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Neogrevane tlaļ ne posode - 3. del: Konstruiranje

Unfired pressure vessels - Part 3: Design

Unbefeuerte Druckbehälter - Teil 3: Konstruktion

Récipients sous pression non soumis à la flamme - Partie 3: Conception

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Unfired pressure vessels - Part 3: Design

Récipients sous pression non soumis à la flamme - Partie 3: Conception

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This amendment A10 modifies the European Standard EN 13445-3:2002; it was approved by CEN on 27 November 2006.

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This amendment 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 Management Centre has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Foreword

This document (EN 13445-3:2002/A10:2008) has been prepared by Technical Committee CEN/TC 54 “Unfired pressure vessels”, the secretariat of which is held by BSI.

This Amendment to the European Standard EN 13445-3:2002 shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2008, and conflicting national standards shall be withdrawn at the latest by September 2008.

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 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.

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

The document includes the text of the amendment itself. The corrected pages of EN 13445-3 will be delivered as issue 30 of the standard.

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, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

Add the following Annex GA:

Annex GA
(informative)

Alternative design rules for flanges and gasketed flange connections

GA.1 Purpose

This annex provides a calculation method for bolted, gasketed circular flange joints. It is applicable to flanges and bolted domed ends, and it is an alternative to the methods in Clauses 11 and 12.

Its purpose is to ensure structural integrity and leak tightness for an assembly comprising two flanges, bolts and a gasket. Flange loadings are shown in Figure GA.3-1. Different types of bolts and gaskets are shown in Figures GA.3-2 to GA.3-3.

This annex does not consider bolted tubesheet flange connections with two gaskets and/or two different fluid pressures. It also does not consider flange joints with integral tubesheet-flange-connections and such with two shells connected to a flange (jacketed vessels or pipes).

NOTE This informative Annex is a further development of the Alternative method contained in Annex G. It may be used particularly in the case of bolted flanged connections of vessels containing gases or vapours, for which it is necessary to fix a maximum allowable leak rate in order to protect the environment. The gasket factors contained in Tables GA.9.1 to GA.9.6 are partially based on research results, and partially on theoretical considerations. Use of such factors should be made with caution, with the agreement - whenever possible - of the gasket manufacturer concerned.

GA.2 Specific definitions

The following terms and definitions apply in addition to those in 11.2.

GA.2.1
integral flange
flange either integral with or welded to the shell, see Figures GA.3-4 to GA.3-8

GA.2.2
blind flange
flat closure connected by bolts, see Figure GA.3-9

GA.2.3
loose flange
separate flange-ring abutting a stub or collar, see Figure GA.3-10

GA.2.4
hub
axial extension of a flange-ring, usual connecting flange-ring to shell, see Figures GA.3-4 and GA.3-5

GA.2.5
collar or stub
abutment for a loose flange, see Figure GA.3-10

GA.2.6
load condition
application of a set of applied simultaneous loads; designated by the identifier I

GA.2.7
load change
change of load condition

GA.2.8
assembly condition
as defined in 11.2 and designated by I = 0 in this annex

GA.2.9
subsequent condition
load condition subsequent to the assembly condition, e.g. working condition, test condition, conditions arising during start-up and shut-down, designated by I = 1, 2, 3…

GA.2.10
external loads
forces and/or moments applied to the joint by attached equipment, e.g. weight or thermal expansion of pipes

GA.2.11
compliance
inverse of the stiffness of the assembly, symbol Y, units mm/N

GA.2.12
flexibility modulus
inverse of the stiffness modulus of a component, excluding the elastic constants of the material; axial; symbol X, units 1/mm; rotational: symbol Z; units $1/mm^3$

GA.3 Specific symbols and abbreviations

GA.3.1 Use of figures (General)

Figures GA.3-1 to GA.3-10 serve only to illustrate the notation. They are not intended to give all the detail of different designs. They do not illustrate all possible flange types for which the method is valid.

GA.3.2 Subscripts

Subscripts to indicate parts are always large (uppercase). Subscripts to indicate properties (behaviour) may be small (lowercase). Subscripts written in brackets (I and/or J) may be waived.

A	for	Assembly load condition, Additional (F_A, M_A)
B	for	Bolt
C	for	Contact (bolt/nut/washer/flange)
E	for	Equivalent or effective values (cylinder, gasket pressure)
F	for	Flange
G	for	Gasket
H	for	Hub
I	for	Load condition identifier, written in brackets, (I = 0, 1, 2, 3 …)
J	for	Identification for parts of the one or other side of the flange connection, or for cases to determine tightness parameters, written in bracket, (J = 1 or 2)
L	for	Loose flange, Loading
M	for	Moment

P	for	Pressure (fluid pressure)
Q	for	Net axial force due to pressure
R	for	Net axial force due to external loads (Resultant)
S	for	Shell, Shaft, Shear, Subsequent load condition
U	for	Unloading
W	for	Washer
X	for	Flange weakest cross section
X, Y, Z	for	Subscript for components of additional loads (forces, moments)
Δ	for	Symbol for change or difference
act	for	Actual (real, for several times calculated values the last calculated)
av	for	Average
d	for	Design, desired
e	for	Effective
i	for	Interim (calculated, not finally)
max	for	Maximum (also: mx)
min	for	Minimum
nom	for	Nominal
req	for	Required
t	for	Theoretical
0	for	Zero load condition (I = 0, see subscript I), also other use

GA.3.3 Symbols

Units are given in square brackets; [-] indicates that the quantity is dimensionless (dimension [1]).

Subscripts to the symbols are written as follows:

— First subscripts specify the structural element (e.g. F for flange or G for gasket) and the kind of quantity (e.g. 3 for diameter 3 or E for effective).

— If an element exists more than once (e.g. two different flanges, numbered by J = 1 and J = 2), their distinction may be specified by an additional subscript (number in brackets); however it is not necessarily given.

— The last subscript specifies the load condition (I). If it is written, then always in brackets; however it is not necessarily given. In some cases the both last subscripts look as follows: (J, I).

A_B	is the effective total cross-section area [mm^2] of all bolts, Equation (GA.5-43);
A_F, A_L	is the radial cross-section area [mm^2] of flange ring, loose flange, Equations (GA.5-7), (GA.5-11) and (GA.5-14);
A_{Ge}, A_{Gt}	is the gasket area [mm^2], effective, theoretical, Equations (GA.5-67) and (GA.5-56);
A_Q	is the effective area [mm^2] for the axial fluid-pressure force, Equation (GA.5-69);
b_0	is the width [mm] of the chamfer or radius on a loose flange, Figure GA.3-10;

b_{CB}, b_{CF} are contact widths [mm], bolt side, flange side, see GA.5.2.3 and GA.7.2.2;

b_{CC} is the contact width common for bolt and flange side of a washer [mm], Equation (GA.5-49);

b_F, b_L is the effective width [mm] of a flange, loose flange, Equations (GA.5-5) to (GA.5-12);

b_{Ge}, b_{Gi}, b_{Gp}, b_{Gt} are gasket widths [mm], effective, interim, plastic, theoretical, Table GA.5-1, Equations (GA.5-54), (GA.5-65) and (GA.5-66);

b_W is the effective width [mm] of a washer, Equation (GA.5-45);

C_0 is the deformation modulus [MPa] for loading of the gasket at zero compressive stress (Q = 0), see GA.9.2;

C_1 is the rate of change of the deformation modulus [-] for loading of the gasket with compressive stress (Q > 0), see GA.9.2;

c_A, c_B, c_C, c_E, c_F, c_G, c_M, c_S are correction factors [-], Equations (GA.5-26), (GA.5-58), (GA.7-1) to (GA.7-3), (GA.7-5), (GA.7-10), (GA.7-12), (GA.7-24) and (GA.7-30) to (GA.7-33);

d_0 is the inside diameter of the flange ring [mm] or outside diameter of the central part of a blind flange (with thickness e_0). In no case it is greater than the inside diameter of the gasket [mm], Figures GA.3-4 to GA.3-10;

d_1 is the average diameter of hub, thin end [mm], Figures GA.3-4 and GA.3-5;

d_2 is the average diameter of hub, thick end [mm], Figures GA.3-4 and GA.3-5;

d_3 is the bolt hold circle diameter [mm], Figures GA.3-4 to GA.3-10;

d_4 is the flange outside diameter [mm], Figures GA.3-4 to GA.3-10;

d_5 is the diameter of bolt holes [mm], Figures GA.3-4 to GA.3-10, Equations (GA.5-2) and (GA.5-3);

d_6 is the inside diameter of a loose flange [mm], Figure GA.3-10;

d_7 is the diameter of the position of the reaction between a loose flange and a stub or collar [mm], Figure GA.3-1, Equations (GA.5-75) to (GA.5-81);

d_8 is the outside diameter of stub or collar [mm], Figure GA.3-10;

d_9 is the diameter of a central hole in a blind flange [mm], Figure GA.3-9;

d_{B0}, d_{Be}, d_{BS} are bolt diameters (nominal, effective, waisted) [mm], Figure GA.3-2;

d_{B4} is the maximum possible outside contact diameter [mm] between bolt head or nut and flange or washer; Equation (GA.5-48) and Table GA.8-1;

d_{C1}, d_{C2} are extreme contact diameters (inside, outside) [mm], see GA.5.2.3 and GA.7.2.2;

d_{CB}, d_{CF} are average contact diameters [mm], bolt side, flange side, see GA.5.2.3 and GA.7.2.2;

d_{G0}, d_{G1}, d_{G2} are gasket contact diameters (real contact at curved surfaces, theoretical inside, theoretical outside) [mm], Figure GA.3-3;

d_{Ge}, d_{Gi}, d_{Gt} are gasket calculation diameters (effective, interim, theoretical) [mm], Figure GA.3-4, Table GA.5-1;

d_E, d_F, d_L, d_S, d_W, d_X are average diameters of a part or section (designated by the subscript) [mm], Equations (GA.5-6) to (GA.5-22) and (GA.7-26) to (GA.7-46);

d_{W1}, d_{W2} are washer diameters (inside, outside) [mm], Figure GA.3-1, Equations (GA.5-45) to (GA.5-52);

D_G is the deformation modulus [MPa] for loading of the gasket, see GA.9.1;

E_G is the modulus of elasticity [MPa] for unloading/reloading of the gasket, see GA.9.1;

E_B, E_F, E_L, E_S, E_W are the moduli of elasticity [MPa] for bolt, flange, loose flange, shell, washer;

e_0 is the wall thickness of central plate of blind flange (inside d_0) [mm], Figure GA.3-9;

e_1 is the minimum wall thickness at thin end of hub [mm], Figures GA.3-4, GA.3-5;

e_2 is the wall thickness at thick end of hub [mm], Figures GA.3-4, GA.3-5;

e_D, e_E is the wall thickness of equivalent cylinder for load limit and flexibility calculations respectively [mm], Equations (GA.5-16) and (GA.5-17);

e_F, e_L is the effective axial thickness of flange, loose flange [mm], Equations (GA.5-7) to (GA.5-14);

e_G is the gasket axial thickness [mm], Figure GA.3-3;

e_{Gt} is the theoretical thickness; normally this is the thickness given on drawing or specification; for an exception see NOTE in GA.5.3.1; see also Figure GA..3-3;

$e_{G(A)}$ is the thickness actual after all load conditions, calculated for $F_{G(A)} = 0$;

e_N is the thickness (height) of a nut [mm], Figure GA.3-1, Equation (GA.7-2);

e_P is the portion of the flange thickness subject to radial pressure loading [mm], Figures GA.3-4 to GA.3-10;

e_Q is the portion of the flange thickness not subject to radial pressure loading [mm], Figures GA.3-4 to GA.3-10;

e_S is the shell thickness [mm], Figures GA.3-4 to GA.3-10;

e_W is the washer thickness [mm], Figure GA.3-1, Equation (GA.7-14);

e_X is the flange thickness at the weakest section [mm], Figure GA.3-9, Equation (GA.7-46);

F_A is the external axial force [N], Figure GA.3-1, tensile force positive, compressive force negative, $F_A = F_Z$;

F_B is the total force of all bolts [N];

F_G is the gasket force [N];

$F_{G(0),\Delta}$ is the minimum gasket force in assembly condition that guarantees that the required gasket force is maintained in all subsequent conditions [N], Equation (GA.6-24);

F_Q is the axial fluid pressure force [N], Equation (GA.6-1);

F_R is the axial force resulting from F_A and M_B [N], Equation (GA.6-4);

F_S is the resulting shearing force [N] at the gasket, Equation (GA.6-2);

F_X, F_Y, F_Z are the additional forces [N] in the directions X, Y, Z, Figure GA.3-1 and GA.6.1.2;

f_B, f_F, f_L, f_N, f_S, f_W are the nominal design stresses [MPa] for bolts, flange, loose flange, nuts, shell, washers;

h_G, h_H, h_L are lever arms (gasket, hub, loose flange) [mm], Figure GA.3-1, and Equations (GA.5-72) to (GA.5-84);

h_P, h_Q, h_R, h_S, h_T are lever arm corrections [mm], Equations (GA.5-27) to (GA.5-30), (GA.5-38), (GA.5-39) and (GA.5-70);

h_V is the maximum lever arm variation for loose flanges [mm], Equations (GA.5-80) to (GA.5-84);

I is the load condition identifier [-], for assembly condition $I = 0$, for subsequent conditions $I = 1, 2, 3 \ldots$;

j_M, j_S are sign numbers for moment, shear force (+1 or –1) [-], Equations (GA.7-34) and GA.7-35);

K_0 is the modulus of elasticity [MPa] for unloading/reloading of the gasket at zero compressive stress ($Q = 0$), see GA.9.1;

K_1 is the rate of change of the modulus of elasticity [-] for unloading/reloading of the gasket with compressive stress ($Q > 0$), see GA.9.1;

k_Q, k_R, k_M, k_S are correction factors [-], Equations (GA.5-31) to (GA.5-34), (GA.7-36) and (GA.7-37);

l_B, l_S are bolt axial dimensions [mm], Figure GA.3-2 and Equations (GA.5-44) and (GA.6-6);

l_H is the length of hub [mm], Figures GA.3-4 and GA.3-5;

M1, M2, MJ is an exponent for tightness calculations [-], case 1, case 2, general (J = 1, 2), see GA.6 and GA.9;

M_B is the external bending moment [Nmm], Equation (GA.6-3);

M_t is the bolt assembly torque [Nmm], Equation (GA.8-5);

M_X, M_Y, M_Z are the additional moments [Nmm] with the vector directions X, Y, Z, related to the mid-plane of the gasket, Figure GA.3-1 and GA.6.1.2;

N1, N2, NJ is an exponent for tightness calculations [-], case 1, case 2, general (J = 1, 2), see GA.6 and GA.9;

N_R is the number of times that the joint is re-made during the service life of the flanges, Equation (GA.6-34); without of influence on results for $N_R \leq 10$;

n_B is the number of bolts [-], Equations (GA.5-1), (GA.5-4) and GA.5.2;

P is the fluid pressure [MPa], internal pressure positive, external negative, see GA.6.1;

p_B is pitch between bolts [mm], Equation (GA.5-1);

p_t is pitch of the bolt-thread [mm], Table GA.8-1;

Q, $Q_{(I)}$ is the mean existing effective compressive stress in gasket [MPa] in load condition No.I;

$Q_{A,min}$ is the minimum required compressive stress in gasket [MPa] for assembly condition, see GA.6.5;

Q_{A0}, Q_{A1}, Q_{A2}, Q_{AJ} is a gasket material parameter for tightness [MPa], defining required values for assemblage, case 0, case 1, case 2, general (J = 1, 2), see GA.6 and GA.9;

$Q_{E\,(I)}$ is the mean existing compressive stress in gasket [MPa], effective in load condition No. I for deformation with prevented sliding on surfaces, Equations (GA.5-59) to (GA.5-63);

$Q_{S,min}$ is the minimum required compressive stress in gasket [MPa] for subsequent load conditions, see GA.6.5;

Q_R is the resistance of the gasket against destruction or damage [MPa], excluding support by friction on the contact flange surfaces, including safety margins, which are the same for all load conditions, see GA.9.1;

q is a parameter [-] to determine the contact widths at washers, see GA.7.2.2;

r_2 is the radius of curvature in gasket cross section [mm], Figure GA.3-3;

S_W is the strength of a washer [Nmm], Equation (GA.7-14); (S corresponds to a resistance W);

(TP) is the tightness parameter [not dimensionless], defined in GA.9.1.2;

special values are $(TP)_{1mx}$ and $(TP)_{2mx}$ (maximum values for the cases 1 and 2);

t_B, t_F, t_G, t_L, t_S, t_W are design temperatures (average for the part designated by the subscript) [°C], Equation (GA.6-5);

t_0 is the temperature of the joint at bolting-up [°C], usually +20 °C;

U is an axial deformation of the gasket [-], used for explanation in GA.9.1, $U = \Delta e_G/e_G$;

W_F, W_L, W_X are resistances (of the part or section designated by the subscript) [Nmm], Equations (GA.7-26), (GA.7-44), (GA.7-46) and (GA.7-48);

W_Q is a special resistance of stub or collar [Nmm], supported by the resistance of the gasket Q_R, Equation (GA.7-50);

$x_{(I)}$ is an auxiliary parameter [-] to find the optimum load transfer position for loose flange with stub or collar, see GA.5.4.2 and GA.7.6.3;

X_B, X_G,X_W are axial flexibility moduli of bolts, gasket, washer [1/mm], Equations (GA.5-44), (GA.5-53) and (GA.5-68);

Y_B, Y_G, Y_Q, Y_R are axial compliances of the joint [mm/N] corresponding to loads F_B, F_G, F_Q, F_R, Equations (GA.6-8) to (GA.6-11);

Z_F, Z_L are rotational flexibility moduli of flange, loose flange [1/mm^3], Equations (GA.5-35), (GA.5-36) and (GA.5-40) to (GA.5-42);

α_B, α_F, α_G, α_L, α_W are average thermal expansion coefficients [K^{-1}], averaged between t_0 and t_B, t_F, t_G, t_L, t_W;

β, γ, δ, ϑ , κ, λ are intermediate working variables [-], Equations (GA.5-15), (GA.5-23) to (GA.5-25), (GA.5-79), (GA.7-28) and (GA.7-29);

$\Delta e_{G(0)}$ is the change of the gasket thickness [mm] during bolt tightening in assemblage (up to the end of the load condition No. 0), Equation (GA.5-63);

$\Delta e_{G(I)}$ is the change of the gasket thickness [mm] after assemblage up to the end of load condition No. I, Equation (GA.5-63);

$\Delta U_{T(I)}$ is the overall axial thermal deformation [mm] relative to assemblage in load condition No. I, Equation (GA.6-5);

$\Delta U_{G(I)}$ is the overall axial elastic and thermal deformation [mm] at the gasket relative to assemblage in load condition No. I, Equation (GA.6-12);

ε_{n+}, ε_{n-}, ε_{1+}, ε_{1-} are the scatter values of the initial bolt load [-] for n_B bolts and 1 bolt, above and below the nominal value respectively, see GA.8.2;

Θ_F, Θ_L is the rotation of flange, loose flange, due to an applied moment [-],Equations (GA.8-7) and (GA.8-8);

μ_B, μ_G is the coefficient of friction at the bolts, at the gasket [-], see GA.8, GA.9;

ρ is a diameter ratio for blind flanges [-], Equation (GA.5-37);

Φ_B, Φ_C, Φ_F, Φ_G, Φ_L, Φ_W, Φ_X are load ratios (of the part or section designated by the subscript) [-], Equations (GA.7-1), (GA.7-4), (GA.7-7) to (GA.7-9), (GA.7-23), (GA.7-25) and (GA.7-43) to (GA.7-49);

φ_G is the angle of inclination of a sealing face [rad or deg], Figure GA.3-3, Table GA.5-1;

φ_S is the angle of inclination of the connected shell [rad or deg], Figures GA.3-6, GA.3-7, with sign convention;

Ψ is the load ratio of flange ring due to radial force [-], Equation (GA.7-38);

Ψ_Z is the particular value of Ψ[-], Table GA.7-1.

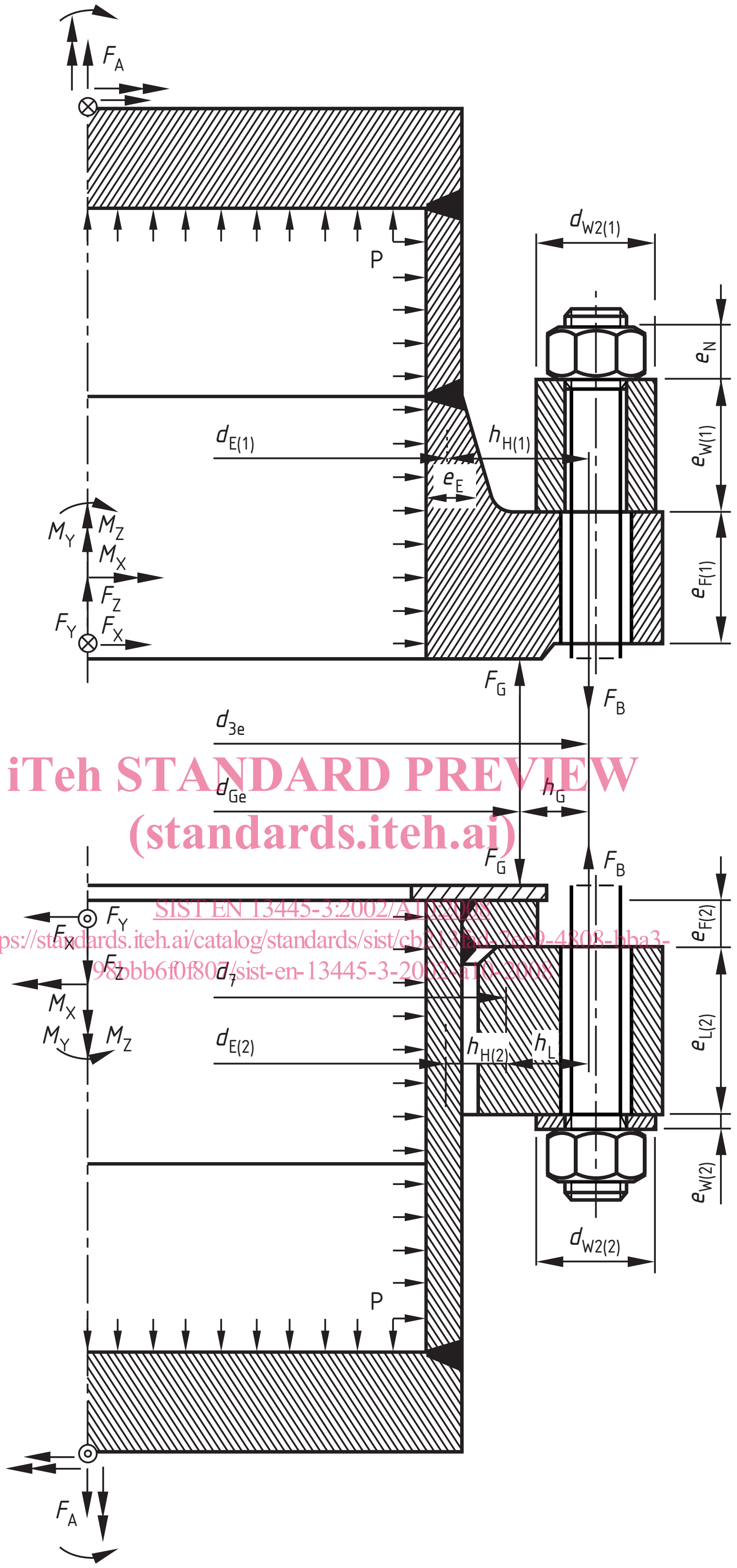

Figure GA.3-1 — Applied loads and lever arms (Integral flange and loose flange)

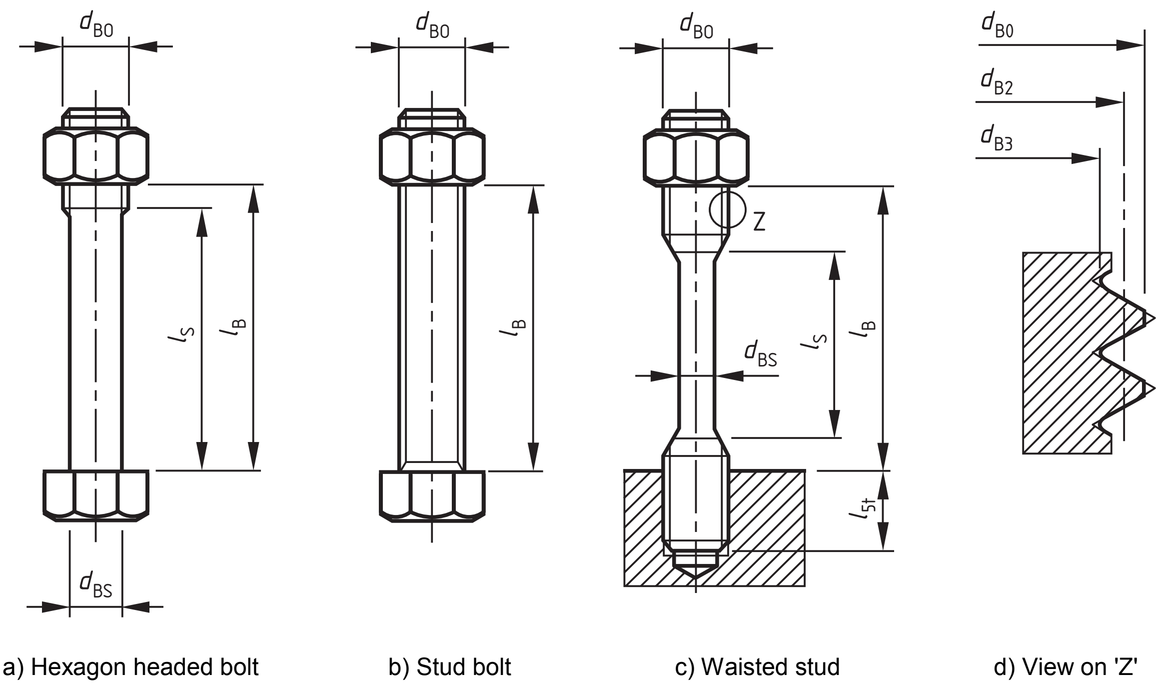

Figure GA.3-2 — Bolt details

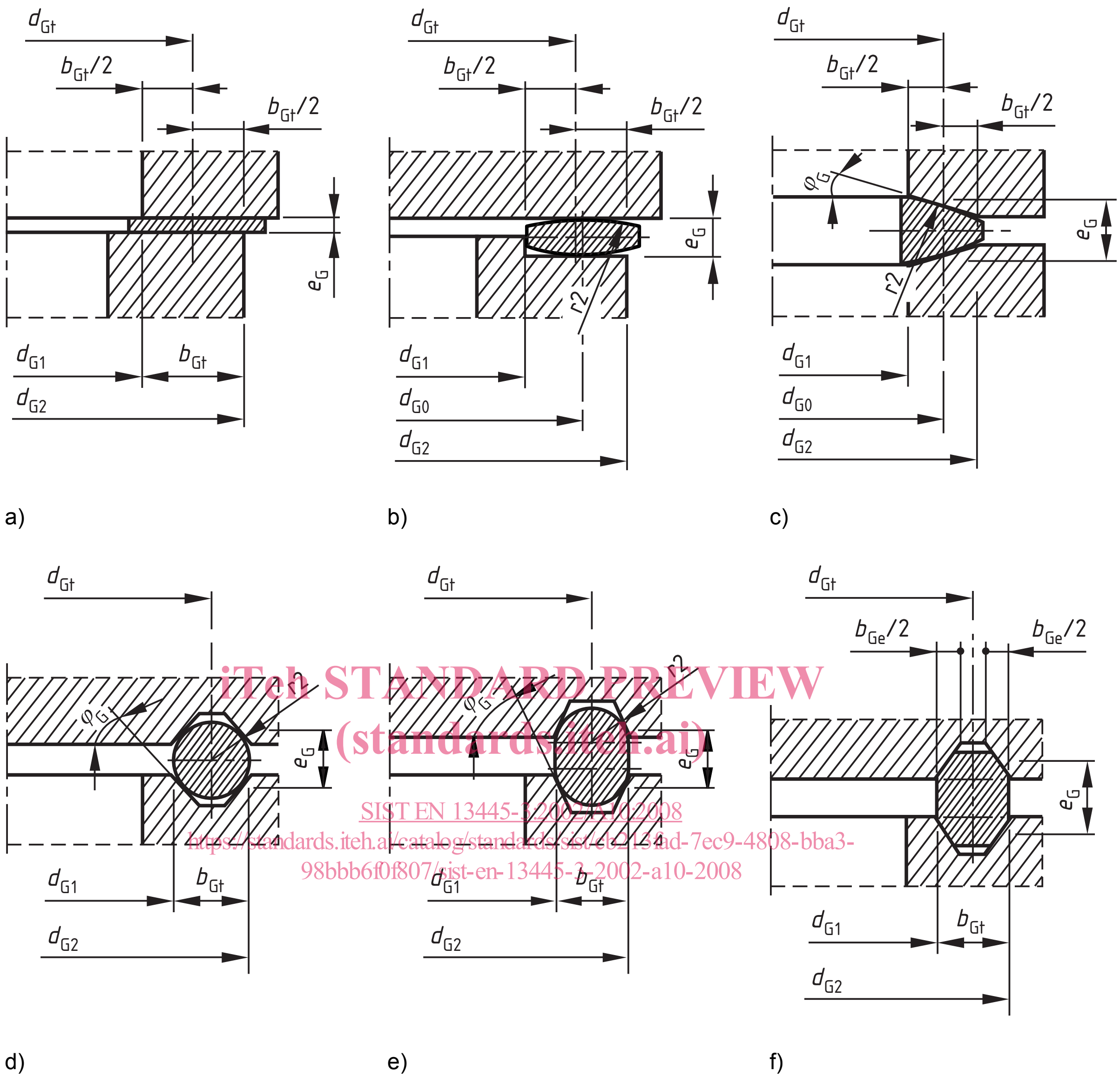

Figure GA.3-3 — Gasket details