SLOVENSKI STANDARD
SIST EN 13445-3:2009/A2:2014

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Neogrevane tlačne posode - 3. del: Konstruiranje - Dopolnilo A2

Unfired pressure vessels - Part 3: Design

Unbefeuerte Druckbehälter - Teil 3: Konstruktion

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

Ta slovenski standard je istoveten z: EN 13445-3:2009/A2:2013

ICS:

23.020.30	Tlačne posode, plinske jeklenke	Pressure vessels, gas cylinders

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English Version

Unfired pressure vessels - Part 3: Design

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

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This amendment A2 modifies the European Standard EN 13445-3:2009; it was approved by CEN on 9 November 2013.

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

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Foreword

This document (EN 13445-3:2009/A2:2013) has been prepared by Technical Committee CEN/TC “Unfired pressure vessels”, the secretariat of which is held by BSI.

This Amendment to the European Standard EN 13445-3:2009 shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2014, and conflicting national standards shall be withdrawn at the latest by June 2014.

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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 97/23/EC.

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document.

This document was submitted to the Formal Vote under reference number EN 13445-3:2009/FprA5.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Modification to 16.12

Delete the existing 16.12 and substitute the following.

16.12 Vertical vessels with skirts

16.12.1 Purpose

This clause gives rules for the design of support skirts for vertical vessels. It deals with the skirt itself and local stresses in the region where skirt and pressure vessel join and with the design of the base ring.

16.12.2 Specific symbols and abbreviations (see Figure 16.12-1, Figure 16.12-2, Figure 16.12-3 and Figure 16.12-4)

The following symbols and abbreviations are in addition to those in Clause 4 and 16.3:

a is the lever-arm due to offset of centre-line of shell wall;

e_B is the analysis thickness of vessel wall;

e_Z is the analysis thickness of skirt;

f_Z is the allowable design stress of skirt;

f_T is the allowable design stress of the ring (Shape A);

r is the inside knuckle radius of torispherical end;

R is the inside crown radius of torispherical end;

D_B is the mean shell diameter;

D_Z is the mean skirt diameter;

F_{Zn} is the equivalent force in the considered point ($n = p$ or $n = q$) in the skirt;

F_G is the weight of vessel without content;

ΔF_G is the vessel weight below section 2-2;

F_F is the weight of content;

M is the global bending moment, at the height under consideration;

ΔM is the moment increase due to change of centre of gravity in cut-out section;

P_H is the hydrostatic pressure;

W is the section modulus of ring according to Figure 16.12-1;

α is a stress intensification factor (see equations (16.12-33) to (16.12-36));

γ_a is the knuckle angle of a domed end (see Figure 16.12-2);

γ is part of the knuckle angle (see Figure 16.12-2);

σ is the stress;

Subscripts:

a refers to the external shell surface, i.e. side facing away from central axis of shell;

b refers to bending;

m refers to membrane stress;

i refers to the inside shell surface;

o refers to the outside shell surface;

p is the point in the section under consideration where the global moment causes the greatest tensile force in the skirt (e.g. side facing the wind = windward side);

q is the point in the section under consideration where the global moment causes the greatest compressive force in the skirt (e.g. side facing away from the wind = leeward side);

1 is the section 1-1 (see Figures 16.12-1 to 16.12-4);

2 is the section 2-2;

3 is the section 3-3;

4 is the section 4-4;

5 is the section 5-5.

16.12.3 Connection skirt / shell

16.12.3.1 Conditions of applicability

a) For tall vertical vessels, the loads on the skirt shall be determined according to Clause 22.

b) Attention shall be paid to the need to provide inspection openings.

16.12.3.2 Forms of construction

The forms of construction covered in this section are:

a) Structure shape A: Skirt connection via support in cylinder area – Figure 16.12-1;

Cylindrical or conical skirt with angle of inclination ≤ 7° to the axis;

b) Structure shape B: Frame connection in knuckle area - Figure 16.12-2;

Cylindrical or conical stand frame with angle of inclination ≤ 7° to the axis and welded directly onto the domed end in the area $0^\circ \leq \gamma \leq 20^\circ$;

Wall thickness ratio: $0{,}5 \leq e_B/e_Z \leq 2{,}25$;

Torispherical end of Kloepper or Korbbogen type (as defined in 7.2) or elliptical end having an aspect ratio $K \leq 2$ (where K as defined in equation (7.5-18)) and a thickness not less than that of a Korbbogen-type end of same diameter;

c) Structure shape C: Skirt slipped over vessel shell - Figure 16.12-3;

Cylindrical skirt slipped over vessel shell and welded on directly

It is assumed that, on either side of the joining seam for a distance of 3 e_B, there is no disturbance due to openings, end connections, vessel circumferential welds, etc.;

Note has to be taken of the risk of crevice corrosion.

Outside the above limitations, subclauses 16.12.3.4.1 and 16.12.3.4.2 do not apply. Nevertheless, subclause 16.12.3.4.3 may be used subject to calculate existing stresses by elastic shell theories.

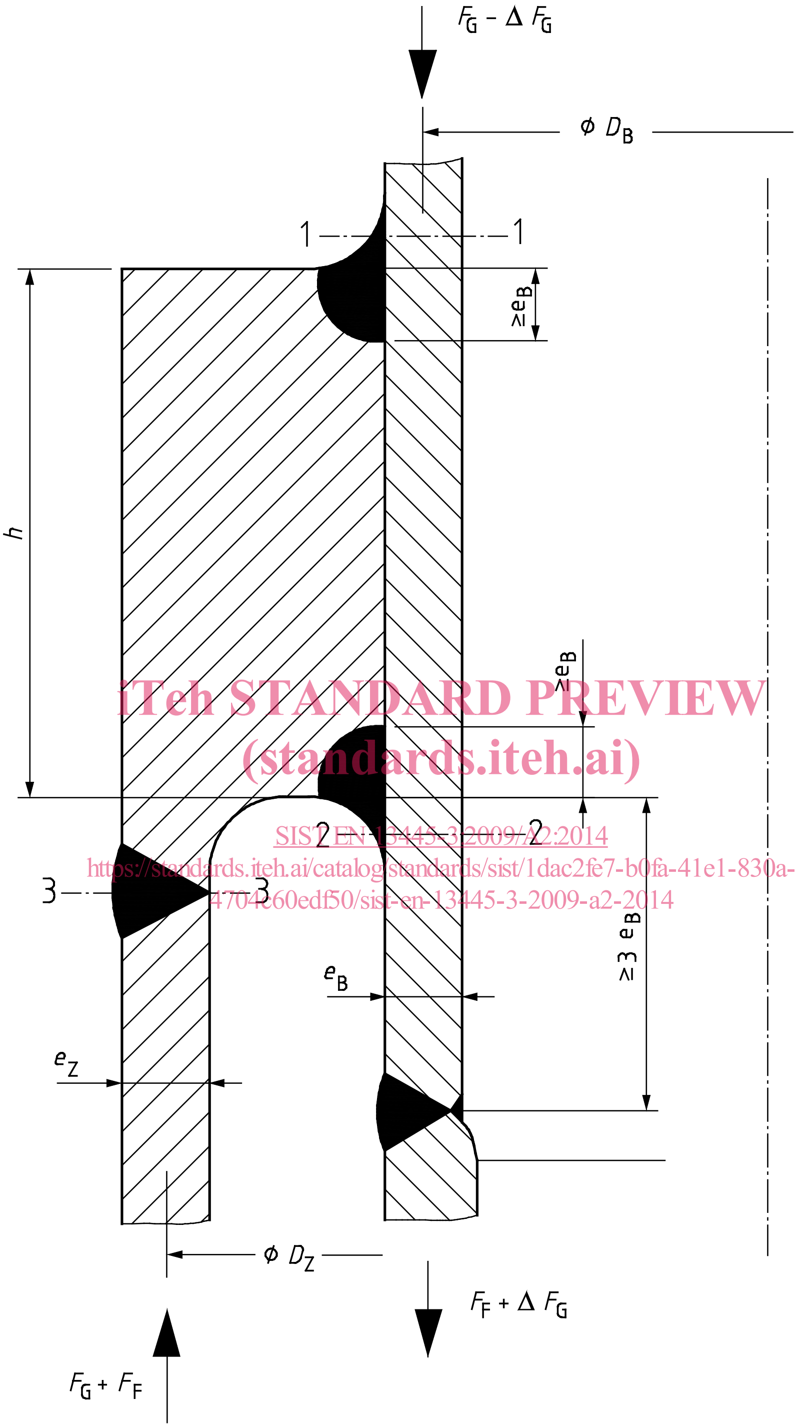


Figure 16.12-1 — Shape A: Skirt connection with supporting ring (Membrane forces due to self weight and fluid weight)

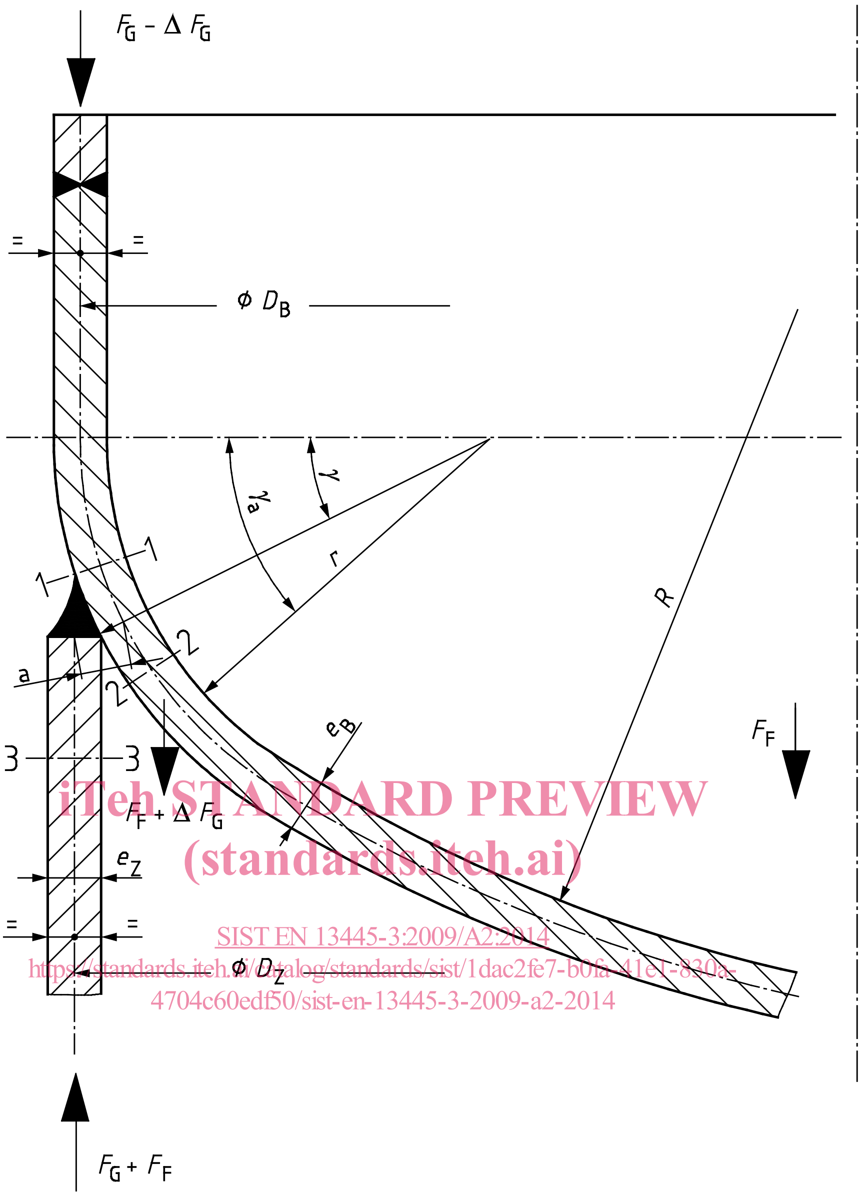


Figure 16.12-2 — Shape B: Skirt connection in knuckle area (Membrane forces due to self weight and fluid weight)

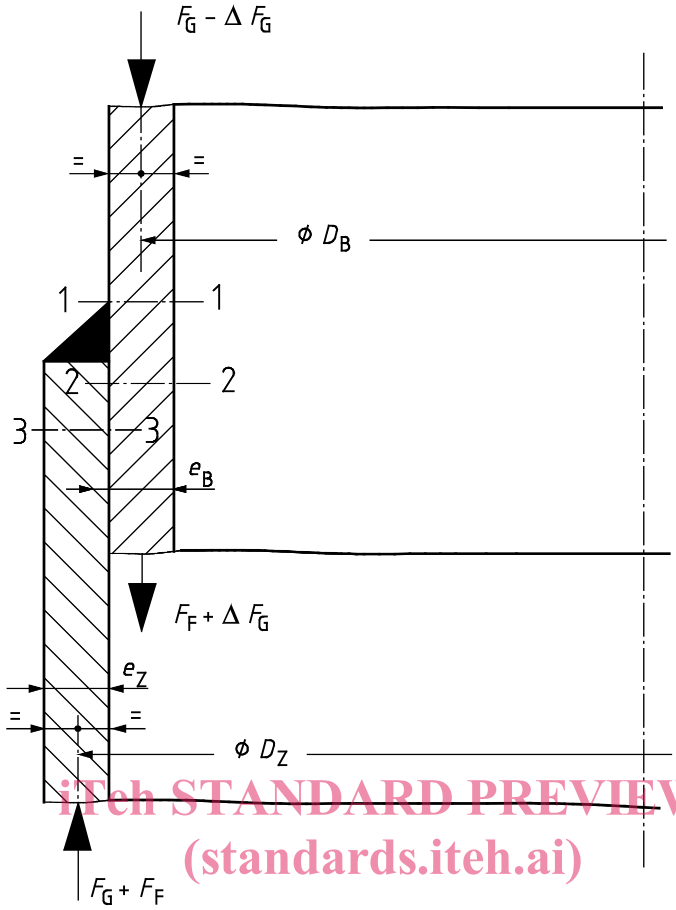
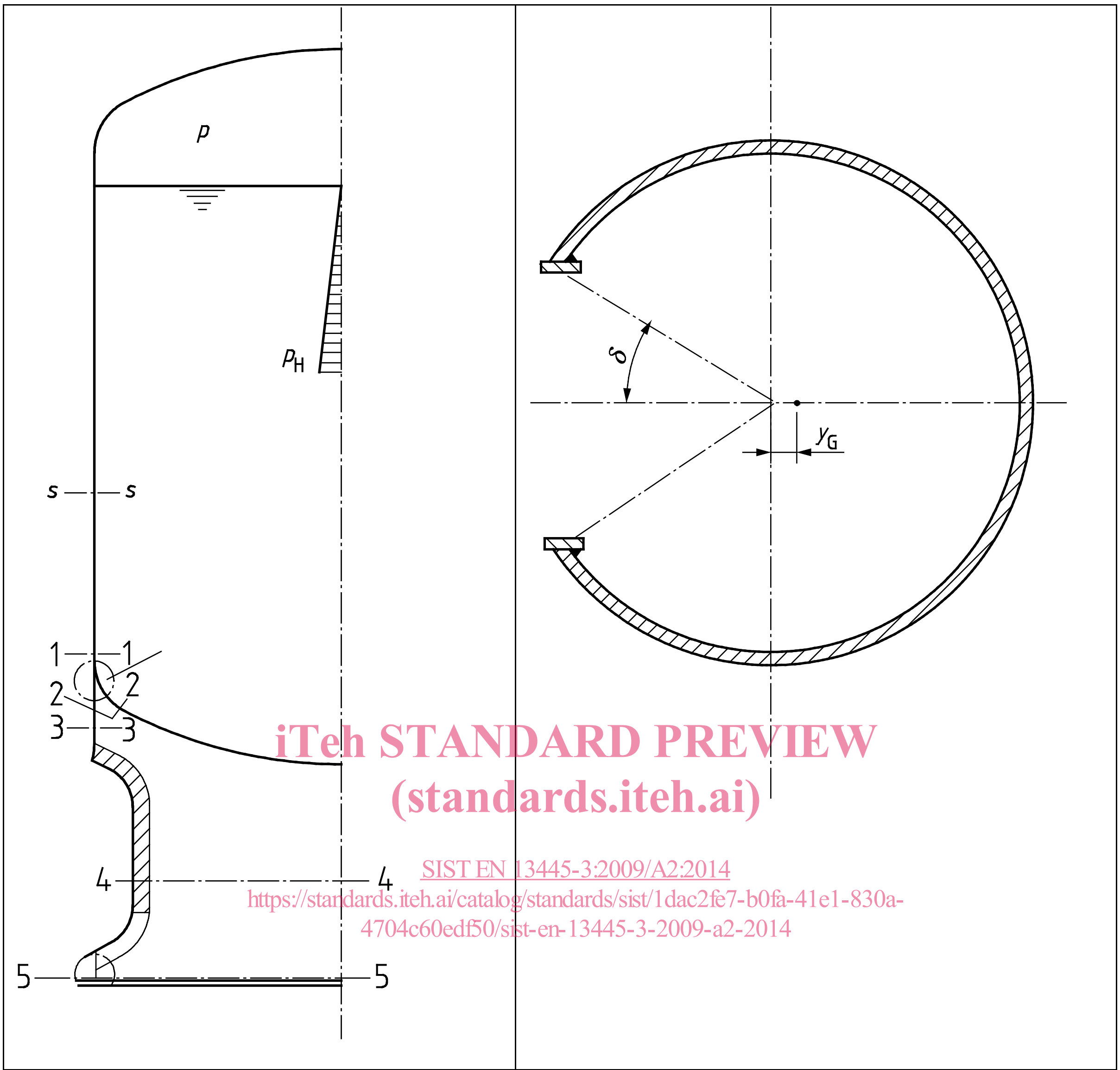


Figure 16.12-3 — Shape C: Skipped-over skirt area (Membrane forces due to self weight and fluid weight)



(a) = Section 1-1 to 5-5

(b) = Section 4-4

Figure 16.12-4 — Schematic diagram of stand frame - sections

16.12.3.3 Forces and moments

The values F_n and M_n at the respective sections $n = 1$ to $n = 4$ are determined as a function of the combination of all the loads to be taken into consideration in this load case (see Figure 16.12-4). Further checking may be necessary if the wall thickness in the skirt is stepped.

16.12.3.4 Checking at connection areas (sections 1-1, 2-2 and 3-3)

In the connection area, sections 1, 2 and 3 defined in Figure 16.12-1, Figure 16.12-2 and Figure 16.12-3 have to be checked. Checking is required for the membrane and the total stresses, while only the respective longitudinal components are being taken into account.

The section force F_z in the skirt in the region of the joint depends on the position (n), i.e. whether the moment strengthen (q) or weakens (p) the load component:

$$F_{\mathrm{Zp}} = -F_1 - F_{\mathrm{G}} - F_{\mathrm{F}} + 4\frac{M_1}{D_{\mathrm{Z}}} \quad (16.12\text{-}1)$$

$$F_{\mathrm{Zq}} = -F_1 - F_{\mathrm{G}} - F_{\mathrm{F}} - 4\frac{M_1}{D_{\mathrm{Z}}} \quad (16.12\text{-}2)$$

where

F_1 is the global additional axial force in section 1-1;

M_1 is the resulting moment due to external loads in section 1-1 above the joint; between the pressure-loaded shell and skirt.

16.12.3.4.1 Membrane stresses

The checking procedure for membrane stresses is the same for structural shapes A, B and C. The membrane stresses at point 1-1 are:

$$\sigma_{1\mathrm{p}}^{\mathrm{m}} = \frac{F_{\mathrm{Zp}} + \Delta F_{\mathrm{G}} + F_{\mathrm{F}}}{\pi\, D_{\mathrm{B}}\, e_B} + \frac{P\, D_{\mathrm{B}}}{4\, e_{\mathrm{B}}} \quad (16.12\text{-}3)$$

$$\sigma_{1\mathrm{q}}^{\mathrm{m}} = \frac{F_{\mathrm{Zq}} + \Delta F_{\mathrm{G}} + F_{\mathrm{F}}}{\pi\, D_{\mathrm{B}}\, e_B} + \frac{P\, D_{\mathrm{B}}}{4\, e_{\mathrm{B}}} \quad (16.12\text{-}4)$$

Check that:

$$\left|\sigma_{1\mathrm{p}}^{\mathrm{m}}\right| \le f \quad (16.12\text{-}5)$$

$$\left|\sigma_{1\mathrm{q}}^{\mathrm{m}}\right| \le f \quad (16.12\text{-}6)$$

The minimum required wall thickness in section 1-1 are obtained from next equations:

$$e_{1\mathrm{p}}^{\mathrm{m}} = \frac{1}{f}\left(\frac{F_{\mathrm{Zp}} + \Delta F_{\mathrm{G}} + F_{\mathrm{F}}}{\pi\, D_{\mathrm{B}}} + \frac{P\, D_{\mathrm{B}}}{4}\right) \quad (16.12\text{-}7)$$

$$e_{1\mathrm{q}}^{\mathrm{m}} = \frac{1}{f}\left(\frac{F_{\mathrm{Zq}} + \Delta F_{\mathrm{G}} + F_{\mathrm{F}}}{\pi\, D_{\mathrm{B}}} + \frac{P\, D_{\mathrm{B}}}{4}\right) \quad (16.12\text{-}8)$$

The calculation of this wall thickness is necessary for structural shape A.

If $\sigma_{1\mathrm{p}}^{\mathrm{m}}$ or $\sigma_{1\mathrm{q}}^{\mathrm{m}}$ is a compressive stress, a stability check shall be carried out according to 16.14. This check is not required if the longitudinal stress component is less than 1,6 times the value of the resulting meridian membrane compressive stress for a vacuum or partial vacuum load case, provided the latter was checked according to Clause 8. This applies also to other sections in the cylindrical area of the shell.

Regardless of the check point, the membrane stress in section 2-2 is:

$$\sigma_2^m = \sigma_{2q}^m = \sigma_{2p}^m = \frac{F_F + \Delta F_G}{\pi\, D_B\, e_B} + \frac{P\, D_B}{4\, e_B} \tag{16.12-9}$$

Check that:

$$\left|\sigma_2^m\right| \le f \tag{16.12-10}$$

The minimum required wall thickness in section 2-2 is obtained from next equation:

$$e_2^m = \frac{1}{f}\left(\frac{\Delta F_G + F_F}{\pi\, D_B} + \frac{P\, D_B}{4}\right) \tag{16.12-11}$$

The calculation of this wall thickness is necessary for structural shape A.

In section 3-3 of the skirt, the membrane stresses are equal to:

$$\sigma_{3p}^m = \frac{F_{Zp}}{\pi\, D_Z\, e_Z} \tag{16.12-12}$$

$$\sigma_{3q}^m = \frac{F_{Zq}}{\pi\, D_Z\, e_Z} \tag{16.12-13}$$

Check that:

$$\left|\sigma_{3p}^m\right| \le f_Z \tag{16.12-14}$$

$$\left|\sigma_{3q}^m\right| \le f_Z \tag{16.12-15}$$

The minimum required wall thicknesses in section 3-3 are obtained from next equations:

$$e_{3p}^m = \frac{1}{f_Z}\left(\frac{F_{Zp}}{\pi\, D_Z}\right) \tag{16.12-16}$$

$$e_{3q}^m = \frac{1}{f_Z}\left(\frac{F_{Zq}}{\pi\, D_Z}\right) \tag{16.12-17}$$

The calculation of this wall thickness is necessary for structural shape A.

If σ_{3p}^m or σ_{3q}^m is a compressive stress, the stability check may also be carried out according to 16.14.

16.12.3.4.2 Bending stresses

a) Structural shape A - Figure 16.12-1

The local bending moment at points p and q is:

$$M_p = 0,5\left(D_Z - D_B\right)\, F_{Zp} \tag{16.12-18}$$