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Industrial valves - Shell design strength - Part 2: Calculation method for steel valve shells

Industriearmaturen - Gehäusefestigkeit - Teil 2: Berechnungsverfahren für drucktragende Gehäuse von Armaturen aus Stahl

Robinetterie industrielle - Résistance mécanique des enveloppes - Partie 2 : Méthode de calcul relative aux en-veloppes d'appareils de robinetterie en acier

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Industriearmaturen - Gehäusefestigkeit - Teil 2: Berechnungsverfahren für drucktragende Gehäuse von Armaturen aus Stahl

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Foreword

This document (prEN 12516-2:2011) has been prepared by Technical Committee CEN/TC 69 “Industrial Valves”, the secretariat of which is held by AFNOR.

This document is currently submitted to the CEN Enquiry.

This document will supersede EN 12516-2:2005.

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 (Pressure Equipment Directive).

For relationship with EU Directive 97/23/EC (Pressure Equipment Directive), see informative Annex ZA, which is an integral part of this document.

EN 12516*, Industrial valves – Shell design strength,* consists of four parts:

- *Part 1: Tabulation method for steel valve shells;*
- *Part 2: Calculation method for steel valve shells;*
- *Part 3: Experimental method;*
- *Part 4: Calculation method for valve shells manufactured in metallic materials other than steel.*

Introduction

EN 12516, *Industrial valves — Shell design strength*, is in four parts. Part 1 and Part 2 specify methods for determining the thickness of steel valve shells by tabulation or calculation methods respectively. Part 3 establishes an experimental method for assessing the strength of valve shells in steel, cast iron and copper alloy by applying an elevated hydrostatic pressure at ambient temperature. Part 4 specifies methods for calculating the thickness for valve shells in metallic materials other than steel.

The calculation method, Part 2 is similar in approach to DIN 3840 where the designer is required to calculate the wall thickness for each point on the pressure temperature curve using the allowable stress at that temperature for the material he has chosen (see Bibliography, reference [2]). The allowable stress is calculated from the material properties using safety factors that are defined in Part 2. The equations in Part 2 consider the valve as a pressure vessel and ensure that there will be no excessive deformation or plastic instability.

The tabulation method, Part 1 is similar in approach to ASME B16.34 in that the designer can look up the required minimum wall thickness dimension of the valve body from a table. The internal diameter of the inlet bore of the valve gives the reference dimension from which the tabulated wall thickness of the body is calculated.

The tabulated thicknesses in Part 1 are calculated using the thin cylinder equation that is also used in Part 2. The allowable stress used in the equation is equal to 120,7 N/mm^2 and the operating pressure, p_c, in N/mm^2, varies for each PN and Class designation. Part 1 gives these p_c values for all the tabulated PN and Class designations.

Part 1 specifies PN, Standard Class and Special Class pressure temperature ratings for valve shells with bodies having the tabulated thickness. These tabulated pressure temperature ratings are applicable to a group of materials and are calculated using a selected stress, which is determined from the material properties representative of the group, using safety factors defined in Part 1.

Each tabulated pressure temperature rating is given a reference pressure designation to identify it.

The tabulation method gives one thickness for the body for each PN (see 3.1) or Class designation depending only on the inside diameter, D_i, of the body at the point where the thickness is to be determined.

The calculated pressure is limited by the ceiling pressure which sets up an upper boundary for high strength materials and limit the deflection.

A merit of the tabulation method, which has a fixed set of shell dimensions irrespective of the material of the shell, is that it is possible to have common patterns and forging dies. The allowable pressure temperature rating for each material group varies proportionally to the selected stresses of the material group to which the material belongs, using the simple rules above.

A merit of the calculation method is that it allows the most efficient design for a specific application using the allowable stresses for the actual material selected for the application.

The two methods are based on different assumptions, and as a consequence the detail of the analysis is different (see Bibliography, reference [3]). Both methods offer a safe and proven method of designing pressure-bearing components for valve shells.

1 Scope

This part of EN 12516 specifies the method for the strength calculation of the shell with respect to internal pressure of the valve. Alternatively the strength can be verified by means of some other approved procedures.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 19, *Industrial valves — Marking of metallic valves*

EN 1092-1, *Flanges and their joints — Circular flanges for pipes, valves, fittings and accessories, PN designated — Part 1: Steel flanges*

EN 1591-1, *Flanges and their joints — Design rules for gasketed circular flange connections — Part 1: Calculation method*

EN 10269, *Steels and nickel alloys for fasteners with specified elevated and/or low temperature properties*

EN 12266-1, *Industrial valves — Testing of metallic valves — Part 1: Pressure tests, test procedures and acceptance criteria — Mandatory requirements*

EN 12266-2, *Industrial valves — Testing of metallic valves — Part 2: Tests, test procedures and acceptance criteria — Supplementary requirements*

EN 13445-3, *Unfired pressure vessels — Part 3: Design*

EN ISO 3506-1, *Mechanical properties of corrosion-resistant stainless-steel fasteners — Part 1: Bolts, screws and studs (ISO 3506-1:2009)*

3 Symbols and units

The following symbols are used:

Table 1 — Symbols characteristics and units

Symbol	Unit	Characteristic
a_H	mm	Lever arm for force FH
a_S	mm	Lever arm for bolt force
a_R	mm	Lever arm for bolt force
a_V	mm	lever arm
B	—	calculation coefficient
B_0	—	calculation coefficient

Table 1 — (*continued*)

Symbol	Unit	Characteristic
B_{0n}	—	calculation coefficient for oval cross-sections
B_1	—	calculation coefficient
B_2	—	calculation coefficient
B_3	—	calculation coefficient
B_5	—	correction factor
B_F	—	calculation coefficient
B_{FI}	—	calculation coefficient
B_{FII}	—	calculation coefficient
B_h	—	calculation coefficient
B_M	—	calculation coefficient
B_{MI}	—	calculation coefficient
B_{MII}	—	calculation coefficient
B_n	—	calculation coefficient
B_P	—	calculation coefficient
B_{PI}	—	calculation coefficient
B_{PII}	—	calculation coefficient
b	mm	Double flange width
b_1	mm	Width in cross section
b_1	mm	Width of the seal
b_2	mm	Width in cross section
b_2	mm	Width of the seal
b'_1	mm	Width in cross section
b_D	mm	Width of the seal
b_s	mm	effective width for
C_x	—	calculation coefficient

Table 1 — *(continued)*

Symbol	Unit	Characteristic
C_y	—	calculation coefficient
C_z	—	calculation coefficient
C	—	design allowance
c_1	mm	Fabrication tolerance
c_2	mm	Corrosion allowance
d_o	mm	Outside diameter
D_0	mm	Diameter in base body
d_{01}	mm	Diameter in base body
d_{02}	mm	Diameter in base body
d'_0	mm	Outside diameter
D_1	mm	Diameter in branch
D_2	mm	Diameter in further branch
D_4	mm	Outside diameter of collar flange
d_A	mm	Outside diameter of the plate/cover
d_a	mm	Flange diameter
d_b	mm	Mean diameter for calculating the pressure faces
d_i	mm	Inside diameter body
d_f	mm	Diameter of the biggest inscribed circle
d_k	mm	Diameter in knuckle
d_K	mm	Diameter in corner welds
d_L	mm	Hole diameter
d'_L	mm	Reduced bolt hole diameter
d_m	Mm	Mean diameter of the plate/cover
d_{mA}	Mm	Mean diameter of the face
d'_m	Mm	Mean diameter

Table 1 — (*continued*)

Symbol	Unit	Characteristic
d_D	mm	Mean diameter of the seal
d_s	mm	Required bolt diameter
d_t	mm	Bold circle diameter / Reference circle diameter
d_p	mm	Diameter of centre of gravity
d_{ast}	mm	Stuffing box outside diameter
d_{ist}	mm	Stuffing box inside diameter
d_{S0}	mm	Calculated bolt diameter without design allowance
d_V	mm	Diameter of the vertical force at the cone
E	MPa or N/mm^2	Modulus of elasticity
E_D	MPa or N/mm^2	Modulus of elasticity for material of the seal
e	mm	Wall thickness
e_a	mm	Wall thickness (final / actual)
e_{ac}	mm	Actual wall thickness less c_1 and c_2
e_{ac0}	mm	Final wall thickness less c_1 and c_2 for base body
e_{ac1}	mm	Final wall thickness less c_1 and c_2 for branch
e_{ac2}	mm	Final wall thickness less c_1 and c_2 for further branches
e_{ac3}	mm	Final wall thickness less c_1 and c_2 for further branches
e_{acF}	mm	Thickness of flange neck
e_{a0}	mm	Final wall thickness for base body
e_{a1}	mm	Final wall thickness for branch
e_c	mm	Calculated wall thickness, without c1 and c2

Table 1 — (*continued*)

Symbol	Unit	Characteristic
F_{DV}	N	Minimum bolt force for the assembly condition
F_F	N	Flange force
F_H	N	Horizontal component force
F_S	N	Bolt force for operating conditions
F_{SB}	N	Minimum bolt force
F_{SO}	N	Bolt force for assembly conditions
F_T	N	Tensile force
F_V	N	Vertical force at the cone
F_Z	N	Additional force
F	MPa or N/mm^2	Nominal design stress
f_d	MPa or N/mm^2	Maximum value of the nominal design stress for normal operating load cases
$f_{d/t}$	MPa or N/mm^2	Nominal design stress for design conditions at temperature t °C
g_1, g_2	mm	Welding throat depth
H	mm	Plate thickness
h_0	mm	Minimum height for the seating shoulder
h_1	mm	Minimum height of the inserted ring
h_D	mm	Minimum depth of the sealing ledge
h_r	mm	Plate thickness
h_A	mm	Height of flange hub
h_c	mm	Plate thickness
h_F	mm	Thickness of flange
h_N	mm	Reduced plate thickness

Table 1 — (*continued*)

Symbol	Unit	Characteristic
k_c	—	Welding factor
l	mm	Length
l_0	mm	Effective length for cylindrical bodies
l_1	mm	Effective length for cylindrical bodies
l_2	mm	Effective length for cylindrical bodies
l_3	mm	Effective length for cylindrical bodies
l'	mm	Length which is influenced by the entry nozzle
l'_0	mm	Length for calculating body shapes in cross section II
$\cap l_3$	mm	Length for calculating body shapes in cross section II
M	Nm	External moment
M_i	Nm	Summary of moments M_P, M_F, M_M
M_a	Nm	External moment
M_{a0}	Nm	Moment for assembly condition
M_{aB}	Nm	Moment for operation condition
M_F	Nm	Single force (point force)
M_i	Nm	Moment
M_{max}	Nm	Maximum bending moment
M_M	Nm	Rim moment
M_P	Nm	Resulting moment from internal pressure
M_r	Nm	Bending moment in radial direction
Mt	Nm	Bending moment in tangential direction
m	—	Gasket coefficient
n	—	Number of bolts
$n1$	—	Load carrying factor
p	MPa or N/mm2	Pressure

Table 1 — *(continued)*

Symbol	Unit	Characteristic
p_c	MPa or N/mm^2	Calculation pressure
p_d	MPa or N/mm^2	Design pressure
p_F	MPa or N/mm^2	Contact pressure
P_S		Centre of gravity
PS	MPa or N/mm^2	Maximum allowable pressure
R	Mm	Radius for calculating load cases
R_{eH}	MPa or N/mm^2	Yield strength
$R_{eH/t}$	MPa or N/mm^2	Upper yield strength at temperature t °C
R_i	Mm	Inner Radius of spherical cap
R_m	MPa or N/mm^2	Tensile strength
$R_{m/t}$	MPa or N/mm^2	Tensile strength at temperature t °C
$R_{m/T/t}$	MPa or N/mm^2	Creep rupture strength for T hours at temperature t °C
$R_{p0,2}$	MPa or N/mm^2	0,2 % - proof strength
$R_{p0,2/t}$	MPa or N/mm^2	0,2 % - proof strength at temperature t °C
$R_{p0,2}/_{T_{Test}}$	MPa or N/mm^2	0,2 % - proof strength at test tempera-ture t °C
$R_{p1,0}/_{T_{Test}}$	MPa or N/mm2	1,0 % - proof strength at test tempera-ture t °C
Rp1,0	MPa or N/mm2	1,0 % - proof strength