SLOVENSKI STANDARD
SIST EN 12573-3:2000

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Welded static non-pressurized thermoplastic tanks - Part 3: Design and calculation for single skin rectangular tanks

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Geschweißte ortsfeste drucklose Behälter (Tanks) aus Thermoplasten - Teil 3: Konstruktion und Berechnung von einwandigen Rechteckbehältern (-tanks)

Cuves statiques soudées en matieres thermoplastiques sans pression - Partie 3: Conception et calcul des cuves parallélépipédiques rectangles a simple paroi

Ta slovenski standard je istoveten z: **EN 12573-3:2000**

ICS:

23.020.10	Nepremi ne posode in rezervoarji	Stationary containers and tanks

SIST EN 12573-3:2000 **en**

EUROPEAN STANDARD
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English version

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This European Standard was approved by CEN on 14 February 2000.

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This European Standard 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

Central Secretariat: rue de Stassart, 36 B-1050 Brussels

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Contents

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 266 "Thermoplastic static tanks", 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of an identical text or by endorsement, at the latest by September 2000, and conflicting national standards shall be withdrawn at the latest by September 2000.

The informative annex A gives some construction details of rectangular tanks as examples.

prEN 12573:1999 "Welded static non-pressurised thermoplastic tanks" consists of:

- Part 1: General principles
- Part 2: Calculation of vertical cylindrical tanks
- Part 3: Design and calculation of single skin rectangular tanks
- Part 4: Design and calculation of flanged joints

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This standard specifies the design and calculation for single skin rectangular tanks, fabricated from the following thermoplastics:

Polyethylene (PE)
Polypropylene (PP)
Poly (vinyl chloride) (PVC)
Poly (vinylidene fluoride) (PVDF)

The tanks may be strengthened on the outside by means of ribs or frames made of the same or other materials. This standard is only applicable to tanks which are not intended to withstand internal pressure or vacuum, other than that which may occur during the transfer of fluids (including gases) in their normal operation. The calculation takes into account short-term and long-term active pressures as well as the hydrostatic loading. The following values are long-term pressures and represent the limiting values:

Overpressure: 0,0005 N/mm^2 (0,005 bar)
Low pressure: 0,0003 N/mm^2 (0,003 bar)

Plate theory was used as the basis of the calculation in this document. Reference to membrane theory is given in Annex B.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

prEN 12573-1:1999 Welded static non-pressurised thermoplastic tanks – Part 1: General principles

EN 1778 Characteristic values for welded thermoplastic constructions – Determination of allowable stresses and moduli for design of thermoplastic equipment

3 Definitions, symbols and abbreviations

For the purposes of this part of this Standard the following definitions, symbols and abbreviations apply:

3.1 Definitions

3.1.1 **Skin:** Basic structural element of the tank.

3.1.2 **Stiffener:** Section attached horizontally or vertically to the skin of the tank.

3.1.3 **Wall:** Skin of the tank plus stiffeners.

3.1.4 **Panel:** Area of the skin between stiffeners.

3.1.5 **U-frame:** Stiffener running beneath the base and vertically up the side of the tank.

3.2 Symbols and abbreviations

E	is the elastic modulus of the stiffener material (with plastics, this corresponds to E_c), in Newton per square millimetre
$E_{c(al.)D}$	is the allowable creep modulus at the design condition for deformation (temperature, stress, time, medium), in newton per square millimetre, see EN 1778
F	is the force, in newton
f	is the maximum deflection, in millimetre
J	is the moment of inertia of stiffener, in millimetre to the fourth power
k	is the correction coefficient for the deflection of the wall
M	is the bending moment, in newton millimetre
N	is the rigidity coefficient
p	is the excess pressure on the tank base, in newton per square millimetre
p_D	is the uniformly distributed load acting on the cover, in newton per square millimetre
p_m	is the mean value of excess pressure for calculation of skin thickness, in newton per square millimetre
p_1	is the mean value of excess pressure for calculation of the stiffener, in newton per square millimetre
t	is the skin thickness, in millimetre
W	is the moment of resistance of rim stiffeners, in cubic millimetre
x	is the length of the tank or distance between the vertical stiffeners, in millimetre
x'	is the effective length of panels assigned to stiffeners, in millimetre
y	is the depth of the tank or distance between the horizontal stiffeners, in millimetre
y'	is the effective depth of panels assigned to stiffeners, in millimetre
z	is the width of the tank or panel, in millimetre
$\alpha_1 \ldots \alpha_5$	is the deformation coefficient
$\beta_1 \ldots \beta_5$	is the stress coefficient
$\sigma_{al.}$	is the allowable stress, in newton per square millimetre, see EN 1778

4 General considerations in design calculations

General principles in accordance with prEN 12573-1:1999.

Calculation methods are given only for the tank designs illustrated in figures 1 to 5.

Welds should be situated in regions of low bending moments; the maximum bending moments are shown in figures 6, 7 and 8.

> NOTE: The design should take account of the effects of thermal expansion between the tank wall and any external stiffening.

The maximum deflection shall not be larger than the half skin thickness.

$$f \leq 0{,}5\ t$$

For construction details of rectangular tank see annex A.

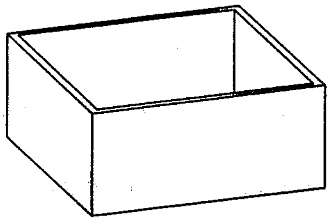


Figure 1: Unstiffened tank

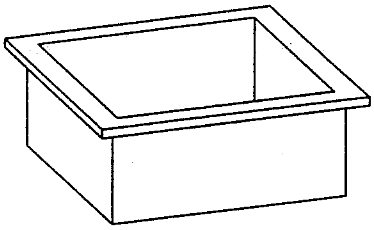


Figure 2: Tank with a horizontal rim stiffener

Figure 3: Tank with intermediate horizontal stiffeners

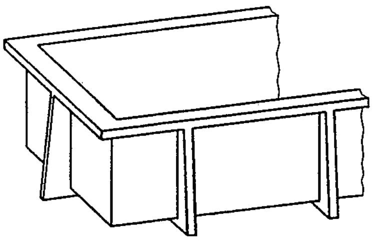


Figure 4: Tank with vertical stiffeners

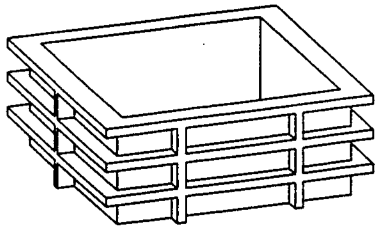


Figure 5: Tank with cross-ribbed horizontal and vertical stiffeners

5 Unstiffened tanks sitting on a continuous flat rigid surface

5.1 General

The calculation of the minimum skin thickness depends on the ratio between the length (x) and depth (y) (see figure 6). The thickness of the base shall be of similar magnitude to the actual thickness of the skin.

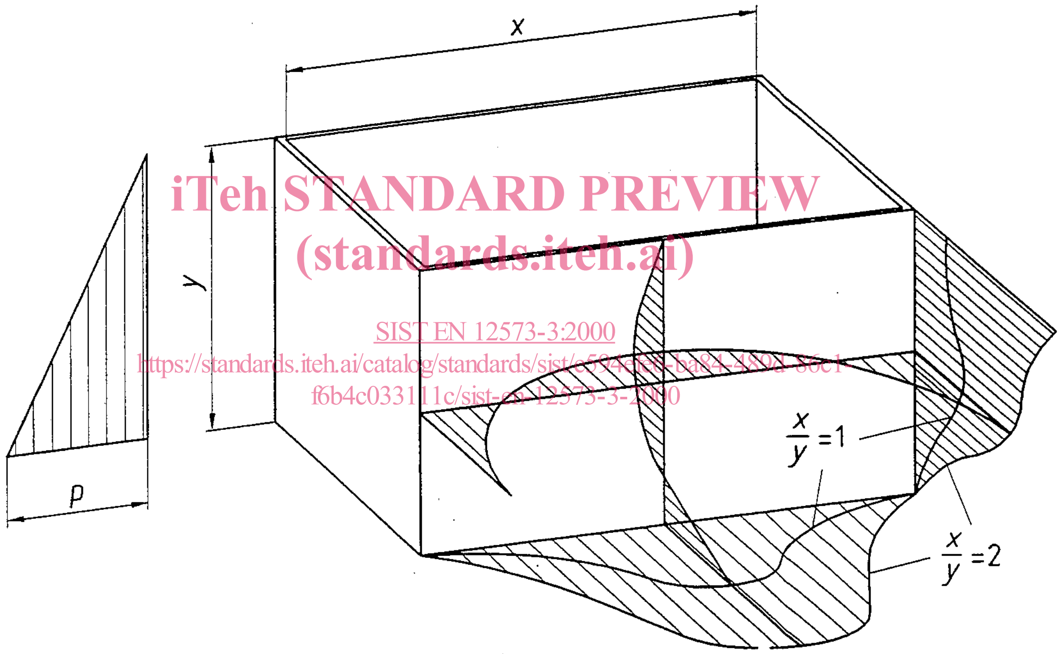


Figure 6:Principal distribution of bending moments in an unstiffened tank

5.2 Aspect ratio x/y < 0,5

The minimum skin thickness shall be calculated according to equation (1).

$$t = \sqrt{\frac{p\,x^2}{2{,}5\,\sigma_{al.}}} \qquad (1)$$

NOTE 1: In equation (1) for the skin thickness (t), the skin has been assumed as a beam fixed at both ends with the load distributed uniformly between these two points. This leads to a factor of 2 in the denominator. To provide better agreement with measured values, the factor was increased to 2,5.

The maximum deflection of the skin shall be calculated according to equation (2).

$$f = \frac{p\,x^4}{32\,k\,E_{c(al.)_D}\,t^3} \qquad (2)$$

The correction coefficient k is either 1 when x < y or 2 when x/y ≈ 0,5.

NOTE 2: In equation (2) for the deflection, there is a factor of 32 in the denominator when a beam is fixed at both ends with the load distributed uniformly between these two points. However, it is possible to use equations based on plate theory which exactly correspond to the particular load case and lead to a factor of 68 if x/y ≈ 0,5. Therefore, an additional correction coefficient k was introduced, which, depending on x/y, gives sufficiently accurate results.

5.3 Aspect ratio 0,5 ≤ x/y ≤ 4

The minimum skin thickness shall be calculated according to equation (3).

$$t = \sqrt{\beta_1 \frac{p\,y^2}{\sigma_{al.}}} \qquad (3)$$

The maximum deflection of the skin shall be calculated according to equation (4).

$$f = \frac{\alpha_1\,p\,y^4}{E_{c(al.)_D}\,t^3} \qquad (4)$$

The values for β_1 and α_1 shall be taken from table 1.

5.4 Aspect ratio x/y > 4

The minimum skin thickness shall be calculated according to equation (5).

$$t = \sqrt{\frac{p\,y^2}{\sigma_{al.}}} \qquad (5)$$

The maximum deflection of the skin shall be calculated according to equation (6).

$$f = \frac{p\,y^4}{2{,}5\,E_{c(al.)_D}\,t^3} \qquad (6)$$

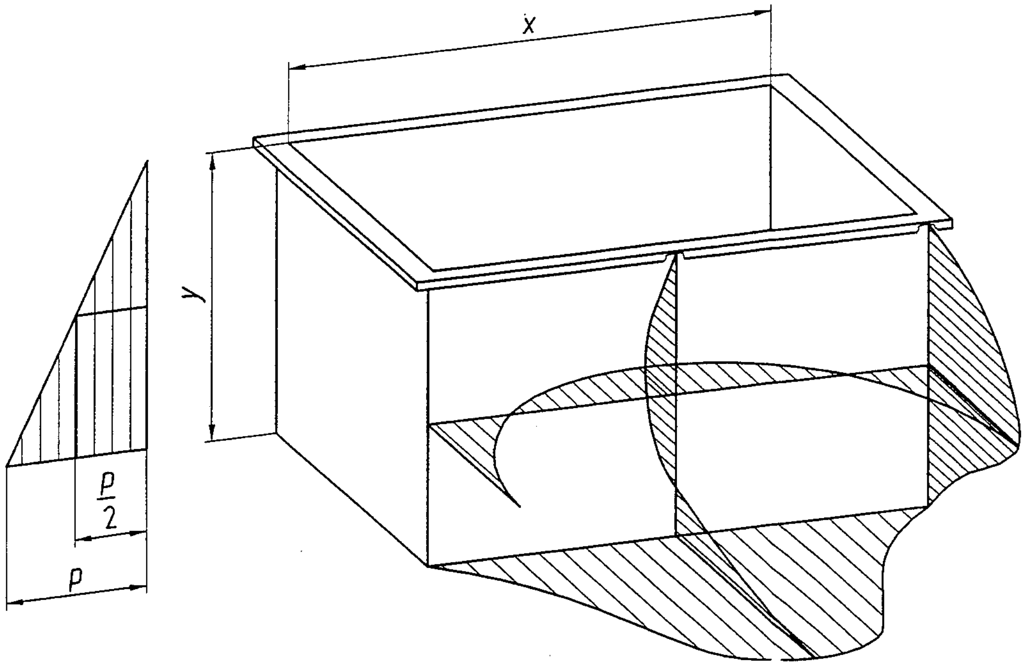
NOTE: The tank wall here is considered as a cantilever with a triangular load.

6 Tanks with rim stiffening supported on a continuous flat rigid surface

6.1 Calculation of the skin thickness

6.1.1 General

The calculation of the minimum skin thickness is based on the assumption that the rim stiffening constitutes a firm support. The thickness of the base shall be of similar magnitude to the actual thickness of the skin (see figure 7).



$\frac{p}{2}$ = average area load

Figure 7: Principal distribution of bending moments in a tank with rim stiffening

6.1.2 Aspect ratio x/y < 0,5

The minimum skin thickness shall be calculated according to equation (7).

$$t = \sqrt{\frac{p\,x^2}{3\,\sigma_{al.}}} \qquad (7)$$

NOTE 1: In equation (7) for the skin thickness (t), the skin has been assumed as a beam, fixed at both ends with the load distributed uniformly between these two points. This leads to a factor of 2 in the denominator. To provide better agreement with measured values, the factor was increased to 3.

The maximum deflection of the skin shall be calculated according to equation (8).

$$f = \frac{p\,x^4}{32\,k\,E_{c(al.)_D}\,t^3} \qquad (8)$$

The correction coefficient k is either 1 when $x < y$ or 2 when $x/y \approx 0{,}5$.

NOTE 2: In equation (8) for the deflection, there is a factor of 32 in the denominator when a beam is fixed at both ends with the load distributed uniformly between these two points. However, it is possible to use equations based on plate theory which exactly correspond to the particular load case and lead to a factor of 68 if $x/y \approx 0{,}5$. Therefore, an additional correction coefficient k was introduced, which, depending on x/y, gives sufficiently accurate results.

6.1.3 Aspect ratio 0,5 ≤ x/y ≤ 2

The minimum skin thickness shall be calculated according to equation (9).

$$t = \sqrt{\frac{\beta_2\,p\,y^2}{\sigma_{al.}}} \qquad (9)$$

The maximum deflection of the skin shall be calculated according to equation (10).

$$f = \frac{\alpha_2\,p\,y^4}{E_{c(al.)_D}\,t^3} \qquad (10)$$

The values for β_2 and α_2 shall be taken from table 1.

6.1.4 Aspect ratio x/y > 2

The minimum skin thickness shall be calculated according to equation (11).

$$t = \sqrt{\frac{p\,y^2}{2{,}5\,\sigma_{al.}}} \qquad (11)$$