BRITISH STANDARD

BS EN 12573-4:2000

Welded static non-pressurized thermoplastic tanks —

Part 4: Design and calculation of flanged joints

The European Standard EN 12573-4:2000 has the status of a British Standard

Confirmed April 2012

ICS 23.020.10

National foreword

This British Standard is the official English language version of EN 12573-4:2000.

The UK participation in its preparation was entrusted to Technical Committee PRI/62, Static thermoplastic tanks, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Find" facility of the BSI Standards Electronic Catalogue.

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Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 16, an inside back cover and a back cover.

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English version

Welded static non-pressurized thermoplastic tanks - Part 4: Design and calculation of flanged joints

Cuves statiques soudées en matières thermoplastiques sans pression - Partie 4: Conception et calculs des joints à brides

Geschweißte ortsfeste drucklose Behälter (Tanks) aus Thermoplasten - Teil 4: Konstruktion und Berechnung von Flanschverbindungen

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

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a 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 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

Ref. No. EN 12573-4:2000 E

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.

EN 12573:2000 "Welded static non-pressurized 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

The normative Annex A gives the values for the calculation of loose metal backing rings

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 part of this standard specifies the design and calculation of circular flanged joints, fabricated in the following thermoplastics:

Polyethylene (PE)

Polypropylene (PP)

Poly (vinyl chloride) (PVC)

Poly (vinylidene fluoride) (PVDF)

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.

EN 12573-1:2000 Welded static non-pressurized 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 Symbols and abbreviations

For the purposes of this part of this standard the following symbols and abbreviations apply:

A_1	is the reduction factor to take account of the effect of specific strength, see EN 1778
A_{2K}	is the reduction factor taking into account the effect of surrounding medium, see EN 1778
a	is the depth of the weld seam, in millimetres
b	is the effective double flange width, in millimetres
b_D	is the gasket width, in millimetres
C,	are welding process constants
c	is the corrosion allowance, in millimetres
d_D	is the gasket mean diameter, in millimetres
d_K	is the bolt shank diameter, in millimetres
d_L	is the bolt hole diameter, in millimetres
d'_L	is the reduced bolt hole diameter, in millimetres
d_a	is the outside diameter of flange, in millimetres
d_i	is the inside diameter of cylindrical components, in millimetres
d_t	is the pitch circle diameter, in millimetres
d_1	is the inside diameter of loose backing ring, in millimetres
d_2	is the mean contact diameter of a flange or stub flange, in millimetres
d_3	is the d_1 + 2 x flange edge radius, in millimetre, see Figure 15
f_1	is the depth of the weld undercut, in millimetres
h_D	is the gasket thickness, in millimetres
h_F	is the required thickness of a flange plate, in millimetres
K	is the creep strength at the design temperature and lifetime, in newtons per square millimetre, see EN 1778
K'	is the creep strength at a test condition (temperature and time), in newtons per square millimetre
K_D	is the deformation resistance of gasket material, in newtons per square millimetre
K_{Fl}	is the allowable yield stress of loose backing ring material (metal), in newtons per square millimetre
K_{Schr}	is the allowable yield stress of bolt material, in newtons per square millimetre
k_O	is the characteristic value of a gasket in the assembled condition, in millimetres
k_1	is the characteristic value of a gasket in the operating condition, in millimetres
L_a	is the flange neck height, in millimetres
l	is the lever arm of bolt force, in millimetres
n	is the number of bolts
P_{DV}	is the assembly force, in newtons
P_{Fl}	is the surface pressure, in newtons per square millimetre
P_{SB}	is the bolt force in operating condition, in newtons
P'_{SB}	is the bolt force at test pressure, in newtons
P_{SO}	is the bolt force in assembled condition prior to application of pressure, in newtons
p	is the operating pressure above atmospheric, in bar
p'	is the test pressure, in bar
S	is the safety factor, see part 1
S_M	is the safety factor for metals in operating condition
S'_M	is the safety factor for metals in test and assembled condition
t	is the wall thickness of cylindrical component, in millimetres
v	is the weakening coefficient
W_1, W_2, W_3	are the moments of resistance of the flange, in cubic millimetres
y_1, y_2	is the lever arm of the forces acting on the O-ring, in millimetres
α	is the angle, in degrees

4 Design requirements

4.1 General

Various types of flanges are characterized by their shapes as shown in Figure 1 to 4:

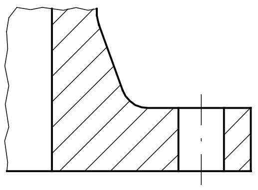


Figure 1: Fusion weld, moulded full face flange

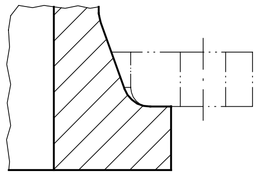


Figure 2: Fusion welded stub flange

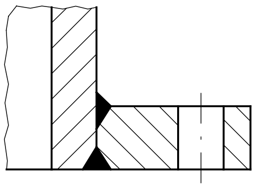


Figure 3: Welded-on full face flange

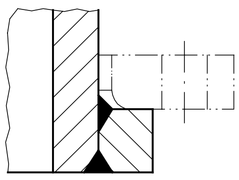


Figure 4: Welded-on stub flange

All these flange joints shall be designed with a continuous gasket or O-ring, see Figures 5 to 10:

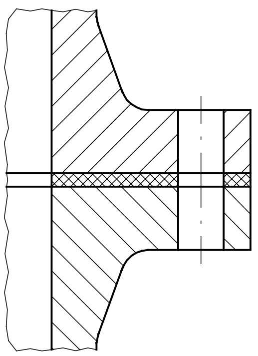


Figure 5: Full face flanges with continuous gasket

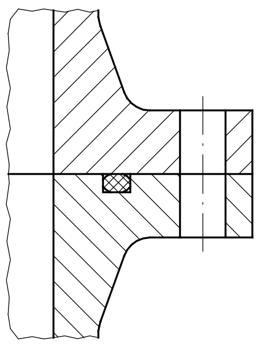


Figure 6: Full faceflanges with O-ring

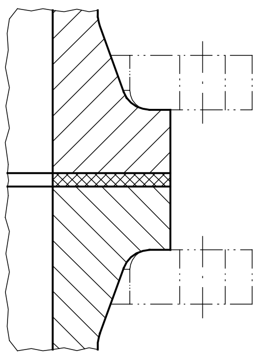


Figure 7:Stub flanges with continuous gasket

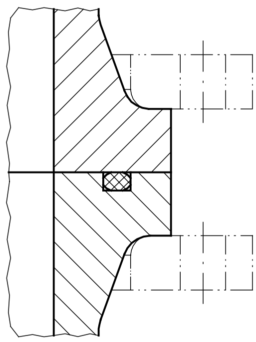


Figure 8: Stub flanges with O-ring

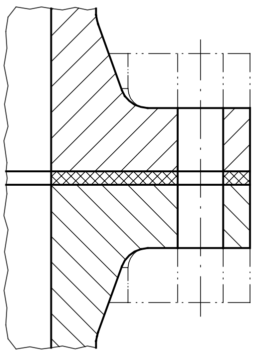


Figure 9: Full face flange and loose metal backing ring

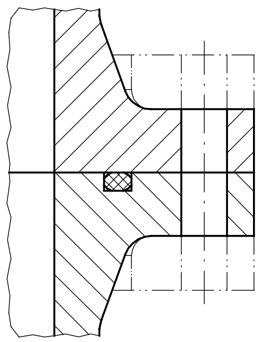


Figure 10: Full face flange and loose metal backing

4.2 Design principles

The number of bolts shall be chosen as large as possible, so that a uniform seal can be ensured. The number of bolts shall be at least four. The bolt spacing in thermoplastic flanges shall not exceed 5 d_L and shall not be greater than 80 mm.

At low pressures the calculation can produce a flange thickness which is so small that the flanges can be deformed by the bolts forces.

When positioned in the side wall of a tank below the liquid level, all flanges shall be reinforced with a loose backing ring (e.g. GRP or steel), see Figure 9 and 10.

NOTE 1: For design examples see [2] of Bibliography.

NOTE 2: When selecting the gasket material, the thermal and chemical resistance should be considered carefully. Gaskets of soft material are preferred.

5 Calculation of the properties of bolts

5.1 General

The inside diameter of the thread of the steel bolt shall be the largest value calculated from equation (1) or (2):

a) for the operating condition

$$d_k = Z\sqrt{\frac{P_{SB}}{K_{Schr} \times n}} + c \quad (1)$$

b) for the assembled condition

$$d_K = Z\sqrt{\frac{P_{SO}}{K_{Schr} \times n}} + c \quad (2)$$

where:

Z = 1,75 for steel bolts, with known allowable yield stress, where $p' \leq 1,3\ p$

c = 3 mm

External forces, e. g. due to thermal expansion, are not taken into account in equations (1) and (2).

5.2 Calculation of the bolt forces in the case of continuous gaskets

5.2.1 Operating condition

The bolt force in the operating condition shall be calculated according to equation (3).

$$P_{SB} = \frac{p}{10}\left(\frac{\pi \times d_D^2}{4} + 3,8\ d_D \times k_1\right) \quad (3)$$

5.2.2 Assembled condition

The bolt force in assembled condition shall be calculated according to equation (4).

$$P_{SO} = P_{DV} = \pi \times d_D \times k_O \times K_D \quad (4)$$

If P_{SO} becomes greater than P_{SB}, then P_{SO} shall be calculated according to equation (5).

$$P_{SO} = 0,2 P_{DV} + 0,8\sqrt{P_{SB} \times P_{DV}} \quad (5)$$

The gasket parameters k_1 and $k_0 \times K_D$ shall be taken from Table 1.

5.3 Calculation of the bolt forces in the case of O-ring gaskets

5.3.1 Flanges with O-ring gasket

The bolt force in the operating condition for flanges with O-ring gaskets, see Figure 11, shall be calculated according to equation (6).

$$P_{SB} = \frac{p \times \pi \times d_D^2}{40} \times \frac{y_1}{y_2} \tag{6}$$

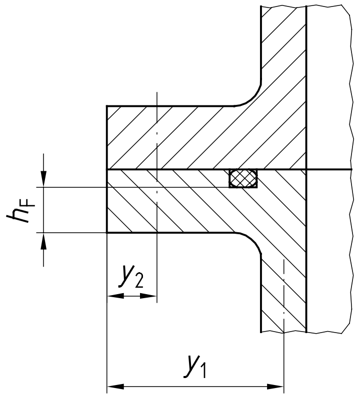


Figure 11: Flange with O-ring gasket

5.3.2 Stub flanges with O-ring gasket

The bolt force in the operating condition for stub flanges with O-ring gaskets, see Figure 12, shall be calculated according to equation (7).

$$P_{SB} = \frac{p \times \pi \times d_D^2}{40} \tag{7}$$

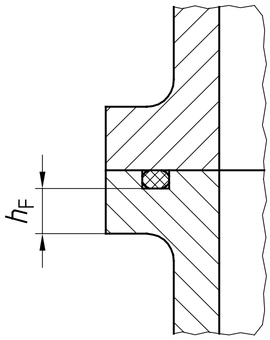
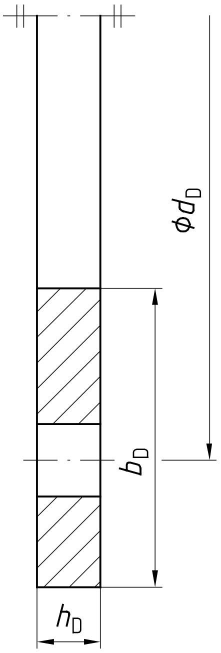
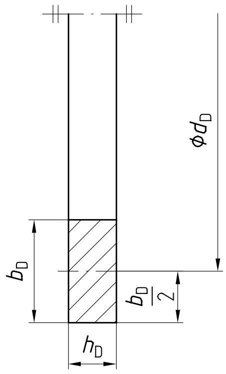


Figure 12: Stub flange with O-ring gasket

Table 1: Gasket parameters for liquids, gases and vapours

Gasket type[1]		Material	Gasket parameters[2]			
			for liquids		for gases and vapours	
with hole	without hole		$k_o \cdot K_D$ N/mm	k_1 mm	$k_o \cdot K_D$ N/mm	k_1 mm
		Rubber	1 b_D	0,5 b_D	2 b_D	0,5 b_D
		PTFE[3]	20 b_D	1,1 b_D	25 b_D	1,1 b_D

1) For flanges with a continuous gasket the effective gasket width becomes 0,5 b_D.

2) Apply to machined and undamaged sealing faces and depend on the hardness of the gasket material being lower than that of the flange material.

3) Polytetrafluoroethylene

6 Calculation of the flange thickness

6.1 General

General principles for the calculation of thermoplastic flange thickness are given in EN 12573-1:2000.

The design of the flanges is determined by the greatest flange resistance required.

For the operating condition the flange resistance shall be calculated according to equation (8).

$$W_1 = \frac{P_{SB} \times A_1 \times A_{2K} \times S}{K} \times 1 \qquad (8)$$

For the test condition the flange resistance shall be calculated according to equation (9).

$$W_2 = \frac{P_{S'B} \times A_1 \times S}{K'} \times l \quad (9)$$

For the assembled condition W_3 is not relevant. The values for K, K', A_1, A_{2K} and S are given in EN 1778.

6.2 Fusion welded, moulded full face flanges and welded-on full face flanges with a continuous gasket or with an O-ring gasket

The lever arm of the bolt force for operating and test condition, see Figures 13 and 14 , shall be calculated according to equation (10).

$$l = \frac{d_t - d_i - t}{2} \quad (10)$$

For the assembled condition the lever arm of the bolt force is zero.

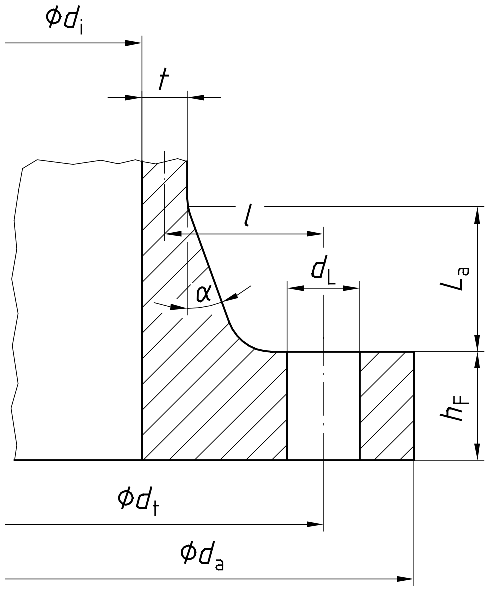


Figure 13 : Fusion welded, moulded full face flange (shown without gasket)

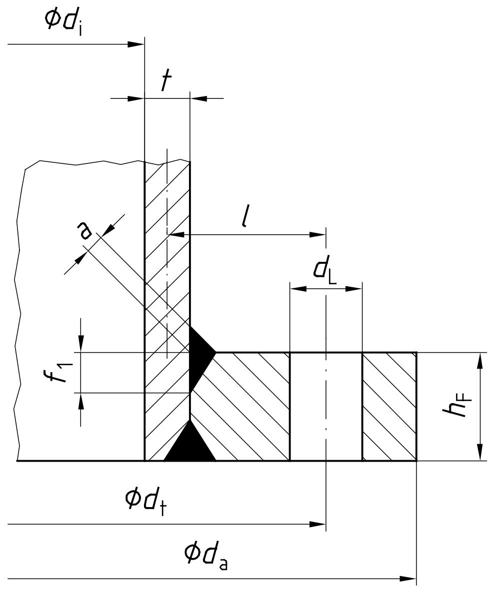


Figure 14:Welded-on full face flange (shown without gasket)

The required height of the flange plate shall be calculated according to equation (11).

$$h_F = C\sqrt{\frac{C_1 \times W}{d_t \times \pi - d_L \times n}} \quad (11)$$

where W is the largest of W_1 or W_2 .

For fusion welded, moulded full face flanges: C = 0,9; C_1 = 2

For welded-on full face flanges: C = 1,1; C_1 = 3

6.3 Fusion welded stub flanges and welded-on stub flanges with continuous gasket or with an O-ring gasket

The lever arm of the bolt force for operating and test condition, see Figures 15 and 16, shall be calculated according to equation (12).

$$l = \frac{d_2 - d_i - t}{2} \quad (12)$$

For the assembled condition the lever arm of the bolt force is zero.

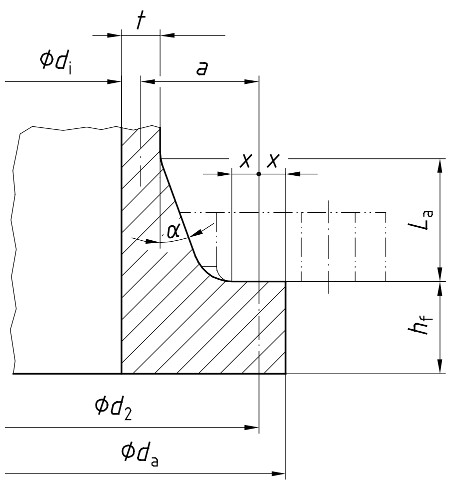


Figure 15:Fusion welded stub flange (shown without gasket)

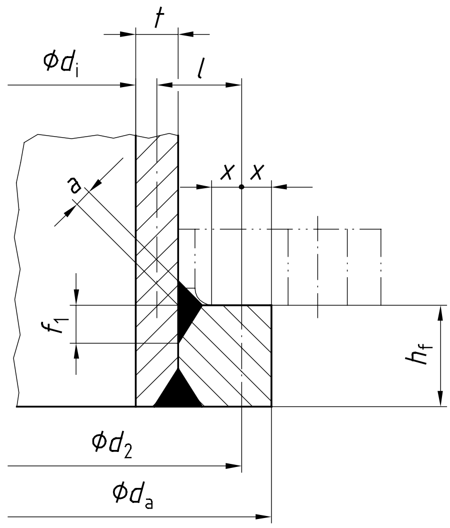


Figure 16:Welded-on stub flange (shown without gasket)

The required height of the stub flange shall be calculated according to equation (13).

$$h_F = C\sqrt{\frac{C_1 \times W}{d_2 \times \pi}} \quad (13)$$

where W is the largest of W_1 or W_2.

For fusion welded stub flanges: C = 0,9; C_1 = 2

For welded-on stub flanges: C = 1,1; C_1 = 3

The surface pressure between loose backing ring and stub flange shall be calculated and assessed according to equations (14) and (15).

$$P_{Fl} = \frac{1{,}27\ P_{SB}}{(d_a^2 - d_3^2)} \leq K \quad (14)$$

$$P_{Fl} = \frac{1{,}27\ P_{SO}}{(d_a^2 - d_3^2)} \leq K \quad (15)$$

7 Calculation of loose metal backing rings

The design of the flange, see Figure 17, is determined by the greatest required flange resistance W_1, W_2 or W_3.

For the operating condition the flange resistance W_1 shall be calculated according to equation (16).

$$W_1 = \frac{P_{SB} \times S_M}{K_{Fl}} \times l \qquad (16)$$

For the test condition the flange resistance W_2 shall be calculated according to equation (17).

$$W_2 = \frac{P_{S'B} \times S_{M'}}{K_{Fl}} \times l \qquad (17)$$

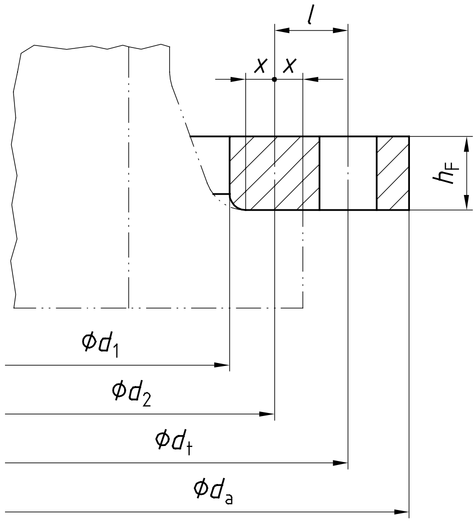


Figure 17: Loose metal backing ring

For the assembled condition the flange resistance W_3 shall be calculated according to equation (18).

$$W_3 = \frac{P_{SO} \times S_{M'}}{K_{Fl}} \times l \qquad (18)$$

If P_{SO} is greater than P_{SB}, the value for P_{SO} shall to be substituted for P_{SB} in equation (16). Equation (18) is then not required.

The values for K_{Fl} and S_M and S'_M shall be taken from Annex A.

The lever arm of the bolt force for the operating, test and assembled condition shall be calculated according to equation (19).

$$l = \frac{d_t - d_2}{2} \qquad (19)$$

The required thickness of the flange plate shall be calculated according to equation (20).

$$h_F = \sqrt{1,27 \frac{W}{b}} \tag{20}$$

where W is the largest of W_1, W_2 or W_3 and

$b = d_a - d_1 - 2d'_L$

where d'_L calculated according to equation (21).

$$d'_L = v\, d_L \tag{21}$$

where v is determined from the graph given in Figure 18.

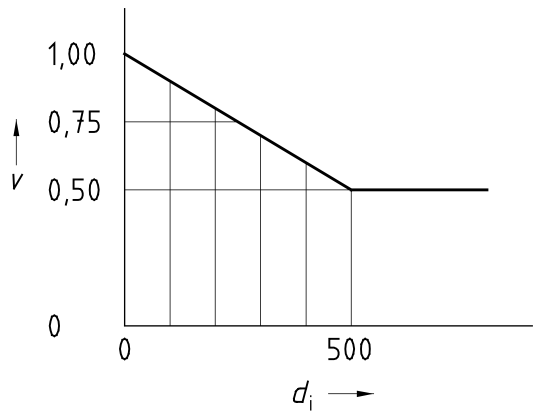


Figure 18: Reduced bolt hole diameter

Annex A (normative)

Material parameters for loose metal backing rings

Material	S_M	S'_M	K_{FI}
Rolled and forged steels	2	2,5	σ_S
Steel casting	2	2,5	$\sigma_{0,2}$
Nodular graphite iron	2	2,5	$\sigma_{0,1}$

σ_S Yield stress

$\sigma_{0,2}$ Stress at 0,2 % elongation

$\sigma_{0,1}$ Stress at 0,1 % elongation

Annex B (informative)

A-deviations

A-deviation: National deviation due to regulations, the alteration of which is for the time being outside the competence of the CEN/CENELEC member.

This European Standard does not fall under any Directive of the EU. In the relevant CEN/CENELEC countries these A-deviations are valid instead of the provisions of the European Standard until they have been removed.

Germany

- Verordnung über Anlagen zur Lagerung, Abfüllung und Beförderung brennbarer Flüssigkeiten zu Lande (Verordnung über brennbare Flüssigkeiten - VbF)

Ausgabe 12.96: Paragraph 4 Absatz 1 und Anhang II Punkt 1.2.1 Absatz a) und Punkt 2.1.2 Absatz (6)

In addition to the requirements of this European Standard the following is valid in Germany:

Walls of tanks for the storage of flammable liquids with flash points below 55 °C or of tanks which shall be installed in a potentially explosive atmosphere shall be constructed in a way that operational processes cannot cause dangerous electrostatic charge.

Therefore the following requirements shall be fullfilled:

- All metal parts of the tanks as well as the electrically conductive layers of the wall shall be conductively connected with each other. The resistance between the conductive parts and the earth shall not exceed 10^6 Ω.

- The bleeder resistor of accessible surfaces inside and outside of the tank shall not exceed 10^8 Ω.

- The surface resistance of the tank walls having no electrically conductive layers shall not exceed 10^9 Ω.

Sweden

- Act (1989:868) and Ordinance (1989:1145) on Flammables and Explosives

- Regulations on Storage and Handling of Flammables, SIND-FS 1981:2 Kap. 3 and SÄIFS 1995:7 Kap. 5.

In addition to the requirements of this European Standard the following is valid in Sweden:

Tanks for flammables have limitations for use. They are only accepted for flammables with flashpoints > 55 °C as heating oil and diesel fuel.

The tanks have to be approved by a C-type body according to EN 45000 and according to technical requirements issued by the Inspectorate.

Installation of tanks for these flammables are only accepted indoors and with requirements on fire resistance linked to the volume.

Bibliography

[1] AD-Merkblatt B 8 "Flansche";
Verband der Technischen Überwachungs-Vereine e. V. (VdTÜV);
Beuth Verlag GmbH, D-10772 Berlin

[2] DVS 2205 Part 4: Appendix

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