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**Basis for calculation of
aluminium alloy pipe flanges
with full face gasket**

ICS 23.040.60

Descriptors : flanges, mathematical calculations, aluminium alloys, gaskets, full-faced flanges

Reference number : JIS B 2207 : 1995 (E)

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of International Trade and Industry through deliberations at Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law:

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Basis for calculation of aluminium alloy pipe flanges with full face gasket

1 Scope This Japanese Industrial Standard specifies the basis for stress calculation of a bolt-fastening circular pipe flange (hereafter referred to as “flange”) which uses a full face gasket made of aluminium or aluminium alloy, the basis for calculation of total load (hereafter referred to as “gasket reaction force”) working on gasket surface when inside pressure is applied, and the basis for calculation of the required thickness of flange plate when design pressure is acting.

Remarks 1 In this Standard, the load used for calculation shall be the load working on the flange when the gasket is fastened and when inside pressure applies. Therefore, the following loads are not taken into account.

- (1) Compulsory force resulted when flange is mounted
 - (2) Outside force transmitted from the connecting piping system while being used
 - (3) Thermal stress generated inside the flange while being used
 - (4) Stress generated owing to the difference of thermal expansion occurring between a flange and bolts while being used
- 2** In both cases where the gasket is fastened and inside pressure works, this Standard can be applied to only when a gasket is compressed by a pair of flange faces at the outside of center circle by bolt holes. Therefore, when flat face flange is adopted, if the gasket at outside of the center circle by bolt holes is not compressed or does not touch the flange face, it is recommended to follow **JIS B 2206**.
- 3** This Standard can be applied to the flange prepared by any combination of material and thickness if its outside diameter, inside diameter, and diameter of center circle by bolt holes have the same dimensions.
- 4** The Normative references to this Standard are as follows.
- JIS B 2206** *Basis for calculation of aluminium alloy pipe flanges*
- JIS B 2241** *Basic dimensions of aluminium alloy pipe flanges*
- 5** The units, numerical values, and formulae given in { } in this Standard are based on the traditional units, and are appended for informative reference.

2 Symbols The symbols used in this Standard are as follows.

A : outside diameter of flange (mm)

A_b : $n(\pi/4)d_b^2$, total effective sectional area of bolts that are practically employed (mm²)

B : inside diameter of flange (mm)

- B_1 : $2(D_g^3 - B^3)/3(D_g^2 - B^2)$ action-position diameter of load by inside pressure added to the ring state part between the inside diameter of flange and inside diameter of gasket (mm). If $D_g = B$, $B_1 = B$ can be obtained.
- b_n : $(A - D_g)/2$, width of gasket (mm)
- C : diameter of center circle by bolt holes (mm)
- C_0 : $(A + B)/2$, diameter of flange ring centroid (mm)
- D_g : inside diameter of gasket (mm)
- d_b : minor diameter of screw thread of bolt or the minimum part of diameter at shank of a bolt, whichever is smaller (mm)
- d_B : diameter of hole for flange bolt (mm)
- E_b : Young's modulus of bolt material (N/mm² {kgf/mm²})
- E_{fi} : Young's modulus of flange material (N/mm² {kgf/mm²})
- E_{hi} : Young's modulus of hub material (N/mm² {kgf/mm²})
- E_{g0} : Young's modulus of gasket material while being compressed (N/mm² {kgf/mm²}) (see Informative reference 1)
- E_g : Young's modulus of gasket material when it is recovered (N/mm² {kgf/mm²}) (see Informative reference 1)
- E_{oi} : Young's modulus of connected pipe material (N/mm² {kgf/mm²})
- g_{0i} : thickness of plate at hub small diameter end (mm)
- g_{1i} : thickness of plate at hub large diameter end (mm)
- G^0 : diameter of reaction-force circle of gasket when it is fastened (mm)
- G_1^0 : diameter of reaction-force circle of gasket at inside part of the center circle by bolt holes when it is fastened (mm)
- G_2^0 : diameter of reaction-force circle of gasket at outside part of the center circle by bolt holes when it is fastened (mm)
- G^P : diameter of reaction-force circle of gasket when inside pressure is applied (mm)
- G_1^P : diameter of reaction-force circle of gasket at inside part of the center circle by bolt holes when inside pressure is applied (mm)
- G_2^P : diameter of reaction-force circle of gasket at outside part of the center circle by bolt holes when inside pressure is applied (mm)
- h_i : length of hub (mm)
- i : 1, 2, express a pair of flanges.
- J_{1i} : shearing force coefficient at part connecting hub with flange ring (N/mm {kgf/mm})
- J_{2i} : shearing force coefficient at part connecting hub with flange ring (mm)
- K_{1i} : moment coefficient at part connecting hub with flange ring (N {kgf})

- K_{2i} : moment coefficient at part connecting hub with flange ring (mm²)
- l_{ob} : $t_{f1} + t_{f2} + t_g$, length of bolt deformation range (mm)
- M^0 : moment acting on flange when gasket is fastened (N·mm {kgf·mm})
- M_1^0 : moment around the axis of flange-ring section centroid generated by gasket reaction force at inside part of center circle by bolt holes when gasket is fastened (N·mm {kgf·mm})
- M_2^0 : moment around the axis of flange-ring section centroid generated by gasket reaction force at outside part of center circle by bolt holes when gasket is fastened (N·mm {kgf·mm})
- M^P : moment acting on the flange when inside pressure is applied (N·mm {kgf·mm})
- M_1^P : moment around the axis of flange-ring section centroid generated by gasket reaction force at inside part of center circle by bolt holes when inside pressure is applied (N·mm {kgf·mm})
- M_2^P : moment around the axis of flange-ring section centroid generated by gasket reaction force at outside part of center circle by bolt holes when inside pressure is applied (N·mm {kgf·mm})
- M_{B1} : moment around the axis of flange-ring section centroid generated by inside pressure which applies to ring-shaped part between flange inside diameter and gasket inside diameter (N·mm {kgf·mm})
- n : number of bolts
- P_0 : $(\pi B^2/4)p$ $\{(\pi B^2/4)(p/100)\}$, load applied on inside diameter surface of flange by inside pressure (N {kgf})
- P_1 : $[\pi(D_g^2 - B^2)/4]p$ $\{[\pi(D_g^2 - B^2)/4](p/100)\}$, load generated by inside pressure which applies to ring-shaped part between flange inside diameter and gasket inside diameter (N {kgf})
- P_b^0 : load by gasket fastening (N {kgf})
- p : designed inside pressure (MPa {kgf/cm²})
- P_{g1}^0 : gasket reaction force at inside part of center circle by bolt holes when gasket is fastened (N {kgf})
- P_{g2}^0 : gasket reaction force at outside part of center circle by bolt holes when gasket is fastened (N {kgf})
- $P_{g1}^{0'}$: gasket reaction force at inside part of circle inscribed in bolt holes when gasket is fastened (N {kgf})
- P_b : bolt load when inside pressure is applied (N {kgf})
- P_g : gasket reaction force when inside pressure is applied (N {kgf})
- P_{g1} : gasket reaction force at inside part of center circle by bolt holes when inside pressure is applied (N {kgf})

P_{g2} : gasket reaction force at outside part of center circle by bolt holes when inside pressure is applied (N {kgf})

$P_{g1'}$: gasket reaction force at inside part of circle inscribed in bolt holes when inside pressure is applied (N {kgf})

r_g : $D_g/2$, inside radius of gasket (mm)

r_{gb} : $(C - d_B)/2$, radius of circle inscribed in bolt holes (mm)

r_{ci}^0 : value which specifies the deformation of flange when gasket is fastened (mm) (see Fig. 1)

r_{ci}^P : value which specifies the deformation of flange when inside pressure is applied (mm) (see Fig. 2)

t_{fi} : plate thickness of flange (mm)

t_g : plate thickness of gasket (mm)

t_{oi} : plate thickness of connecting pipe (mm)

θ_i^0 : rotating angle of flange ring owing to the load by gasket fastening (rad)

θ_i^P : rotating angle of flange ring when inside pressure is applied (rad)

σ_{Hi} : axial stress of hub (N/mm² {kgf/mm²})

σ_{Ri} : radial stress of flange (N/mm² {kgf/mm²})

σ_{Ti} : circumferential stress of flange (N/mm² {kgf/mm²})

σ_a : tolerable tensile stress of bolt material at ordinary temperature (N/mm² {kgf/mm²})

σ_b : tolerable tensile stress of bolt material at the temperature under use (N/mm² {kgf/mm²})

σ_f : tolerable tensile stress of flange material at the temperature under use (N/mm² {kgf/mm²})

Furthermore, when gasket is fastened, tolerable tensile stress at ordinary temperature (N/mm² {kgf/mm²})

σ_n : tolerable tensile stress of material of pipe or pipe-shaped part at the temperature under use (N/mm² {kgf/mm²})

Furthermore, when gasket is fastened, tolerable tensile stress at ordinary temperature (N/mm² {kgf/mm²})

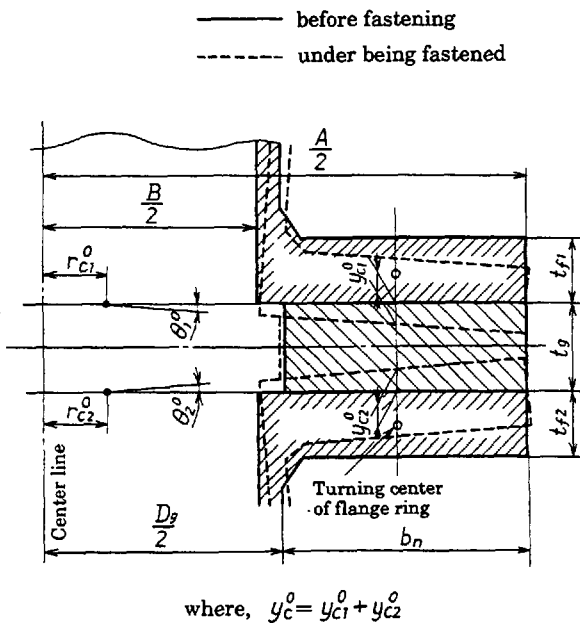


Fig. 1 Deformation of gasket by fastening

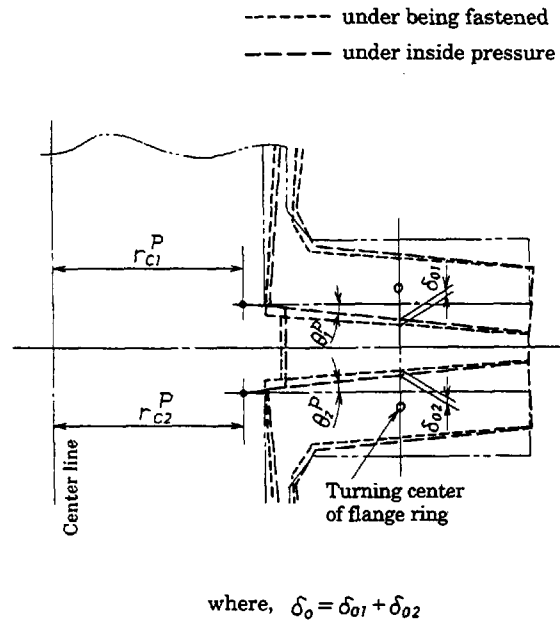


Fig. 2 Recovery of gasket when inside pressure is applied

3 Moment coefficient K_{1i} , K_{2i} and shearing force coefficient J_{1i} , J_{2i} at the part connecting hub with flange ring The moment coefficient K_{1i} , K_{2i} and shearing force coefficient J_{1i} , J_{2i} at the part connecting hub with flange ring shall be obtained from the analysis which the hub with conic section has been replaced with the hub having rectangular section that has the average thickness of its major diameter end and of minor diameter end (the hub length shall be the same.). The moment M_{1i} and shearing force Q_{1i} at the part connecting the hub lower end with the inside diameter end of flange ring shall be calculated as follows.

$$M_{1i} = K_{1i}\theta_i + K_{2i}p \quad \{M_{1i} = K_{1i}\theta_i + K_{2i}(p/100)\}$$

$$Q_{1i} = J_{1i}\theta_i + J_{2i}p \quad \{Q_{1i} = J_{1i}\theta_i + J_{2i}(p/100)\}$$

where,

$$\theta_i : \theta_i^0 \text{ or } \theta_i^P \quad (i = 1, 2)$$

The values of K_{1i} , K_{2i} , J_{1i} , and J_{2i} shall be as follows.

$$\begin{aligned} K_{1i} &= [(-a_{41i}\mu_{2i} - a_{42i}\mu_{3i} + a_{44i}\mu_{4i})a_{3i}'' + (a_{31i}\mu_{2i} + a_{32i}\mu_{3i} - a_{34i}\mu_{4i})a_{4i}'] / D_{ei} \\ K_{2i} &= [(-a_{21i}\Lambda_{6i} + a_{22i}\Lambda_{5i} + a_{24i}\Lambda_{1i})a_{1i}' + (-a_{41i}\mu_{2i} - a_{42i}\mu_{3i} + a_{44i}\mu_{4i})a_{3i}'] / D_{ei} \\ J_{1i} &= [(a_{41i}\mu_{5i} + a_{42i}\mu_{6i} - a_{43i}\mu_{4i})a_{3i}'' + (-a_{31i}\mu_{5i} - a_{32i}\mu_{6i} + a_{33i}\mu_{4i})a_{4i}'] / D_{ei} \\ J_{2i} &= [(-a_{21i}\Lambda_{3i} + a_{22i}\Lambda_{2i} - a_{23i}\Lambda_{1i})a_{1i}' + (a_{41i}\mu_{5i} + a_{42i}\mu_{6i} - a_{43i}\mu_{4i})a_{3i}'] / D_{ei} \end{aligned}$$

where, $\Lambda_{1i} = a_{31i}a_{42i} - a_{32i}a_{41i}$

$$\Lambda_{2i} = a_{31i}a_{43i} - a_{33i}a_{41i}$$

$$\Lambda_{3i} = a_{32i}a_{43i} - a_{33i}a_{42i}$$

$$\Lambda_{4i} = a_{33i}a_{44i} - a_{34i}a_{43i}$$

$$\Lambda_{5i} = a_{34i}a_{41i} - a_{31i}a_{44i}$$

$$\Lambda_{6i} = a_{34i}a_{42i} - a_{32i}a_{44i}$$

$$\mu_{1i} = a_{13i}a_{24i} - a_{14i}a_{23i}$$

$$\mu_{2i} = a_{14i}a_{22i} - a_{12i}a_{24i}$$