σ_m is membrane stress;

ϕ is a factor, see Formula (15.5.1.2–15);

15.4 General

The formulas given in this subclause shall be used for calculation of the membrane and bending stresses in unreinforced and reinforced rectangular pressure vessels. The total stress at the point of consideration shall be taken as the sum of the membrane stress and the bending stress at that location.

For pressure vessels provided with doors a special analysis shall be performed to detect any deformation in the door and the edge of the vessel.

Special care should be taken in the choice of gasket for the door.

15.5 Unreinforced vessels

15.5.1 Unreinforced vessels without a stay

15.5.1.1 General

This method applies to vessels of the type shown in Figure 15.5-1. The given formulas are applicable to vessels with length Lv < 4h. The use of method for shorter vessels is conservative. The walls of short vessels with length Lv < 2h may be designed acc. to requirements in cl. 15.5.5.

It is assumed that the thicknesses of the short and long sides are equal. When they are not, the method in 15.5.3 shall be used.

15.5.1.2 Unperforated plates

Where the thickness of the smaller side is not the same as the thickness of the longer side, the calculation method in 15.5.3 shall be used.

For unreinforced vessels conforming to Figure 15.5-1, the membrane stresses are determined from the following formulas:

at C,

$$\left(\sigma_m\right)_C = \frac{P\left(a+L_2\right)}{e} \qquad (15.5.1.2\text{-}1)$$

at D,

$$\left(\sigma_m\right)_D = \left(\sigma_m\right)_C$$

at B,

$$\left(\sigma_m\right)_B = \frac{P\left(a+L_1\right)}{e} \qquad (15.5.1.2\text{-}2)$$

at A,

$$\left(\sigma_m\right)_A = \left(\sigma_m\right)_B$$

at a corner, e.g. between B and C, it is given by:

$$\left(\sigma_m\right)_{B-C} = \frac{P}{e}\left[a+\sqrt{\left(L_2{}^2+L_1{}^2\right)}\right] \qquad (15.5.1.2\text{-}3)$$

The second moment of area is given by:

$$I_1 = I_2 = e^3/12 \qquad (15.5.1.2\text{-}4)$$

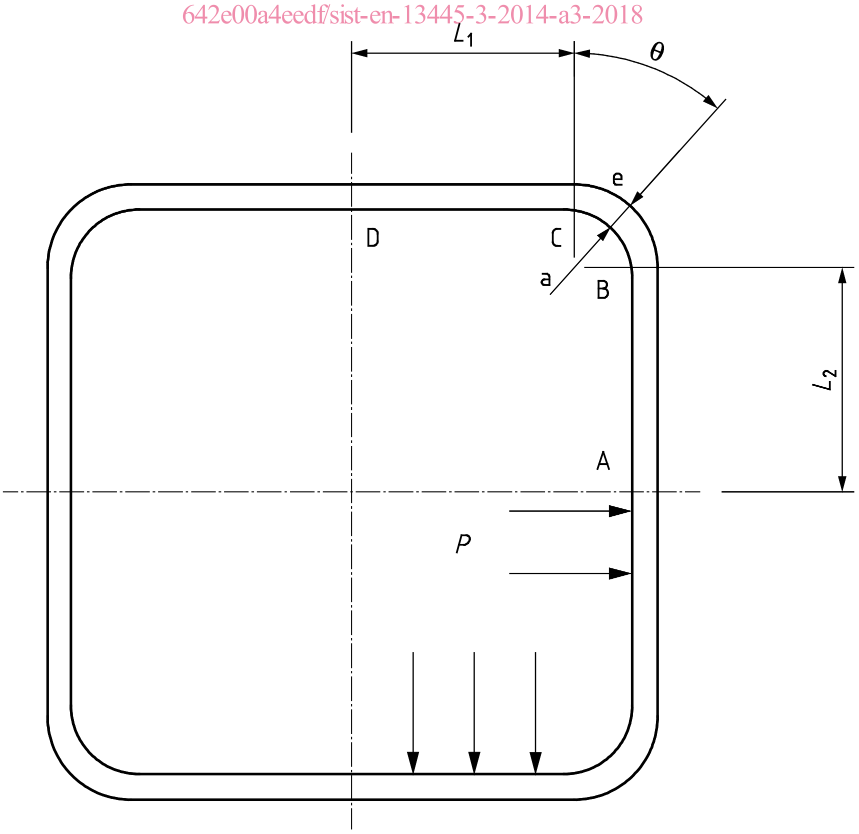

Figure 15.5-1 — Unreinforced vessels

The bending stresses shall be determined from the following formulas:

at C,

$$\left(\sigma_b\right)_C = \pm \frac{e}{4I_1}\left[2M_A + P\left(2a \cdot L_2 - 2a \cdot L_1 + L_2^{\,2}\right)\right] \qquad (15.5.1.2\text{-}5)$$

at D,

$$\left(\sigma_b\right)_D = \pm \frac{e}{4I_1}\left[2M_A + P\left(2a \cdot L_2 - 2a \cdot L_1 + L_2^{\,2} - L_1^{\,2}\right)\right] \qquad (15.5.1.2\text{-}6)$$

at A,

$$\left(\sigma_b\right)_A = \pm \frac{M_A e}{2I_1} \qquad (15.5.1.2\text{-}7)$$

at B,

$$\left(\sigma_b\right)_B = \pm \frac{e}{4I_1}\left(2M_A + PL_2^{\,2}\right) \qquad (15.5.1.2\text{-}8)$$

at the corner,

$$\left(\sigma_b\right)_{B-C} = \pm \frac{e}{4I_1}\left\{2M_A + P\left[2a\left(L_2 \cos\theta - L_1(1-\sin\theta)\right) + L_2^{\,2}\right]\right\} \qquad (15.5.1.2\text{-}9)$$

For these formulas the following shall apply:

a) the maximum value of $\left(\sigma_b\right)_{B-C}$ is given where $\theta = \arctan\left(L_1 / L_2\right)$ (15.5.1.2-10)

and

b) the bending moment M_A per unit length, is given by:

$$M_A = P \cdot (-K_3) \qquad (15.5.1.2\text{-}11)$$

where

$$K_3 = \frac{L_1^{\,2}\left(6\varphi^2 \cdot \alpha_2 - 3\pi\varphi^2 + 6\varphi^2 + \alpha_2^{\,3} + 3\alpha_2^{\,2} - 6\varphi - 2 + 1.5\pi\alpha_2^{\,2} \cdot \varphi + 6\varphi \cdot \alpha_2\right)}{3\left(2\alpha_2 + \pi\varphi + 2\right)} \qquad (15.5.1.2\text{-}12)$$

$$\alpha_2 = \frac{L_2}{L_1} \qquad (15.5.1.2\text{-}13)$$

$$\varphi = \frac{a}{L_1} \qquad (15.5.1.2\text{-}14)$$

At a location, the maximum stress shall be obtained as stated in 15.4 by summarizing the membrane and bending stresses.

15.5.1.3 Perforated plates

The vessel with perforated side plates shall fulfil the requirements of unperforated plates in 15.5.1.2. Side plate of vessel (or pipe) may be perforated by row or rows of holes. The pattern of holes placing is triangular or square. The ligament efficiency of a perforated side plate is given by:

$$\mu = \min\left[\frac{p-d}{p};\frac{1}{\cos\beta}\left(\frac{p_s-d}{p_s}\right)\right] \tag{15.5.1.3-1}$$

where β is the angle of hole pattern as defined in Figure 15.5-2.

Ligament efficiency μ is used to reduce the allowable stresses in 15.5.5 of membrane and bending stresses in perpendicular direction to vessel axis. For short vessels acc. 15.5.4 the ligament efficiency shall be minimum of those defined both in direction of longitudinal axis and perpendicular to longitudinal axis of the vessel and only the first part of Formula (15.5.1.3-1) shall be used.

If the pitch and diameter varies in plate, the smallest value of μ shall be chosen. The strength at single opening, even for opening in row of holes, shall be checked acc. to chapter 15.7.

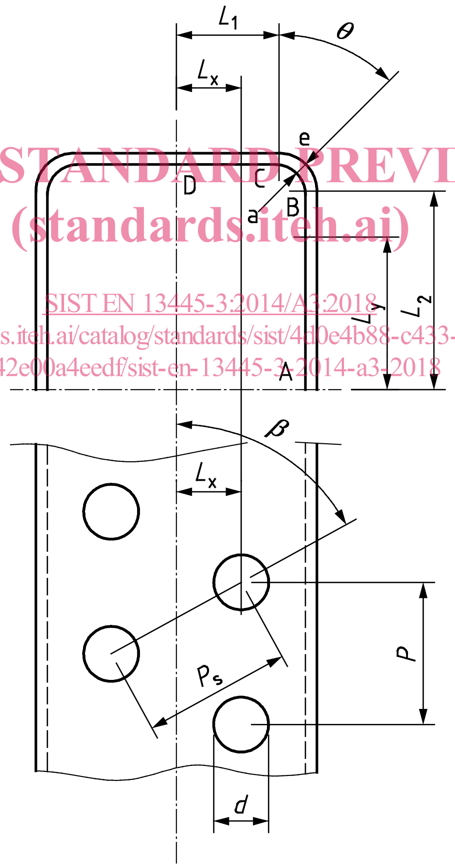

Figure 15.5-2 — Unreinforced vessels with perforated sides

If the ligament efficiency μ is at least 0,2, the membrane stresses shall be determined at point of consideration (mid of ligament) in direction perpendicular to vessel axis from the following formulas:

On longer side

$$(\sigma_m)_y = (\sigma_m)_B \tag{15.5.1.3-2}$$