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# TÖÖSTUSLIKUD VENTIILID. KORPUSE TUGEVUS. OSA 2: TERASEST VENTIILIKORPUSTE ARVUTUSMEETOD

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

EESTI STANDARDIKESKUS
ESTONIAN CENTRE FOR STANDARDISATION

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# Contents

Page


Foreword ..... 4

1 Scope ..... 7

2 Normative references ..... 7

3 Symbols and units ..... 7

4 General conditions for strength calculation ..... 12

5 Design pressure ..... 13

6 Nominal design stresses for pressure parts other than bolts ..... 13
6.1 General ..... 13
6.2 Steels and cast steels other than defined in 6.3, 6.4 or 6.5 ..... 14
6.3 Austenitic steel and austenitic cast steel with a minimum rupture elongation not less than 30 % ..... 14
6.4 Austenitic steel and austenitic cast steel with a minimum rupture elongation not less than 35 % ..... 15
6.5 Ferritic and martensitic cast steel ..... 15
6.6 Creep conditions ..... 15

7 Calculation methods for the wall thickness of valve bodies ..... 15
7.1 General ..... 15
7.2 Wall thickness of bodies and branches outside crotch area ..... 16
7.2.1 General ..... 16
7.2.2 Cylindrical bodies or branches ..... 16
7.2.3 Spherical bodies or branches ..... 17
7.2.4 Conical bodies or branches ..... 17
7.2.5 Bodies or branches with oval or rectangular cross-sections ..... 19
7.3 Wall thickness in the crotch area ..... 26
7.4 Examples of pressure-loaded areas $A_p$ and metallic cross-sectional areas $A_f$ ..... 27
7.4.1 General ..... 27
7.4.2 Cylindrical valve bodies ..... 28
7.4.3 Spherical valve bodies ..... 30
7.4.4 Oval and rectangular cross-sections ..... 31
7.4.5 Details ..... 32

8 Calculation methods for bonnets and covers ..... 35
8.1 General ..... 35
8.2 Covers made of flat plates ..... 35
8.2.1 General ..... 35
8.2.2 Circular cover without opening, with ..... 40
8.2.3 Circular covers with concentric circular opening, with ..... 41
8.2.4 Non-circular covers (elliptical or rectangular) ..... 42
8.2.5 Special covers made of flat circular plates for specific load and clamping conditions ..... 43
8.3 Covers consisting of a spherically domed end and an adjoining flanged ring ..... 55
8.3.1 General ..... 55
8.3.2 Wall thickness and strength calculation of the spherical segment ..... 56
8.3.3 Calculation of the flanged ring ..... 57
8.3.4 Reinforcement of the stuffing box area ..... 59
8.4 Dished heads ..... 59
8.4.1 General remarks ..... 59
8.4.2 Solid dished heads ..... 60
8.4.3 Dished heads with opening ..... 61
8.4.4 Allowances on the wall thickness ..... 63


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**9 Calculation method for pressure sealed bonnets and covers ..... 64**

**10 Calculation methods for flanges ..... 66**
**10.1 General ..... 66**
**10.2 Circular flanges ..... 66**
**10.2.1 General ..... 66**
**10.2.2 Flanges with tapered neck ..... 67**
**10.2.3 Flanges greater than DN 1 000 ..... 69**
**10.2.4 Welding neck with tapered neck according to Figure 48 ..... 70**
**10.2.5 Weld-on flanges ..... 71**
**10.2.6 Reverse flanges ..... 74**
**10.2.7 Loose flanges ..... 74**
**10.3 Oval flanges ..... 76**
**10.3.1 Oval flanges in accordance with Figure 54 ..... 76**
**10.3.2 Oval flanges in accordance with Figure 55 ..... 78**
**10.4 Rectangular or square flanges ..... 80**
**10.4.1 Rectangular or square flanges in accordance with Figure 57 ..... 80**
**10.4.2 Rectangular slip-on flanges in accordance with Figure 58 ..... 80**
**10.5 Calculation of the bolt diameter ..... 81**
**10.5.1 Design temperature ..... 81**
**10.5.2 Diameter of the nominal tensile stress ..... 81**
**10.5.3 Load cases ..... 82**
**10.5.4 Safety factors and allowances ..... 82**

**11 Calculation methods for glands ..... 82**
**11.1 Loads ..... 82**
**11.2 Gland bolts ..... 83**
**11.3 Gland flanges ..... 83**
**11.4 Other components ..... 83**

**12 Fatigue ..... 83**

**13 Marking ..... 83**

**Annex A** (informative) **Characteristic values of gaskets and joints ..... 84**

**Annex B** (informative) **Calculation procedure ..... 96**

**Annex ZA** (informative) **Relationship between this European Standard and the Essential Requirements of EU Directive 97/23/EC ..... 98**

**Bibliography ..... 99**

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# Foreword

This document (EN 12516-2:2014) has been prepared by Technical Committee CEN/TC 69 “Industrial valves”, the secretariat of which is held by AFNOR.

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 April 2015, and conflicting national standards shall be withdrawn at the latest by April 2015.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 12516-2:2004.

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.

In comparison with the previous version, the following significant changes have been made:

a) the normative references were updated;

b) all formulae and figures have been renumbered; in particular 10.6 “Design temperature” became 10.5 “Calculation of the bolt diameter”;

c) some formulae were changed:

   1) Formulae (3) to (6) for calculated wall thickness have been added;

   2) Formulae (9) and (10) for calculation of $e_C$ in case of $d_o$ / $d_i$ > 1,7 have been added;

   3) Formulae (17) and (20) for conical bodies or branches have been added;

d) the figures were changed and/or updated:

   1) a new Figure 1 “Composition of section thickness and tolerance allowances” has been added;

   2) Figure 2 “Cone calculation coefficient” has been over-worked;

   3) former Figures 6a and 6b are now combined in Figure 7 “Calculation coefficient $B_n$ for rectangular cross-sections”;

   4) Figures 23, 24, and 25 used to establish the calculation coefficients $C_x$, $C_y$ and $C_z$ were moved to 8.2.1;

   5) the new Figure 46 “Types of flange connections” has been added;

e) tables were updated:

   1) Table 1 giving the symbols characteristics and units has been revised;

   2) a column for test conditions in Table 2 “Nominal design stresses (allowable stresses)” has been added;

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3) Table 5 “Flat circular plates and annular plates — Bending moments as a function of load cases and clamping conditions” has been revised;

4) Table 7 “Lever arms of the forces in the moment formulae” has been revised;

f) Clause 6 “Nominal design stresses for pressure parts other than bolts” now contains references to PED 97/23/EC;

g) Clause 7 “Calculation methods for the wall thickness of valve bodies” has been restructured; and 7.1 now contains information on calculation of the surface-comparison;

h) Subclauses 8.2.2 and 8.2.3 now draw a distinction between “direct loading” and “not subjected to direct loading”; and 8.2.3 now contains a warning regarding the mean support diameter $d_{mA}$;

i) there is a new Subclause 8.3.3.5 regarding the diameter of centre of gravity;

j) Clause 10 “Calculation methods for flanges” has been over-worked;

k) the former informative Annex A “Allowable stresses” has been deleted;

l) the Annex “Characteristic values of gaskets and joints” has been over-worked;

m) Annex ZA has been updated.

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* (the present document);

— *Part 3: Experimental method*;

— *Part 4: Calculation method for valve shells manufactured in metallic materials other than steel*.

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.

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# Introduction

EN 12516, *Industrial valves — Shell design strength*, is composed of four parts. EN 12516-1 and EN 12516-2 specify methods for determining the thickness of steel valve shells by tabulation and calculation methods respectively. EN 12516-3 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. EN 12516-4 specifies methods for calculating the thickness for valve shells in metallic materials other than steel.

The calculation method, EN 12516-2, is similar in approach to the former 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 [1]). The allowable stress is calculated from the material properties using safety factors that are defined in EN 12516-2. The formulae in EN 12516-2 consider the valve as a pressure vessel and ensure that there will be no excessive deformation or plastic instability.

The tabulation method, EN 12516-1, is similar in approach to ASME B16.34 (see Bibliography, reference [2]) 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 EN 12516-1 are calculated using the thin cylinder formula that is also used in EN 12516-2. The allowable stress used in the formula is equal to 120,7 MPa and the operating pressure, $p_c$, in MPa, varies for each PN and Class designation. EN 12516-1 gives these $p_c$ values for all the tabulated PN and Class designations.

EN 12516-1 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 EN 12516-1.

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 EN 12516-1:2014, 3.1 PN (Body)) 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 limits 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.

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## 1 Scope

This European Standard specifies the method for the strength calculation of the shell with respect to internal pressure of the valve.

## 2 Normative references

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

EN 19:2002, *Industrial valves — Marking of metallic valves*

EN 1092-1:2007+A1:2013, *Flanges and their joints — Circular flanges for pipes, valves, fittings and accessories, PN designated — Part 1: Steel flanges*

EN 1591-1:2013, *Flanges and their joints — Design rules for gasketed circular flange connections — Part 1: Calculation*

EN 10269:2013, *Steels and nickel alloys for fasteners with specified elevated and/or low temperature properties*

EN 12266-1:2012, *Industrial valves — Testing of metallic valves — Part 1: Pressure tests, test procedures and acceptance criteria - Mandatory requirements*

EN 12266-2:2012, *Industrial valves — Testing of metallic valves — Part 2: Tests, test procedures and acceptance criteria - Supplementary requirements*

EN 13445-3:2014, *Unfired pressure vessels — Part 3: Design*

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

## 3 Symbols and units

The following symbols are used:

**Table 1 — Symbols characteristics and units**

| Symbol | Unit | Characteristic |
|---|---|---|
| $a_H$ | mm | lever arm for horizontal force |
| $a_S$ | mm | lever arm for bolt force |
| $a_V$ | mm | lever arm for vertical force |
| $B$ | — | calculation coefficient to determine the thickness of the flange |
| $B_{01...03}$ | — | calculation coefficient for oval and rectangular cross-sections |
| $B_{1...3}$ | — | calculation coefficient for oval and rectangular cross-sections |
| $B_5$ | — | correction factor for oval flanges |
| $B_{FI}$, $B_{FII}$ | — | calculation coefficient for flat circular plates |
| $B_h$ | — | calculation coefficient to determine the thickness of the flange |
| $B_{MI}$, $B_{MII}$ | — | calculation coefficient for flat circular plates |
| $B_{PI}$, $B_{PII}$ | — | calculation coefficient for flat circular plates |

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