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Flanges and their joints - Design rules for gasketed circular flange con-nections - Part 1: Calculation method - Amendment 1

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

This draft amendment is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 74.

This draft amendment A1, if approved, will modify the European Standard EN 1591-1:2001. If this draft becomes an amendment, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for inclusion of this amendment into the relevant national standard without any alteration.

This draft amendment was established by CEN 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 Management Centre has the same status as the official versions.

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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
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Foreword

This document (EN 1591-1:2001/prA1:2005) has been prepared by Technical Committee CEN/TC 74 “Flanges and their joints”, the secretariat of which is held by DIN.

This document is currently submitted to the CEN Enquiry.

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).

This document contains changes on EN 1591-1:2001 which are necessary to adjust the standard to EN 13555:2004 “Flanges and their joints — Gasket parameters and test procedures relevant to the design rules for gasketed circular flange connections”. **The changes against EN 1591-1:2001 are marked up.**

1.3.4 Mechanical model

The Calculation method is based on the following mechanical model:

a) Geometry of both flanges and gasket is axisymmetric. Small deviations such as those due to a finite number of bolts, are permitted. Application to split loose flanges or oval flanges is not permitted.

b) The flange ring cross-section (radial cut) remains undeformed. Only circumferential stresses and strains in the ring are treated; radial and axial stresses and strains are neglected. This presupposition requires compliance with condition 1.3.1 a).

c) The flange ring is connected to a cylindrical shell. A tapered hub is treated as being an equivalent cylindrical shell of calculated wall thickness, which is different for elastic and plastic behaviour, but always between the actual minimum and maximum thickness. Conical and spherical shells are treated as being equivalent cylindrical shells with the same wall thickness; differences from cylindrical shell are explicity taken into account in the calculation formula.

This presupposition requires compliance with 1.3.1 c).

At the connection of the flange ring and shell, the continuity of radial displacement and rotation is accounted for in the calculation.

d) The gasket contacts the flange faces over a (calculated) annular area. The effective gasket width (radial) b_{Ge} may be less than the true width of gasket. This effective width b_{Ge} is calculated for the assembly condition (**I** = 0) and is assumed to be unchanged for all subsequent load conditions (**I** = 1,2 ...). The calculation of b_{Ge} includes the elastic rotation of both flanges as well as the elastic and plastic deformations of the gasket (approximately) in assembly condition.

~~e) The modulus of elasticity of the gasket may increase with the compressive stress Q on the gasket. The Calculation method uses a linear model: $E_G = E_0 + K_1 \times Q$. This is the unloading elasto-plastic secant modulus measured between 100 % and 33 % of the highest stress (Q) in assembly conditions.~~

<u>e) The modulus of elasticity of the gasket may increase with the compressive stress Q on the gasket. The modulus of elasticity is the unloading elasto-plastic secant modulus measured between 100% and 33% for several gasket stress levels.</u>

~~f) Creep of the gasket under compression is approximated by a creep factor g_e (see ENV 1591-2).~~

<u>f) Creep of the gasket under compression is approximated by a creep factor P_{QR} (see ENV 1591-2).</u>

g) Thermal and mechanical axial deformations of flanges, bolts and gasket are taken into account.

h) Loading of the flange joint is axisymmetric. Any non-axisymmetric bending moment is replaced by an equivalent axial force, which is axisymmetric according to equation (44).

i) load changes between load conditions cause internal changes of bolt and gasket forces. These are calculated with account taken of elastic deformations of all components. To ensure leaktightness, the required initial assembly force is calculated (see 5.4) to ensure that the required forces on the gasket are achieved under all conditions (see 5.3 and 5.5).

j) load limit proofs are based on limit loads for each component. This approach prevents excessive deformations. The limits used for gaskets, which depend on $Q_{\max}$ are only approximations.

The model does not take account of the following:

k) Bolt bending stiffness and bending strength. This is a conservative simplification. However the tensile stiffness of the bolts includes (approximately) the deformation within the threaded part in contact with the nut or threaded hole (see equation (34)).

l) Creep of flanges and bolts.

m) Different radial deformations at the gasket (this simplification has no effect for identical flanges).

n) Fatigue proofs (usually not taken into account by codes like this).

o) external torsional moments and external shear loads, e.g. those due to pipework.

3.2 Subscripts and special marks

3.2.1 Subscripts

A – Additional (F_A, M_A)

B – Bolt

~~C – Creep of gasket~~ ($\cancel{g_c}$)

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

M – Moment

P – Pressure

Q – Net axial force due to pressure

R – Net axial force due to external force

S – Shell, shear

T – Shell, modified

X – Weak cross-section

Δ – Symbol for change or difference

av – average

c – calculated

d – design

e – effective

max – maximum

min – minimum

nom – nominal

opt – optimal

req – required

s – non-threaded part of bolt

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], equation (33)

A_F, A_L – Gross radial cross-section area (including bolt holes) of flange ring, loose flange [mm^2], equations (5), (7), (8)

A_{Ge}, A_{Gt} – Gasket area, effective, theoretical [mm^2], equations (39), (36)

C – Coefficient to account for twisting moment in bolt load ratio, equation (71)

~~E_0 – Compressive modulus of elasticity of the gasket [MPa] at zero compressive stress Q = 0 [MPa] (see ENV 1591-2)~~

E_B, E_F, E_G, E_L – Modulus of elasticity of the part designated by the subscript, at the temperature of the part [MPa] (for E_G see ENV 1591-2)

F_A – Additional external axial force [N], tensile force > 0, compressive force < 0, see Figure 1

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, equation (51)

F_Q – Axial fluid-pressure force [N], equation (43)

F_R – Force resulting from F_A and M_A [N], equation (44)

I – Load condition identifier, for assembly condition I = 0, for subsequent conditions I = 1, 2, 3, ...

I_B – Plastic torsion modulus [mm³] of bolt shanks $\left(= \frac{\pi}{12} \times \min\,(d_{Be}; d_{Bs})^3\right)$ 1, equation (71)

~~K_I – Rate of change of compressive modulus of elasticity of the gasket with compressive stress, ENV 1591-2~~

K_s – Systematic error due to the inaccuracy of the bolt tightening method

M_A – Additional external moment [N × mm], Figure 1

M_t – Bolt assembly torque [N × mm], annex D

$M_{t,B}$ – twisting moment [N × mm] applied to bolt shanks as a result of application of the bolt assembly torque M_t, equations (71) and (D.8) to (D.11)

N_R – Number of re-assemblies and re-tightenings during service life of joint, equation (67)

P – Pressure of the fluid [MPa], internal pressure > 0, external pressure < 0 (1 bar = 0,1 MPa)

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

Q – Mean effective gasket compressive stress [MPa], $Q = F_G/A_{Ge}$

$Q_{smin(L)I}$ – Minimum level of gasket surface pressure required for tightness class L after off-loading at load condition I [MPa]

$Q_{min(L)}$ – Minimum level of gasket surface pressure required for tightness class L on assembly (on the effective gasket area) [MPa], equation (49), (see ENV 1591-2)

Q_{smax} – Maximum gasket surface pressure that can be safely imposed upon the gasket at the service temperature without damage (for reference geometry DN40/PN40) [MPa]

Q_{max} – Maximum gasket surface pressure that can be safely imposed upon the gasket at the service temperature without damage (for actual geometry of the gasket used in bolted flange connection) [MPa]

$Q_{max,Y}$ – Maximum gasket surface pressure that can be safely imposed upon the gasket at the service temperature without damage (independent from the geometry of the gasket) [MPa]

T_B, T_F, T_G, T_L – Temperature (average) of the part designated by the subscript [°C] or [K], equation (45)

T_O – Temperature of joint at assembly [°C] or [K] (usually + 20 °C)

U – Axial displacement [mm]; ΔU according to equation (45)

W_F, W_L, W_X – Resistance of the part and/or cross-section designated by the subscript [N × mm], equations (74), (86), (88), (90)

X_B, X_G – Axial flexibility modulus of bolts, gasket [1/ mm], equations (34), (42)

Y_G, Y_Q, Y_R – Axial compliance of the bolted joint, related to F_G, F_Q, F_R [mm/N], equations (46), (47), (48)