SLOVENSKI STANDARD
SIST EN 1591-1:2014

01-februar-2014

Nadomešča:
SIST EN 1591-1:2002+A1:2009
SIST EN 1591-1:2002+A1:2009/AC:2011

Prirobnice in prirobnični spoji - Pravila za konstruiranje prirobničnih spojev, sestavljenih iz okroglih prirobnic in tesnil - 1. del: Izračun

Flanges and their joints - Design rules for gasketed circular flange connections - Part 1: Calculation

Flansche und Flanschverbindungen - Regeln für die Auslegung von Flanschverbindungen mit runden Flanschen und Dichtung - Teil 1: Berechnung

Brides et leurs assemblages - Règles de calcul des assemblages à brides circulaires avec joint - Partie 1: Méthode de calcul

Ta slovenski standard je istoveten z: EN 1591-1:2013

ICS:

23.040.60	Prirobnice, oglavki in spojni elementi	Flanges, couplings and joints

SIST EN 1591-1:2014 **en,fr,de**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 1591-1

December 2013

ICS 23.040.60

Supersedes EN 1591-1:2001+A1:2009

English Version

Flanges and their joints - Design rules for gasketed circular flange connections - Part 1: Calculation

Brides et leurs assemblages - Règles de calcul des assemblages à brides circulaires avec joint - Partie 1: Méthode de calcul

Flansche und ihre Verbindungen - Regeln für die Auslegung von Flanschverbindungen mit runden Flanschen - Teil 1: Berechnung

This European Standard was approved by CEN on 12 October 2013.

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 CEN-CENELEC Management Centre 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 CEN-CENELEC Management Centre has the same status as the official versions.

CEN members are the national standards bodies of 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 United Kingdom.

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

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 1591-1:2013 E

Contents

Page

Foreword

This document (EN 1591-1:2013) has been prepared by Technical Committee CEN/TC 74 “Flanges and their joints”, the secretariat of which is held by DIN.

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 June 2014, and conflicting national standards shall be withdrawn at the latest by June 2014.

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 1591-1:2001+A1:2009.

The major changes in comparison with the previous edition include:

— correction of load ratio calculation for blind flanges;

— integration of spacers (washers);

— modification of bolt load ratio calculation;

— integration of lateral forces and torsion moments applied on the bolted joint;

— integration of an alternative calculation method (more precise) for the determination of the gasket effective width (informative annex);

— integration of the possibility to handle gasket creep/relaxation behaviour through additional deflection;

— integration of an informative annex concerning leakage rates conversions;

— integration of the possibility to check a bolted flange connection for a specified initial bolt load value;

— integration of the possibility to perform a calculation even when no tightness requirement is defined through basic gasket parameters (Annex G).

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(s).

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

EN 1591 consists of several parts:

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

— EN 1591-2, *Flanges and their joints — Design rules for gasketed circular flange connections — Part 2: Gasket parameters*

— CEN/TS 1591-3, *Flanges and their joints — Design rules for gasketed circular flange connections — Part 3: Calculation method for metal to metal contact type flanged joint*

— EN 1591-4, *Flanges and their joints — Part 4: Qualification of personnel competency in the assembly of the bolted connections of critical service pressurized systems*

— CEN/TR 1591-5, *Flanges and their joints — Design rules for gasketed circular flange connections — Part 5: Calculation method for full face gasketed joints*

The calculation method satisfies both leak tightness and strength criteria. The behaviour of the complete flanges-bolts-gasket system is considered. Parameters taken into account include not only basic ones such as:

— fluid pressure;

— material strength values of flanges, bolts and gaskets;

— gasket compression factors;

— nominal bolt load;

but also:

— possible scatter due to bolting up procedure;

— changes in gasket force due to deformation of all components of the joint;

— influence of connected shell or pipe;

— effect of external axial and lateral forces and torsion and bending moments;

— effect of temperature difference between bolts and flange ring.

The use of this calculation method is particularly useful for joints where the bolt load is monitored when bolting up. The greater the precision of this, the more benefit can be gained from application of the calculation method.

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 Scope

This European Standard defines a calculation method for bolted, gasketed, circular flange joints. Its purpose is to ensure structural integrity and control of leak tightness. It uses gasket parameters based on definitions and test methods specified in EN 13555.

The calculation method is not applicable to joints with a metallic contact out of the sealing face or to joints whose rigidity varies appreciably across gasket width. For gaskets in incompressible materials, which permit large deformations, the results given by the calculation method can be excessively conservative (i.e. required bolting load too high, allowable pressure of the fluid too low, required flange thickness too large, etc.).

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 13555:2004, *Flanges and their joints — Gasket parameters and test procedures relevant to the design rules for gasketed circular flange connections*

3 Notation

3.1 Use of figures

Figure 1 to Figure 14 illustrate the notation corresponding to the geometric parameters. They only show principles and are not intended to be practical designs. They do not illustrate all possible flange types for which the calculation method is valid.

NOTE For standard flange types, e.g as shown in EN 1092 or EN 1759, the relevant figures are the following:

Type 01	Figure 10
Type 02	Figure 12
Type 04	Figure 12
Type 05	Figure 11
Type 07	Figure 12
Type 11	Figure 6
Type 12	Figure 13
Type 13	Figure 14
Type 21	Figures 6 to 9

3.2 Subscripts and special marks

3.2.1 Subscripts

A – Additional (F_A, M_A)

B – Bolt

C – Creep of gasket (Δe_{Gc})

D – Equivalent cylinder (tapered hub + connected shell) for load limit calculation

E – Equivalent cylinder (tapered hub + connected shell) for flexibility calculation

F – Flange

G – Gasket

H – Hub

I – Load condition identifier (taking values 0, 1, 2 ...)

L – Loose flange, Lateral (F_{LI})

M – Moment

N – Nut

P – Fluid pressure

Q – Net axial force due to pressure

R – Net axial force due to external force

S – Shell, shear

T – Shell, modified

TG – Torsion (M_{TG})

X – Flange weakest cross section

W – Washer

Δ – Symbol for change or difference

av – average

c – calculated

d – design

e – effective

i – Interim value

max – maximum

min – minimum

nom – nominal

opt – optimal

req – required

s – non-threaded part of bolt

specified – refers to the case of calculation performed for a given (specified) initial bolt load

t – theoretical, torque, thread

0 – initial bolt-up condition (I = 0, see subscript I)

3.2.2 Special marks

~ – Accent placed above symbols of flange parameters that refers to the second flange of the joint, possibly different from the first.

3.3 Symbols

Where units are applicable, they are shown in brackets. Where units are not applicable, no indication is given.

A_B	Effective total cross-section area of all bolts [mm^2], Formula (41)
A_F, A_L	Gross radial cross-section area (including bolt holes) of flange ring, loose flange [mm^2], Formulae (10), (13) and (16)
A_{Ge}, A_{Gt}	Gasket area, effective, theoretical [mm^2], Formulae (56), (53)
A_Q	Effective area for the axial fluid-pressure force [mm^2], Formula (90)
E_B, E_F, E_L E_W	Modulus of elasticity of the part designated by the subscript, at the temperature of the part [MPa]
$E_{G,}$	Modulus of elasticity of the gasket for unloading/reloading at the considered temperature, considering the initial compressed thickness [MPa]
F_A	Additional external axial force [N], tensile force > 0, compressive force < 0, see Figure 1, Formulae (92) and (96)
F_B	Bolt force (sum of all bolts) [N]
F_G	Gasket force [N]
$F_{G\Delta,}$	Minimum gasket force in assembly condition [N] that guarantees, after all load changes, to subsequent conditions the required gasket force, Formulae (105), (106)
F_L	Force resulting from the additional radial forces [N], Formula (93) and (104)
F_Q	Axial fluid-pressure force [N], Formula (91)
F_R	Force resulting from the additional external loads [N], Formula (96)
F_X, F_Y, F_Z	Additional forces along X, Y and Z-axis at gasket interface [N], Formulae (92) and (93)
I	Load condition identifier, for assembly condition I = 0, for subsequent conditions I = 1, 2, 3,...
M_A	Resulting external bending moment [N × mm], Figure 1, Formula (94) and (104)
M_t	Bolt assembly torque [N × mm], Formula (B.4)

$M_{t,B}$	Twisting moment [N × mm] applied to bolt shanks as a result of application of the bolt assembly torque M_t, Formula (B.9)
M_{TG}	Additional external torsion moment due to friction, Formula (95) and (104)
N_R	Number of re-assemblies and re-tightenings during service life of joint, Formulae (119), (2)
P	Pressure of the fluid [MPa], internal pressure > 0, external pressure < 0 (1 bar = 0,1 MPa), Formula (91)

NOTE *P* in this standard is equal to the maximum allowable pressure PS according to the PED.

P_{QR}	Creep factor which is the ratio of the residual and the original gasket surface pressure at load conditions [-] (Annex F).
Q_G	Mean effective gasket compressive stress [MPa], $Q_G = F_G/A_{Ge}$ (57)
Q_A	Gasket surface pressure at assembly prior to the unloading which is necessary for the validity of the corresponding $Q_{smin\ (L)I}$ in all subsequent conditions [MPa], Formula (103).The lowest acceptable value for Q_A is $Q_{min\ (L)}$ from EN 13555.
$Q_{0,min}$	Gasket surface pressure required at assembly prior to the unloading when no specific leak rate is requested [MPa], replacement of Q_A in Formula (103), Annex G
$Q_{min\ (L)}$	Minimum level of gasket surface pressure required for tightness class L at assembly (on the effective gasket area) from EN 13555 test results [MPa] (see 7.4.2 NOTE 1)
$Q_{smin\ (L)}$	Minimum level of gasket surface pressure required for tightness class L in service conditions (on the effective gasket area) from EN 13555 test results [MPa], Formula (104)
Q_{smax}	Maximum gasket surface pressure that can be safely imposed upon the gasket at the considered temperature without damage [MPa], Formula (65), (70), (75) and (128)
T_B, T_F, T_G, T_L, T_W	Temperature (average) of the part designated by the subscript [°C] or [K], Formula (97)
T_O	Temperature of joint at assembly [°C] or [K] (usually + 20 °C), Formula (97)
U^I	Axial displacement due to thermal effect [mm]; ΔU^T according to Formula (97)
W_F, W_L, W_X	Resistance of the part and/or cross-section designated by the subscript [N × mm], Formulae (130), (146), (150), (148)
X_B, X_G, X_w	Axial flexibility modulus of bolts, gasket, washer [1/ mm], Formulae (42), (63), (43), (49), (50)
Y_B, Y_G, Y_Q, Y_R	Axial compliance of the bolted joint, related to F_B, F_G, F_Q, F_R [mm/N], Formulae (99), (100), (101), (102)
Z_F, Z_L	Rotational flexibility modulus of flange, loose flange [mm $^{-3}$], Formulae (34), (38), (35), (39), (40)
b_0	Width of chamfer (or radius) of a loose flange such that: $d_{7min} = d_6 + 2 \times b_0$ [mm], Figure 12, Formula (85)

b_F, b_L	Effective width of flange, loose flange [mm], Formulae (7) to (14)
b_{Gi}, b_{Ge}, b_{Gt}	Gasket width (radial), interim, effective, theoretical [mm], Formula (51), (55), (64), (65), (69), (70), (72), (74) and (75)
b_{KB}	Contact widths bolt side [mm], Formula (48)
b_W	Width of a washer [mm], Formula (44)
c_A, c_B, c_F, c_M, c_S	Correction factors [-],Formulae (123) to (127), (28), (134), (135)
d_0	Inside diameter of flange ring [mm] and also the outside diameter of central part of blank flange (with thickness e_0), in no case greater than inside diameter of gasket [mm], Figures 6 to 14
d_1	Average diameter of hub, thin end [mm], Figures 6, 7, 13 and 14
d_2	Average diameter of hub, thick end [mm], Figures 6, 7, 13 and 14
d_3, d_{3e}	Bolt circle diameter, real, effective [mm], Figures 6 to 14, Formula (6)
d_4	Outside diameter of flange [mm], Figures 6 to 14
d_5, d_{5t}, d_{5e}	Diameter of bolt hole, pierced, blind, effective [mm], Figures 6 to 14, Formulae (4), (5)
d_6	Inside diameter of loose flange [mm], Figures 12, 14
d_7	Diameter of position of reaction between loose flange and stub or collar [mm], Figure 1, Formulae (61) and (84) to (89).
d_8	Outside diameter of collar [mm], Figure 12
d_9	Diameter of a central hole in a blank flange [mm], Figure 11
d_{B0}, d_{Be}, d_{Bs}	Diameter of bolt: nominal diameter, effective diameter, shank diameter [mm], Figure 3, Table A.1
d_{B2}, d_{B3}	Basic pitch diameter, basic minor diameter of thread [mm], see Figure 3
d_{B4}	Maximum possible outside contact diameter between bolt head or nut and flange or washer [mm], Formula (47)
d_{Gi},d_{Ge}, d_{Gt}	Diameter of gasket, interim, effective, theoretical [mm], Figure 4, Formula (56), Table 1
d_{K1}, d_{K2}	Extreme contact diameters (inside, outside) [mm], Formulae (46) and (47)
d_{G0}, d_{G1}, d_{G2}	Real, theoretical inside, theoretical outside contact diameters [mm], Figure 4
d_E, d_F, d_L d_S, d_X, d_w	Average diameter of part or section designated by the subscript [mm], Figures 1 and 6 to 14
d_{w1}, d_{w2}	Inside, Outside diameter of washer [mm], Figure 1, 2
e_0	Wall thickness of central plate of blank flange within diameter d_0 [mm], Figure 11

e_1	Minimum wall thickness at thin end of hub [mm], Figures 6, 7, 13, 14
e_2	Wall thickness at thick end of hub [mm], Figures 6, 7, 13, 14
e_D, e_E	Wall thickness of equivalent cylinder for load limit calculations, for flexibility calculations [mm], Formulae (17) and (18)
e_F, e_L	Effective axial thickness of flange, loose flange [mm], Formulae (10), (13) and (16)
e_{Fb}	Thickness of flange ring at diameter d_3 (bolt position) [mm], Formula (5)
e_{Ft}	Thickness of flange ring at diameter d_{Ge} (gasket force position), relevant for thermal expansion [mm], Formula (98)
$e_G(Q_{G0})$	Initial compressed gasket thickness of gasket under contact pressure Q_{G0} [mm], Formulae (106), (121) can be obtained from the tests according to EN 13555
$e_{G(A)}$	Compressed gasket thickness of gasket after all the situations (including plastic deformation) [mm], Formulae (106), (121) and Annex H
e_{Gt}	Initial theoretical uncompressed thickness of gasket [mm]
e_P, e_Q	Part of flange thickness with (e_P), without (e_Q) radial pressure loading [mm], Figures 6 to 14, such that $e_P + e_Q = e_F$
e_S	Thickness of connected shell [mm], Figures 6 to 10, 12 to 14
e_W	Washer thickness [mm], Figure 1, 2
e_X	Flange thickness at weak section [mm], Figure 11
f_B, f_E, f_F, f_L, f_S, f_W	Nominal design stress [MPa] of the part designated by the subscript, at design temperature [°C] or [K], as defined and used in pressure vessel codes (see Formulae (123), (127), (130) to (133), (140), (145), (146), (148), (150) and (151))
h_G, h_H, h_L	Lever arms [mm], Figure 1, Formulae (81) to (83) and (87) to (89)
h_P, h_Q, h_R, h_S, h_T	Lever arm corrections [mm], Formulae (77), (79) and (80), (31) and (37), (29), (30)
j_M, j_S	Sign number for moment, shear force (+1 or 1), Formulae (136) and (137)
k_Q, k_R, k_M, k_S	Correction factors, Formulae (32), (33), (138), (139)
l_B, l_s	Bolt axial dimensions [mm], Figure 2, Formulae (98) and (42)
l_e	$l_e = l_B - l_S$
l_H	Length of hub [mm], Figures 6, 7, 13, 14, Formulae (17), (18)
m	tightness factor for subsequent conditions (I>0) [-], (Annex G)
n_B	Number of bolts, Formulae (3), (6), (41), (42)
p_B	Pitch between bolts [mm], Formula (3)
p_t	Pitch of bolt thread [mm], Table A.1

r_0, r_1	Radii [mm], Figures 6, 12
r_2	Radius of curvature in gasket cross-section [mm], Figure 4
ΔU^{I}	Differential thermal axial expansions [mm], Formula (97)
Δe_{Gc}	Additional deflection of the gasket due to creep that can be defined from P_{QR} value following the method explained in Annex F (Formula F.3). Equal to 0 if no creep of the gasket is considered, Formulae (105), (106), (120) and (121)
Θ_F, Θ_L	Rotation of flange, loose flange, due to applied moment [rad], Annex C
Ψ	Load ratio of flange ring due to radial force, Formula (140)
Ψ_Z	Particular value of Ψ, Formula (130), Table 2
Φ_B, Φ_F, Φ_G, Φ_L, Φ_X,	Load ratio of part and/or cross-section designated by the subscript, to be calculated for all load conditions, Formulae (123), (129), (145), (151), (128), (149), (147)
α_B, α_F, α_G, α_L, α_W	Thermal expansion coefficient of the part designated by the subscript, averaged between T_0 and T_B, T_F, T_G, T_L, T_S, T_W [K^{-1}], Formula (97)
β, γ, δ, v, κ, λ, x	Intermediate variables, Formulae (19), (25) to (27), (62), (132), (133)
ε_{1+}, ε_{1-}	Scatter of initial bolt load of a single bolt, above nominal value, below nominal value, Annex B
ε_+, ε_-	Scatter for the global load of all the bolts above nominal value, below nominal value, Annex B
μ	Friction factor for bolting, see Annex B
μ_G	Friction factor between the gasket and the flange facing, Table (E.1) and Formula (104)
π	Numerical constant (π = 3,141593)
ρ	Diameter ratio as given in Formula (36)
φ_G	Angle of inclination of a sealing face [rad or deg], Figure 4, Table 1
φ_S	Angle of inclination of connected shell wall [rad or deg], Figures 8, 9