

**Calculation Basis for the Tightening Torques
Specified in Annex B**

Annex C

1 General

- Except for the restrictions shown in Table 2, the tightening torques have been calculated for a maximum temperature of 400° C.
- Flange material P245GH
- Hex bolts 25CrMo4 Up to M20: 0.25 load scatter / From M24: 0.15 load scatter
Note: Whether bolts or studs are used is of no relevance to the calculation. The important criterion is the material of the fastener.
- Consideration of additional loads as per DIN EN 1092-1 for the operation load case only; reduced in proportion to the allowable pressure at elevated temperatures

The stress reserves for external loads as per DIN EN 1092-1 taken into account with this approach cover the required utilisation reserves for loads and moments as determined by the simplified procedure for the evaluation of low-stress piping installation (e.g. as per AD 2000-Merkblatt HP 100 R, DIN EN 13480-3 Annex Q). For piping that cannot be analysed by simplified procedures, a stress and flexibility analysis will be needed. Should this result in higher additional loads, case-by-case evaluations will be needed.

- Lubrication with MoS2 or equivalent. An average friction coefficient of 0.13 was used for the calculation.
- Use of hardened washers (to reduce friction and the preload scatter on bolt tightening)
- At a Q_A value of 30 MPa, the gasket must have a minimum P_{QR} value of 0.75 at room temperature and 0.45 at the maximum service temperature. The minimum required Q_{smax} value at room temperature is 150 MPa; the minimum required Q_{smax} value for spiral-wound and grooved metal gaskets is 170 MPa.

For the determination of Q_{smax} , DIN EN 13555, version 2014 (Figure 2) introduces "penetration" as a new failure criterion. This leads to drastically reduced Q_{smax} values that in many cases are impractical for calculation in practice. For this reason, the Q_{smax} values for PTFE gaskets must be determined according to DIN EN 13555, version 2005. This presupposes that gaskets characteristics up to Q_{smax} are specified in the gasket data sheets. This approach is on the safe side because the high compressive loads acting on the gasket inner edge area, e.g. due to the slope of the flange face, cannot be attained.

- The gasket must have a minimum modulus of elasticity of 1000 MPa at a seating stress of 60 MPa and room temperature.
- Tightness class L 0,01 must be attained at a Q_A value of not more than 30 MPa at 40 bar with the required $Q_{smin(L)}$ value being not greater than 10 MPa.
- Grooved metal / spiral-wound gaskets (same requirements as for other flat gaskets)
- Graphite gaskets with perforated metal, expanded metal or flat metal inserts or metal foil inlays can be used as an alternative to tanged metal inserts.
- Tolerances and corrosion allowances have not been taken into account.

The Q_A and $Q_{smin(L)}$ values for the respective pressure rating were used in the calculation.

If flange materials or bolt materials with a higher nominal strength (yield strength) are used, these will be covered by the tightening torques.

Only flanges of P245GH with hex bolts of 25CrMo4 were considered in the calculation since sample calculations have shown that higher-grade materials will be covered despite higher rating pressures.

The p/t ratings given in DIN EN 1092-1, Draft 2005 (see Table 1) have been used as a calculation basis. The values given in DIN EN 1092-1, version 2008, are slightly lower and are thus covered.

Table 1 — p/t ratings of standard materials as per DIN EN 1092-1, draft 2005

P245GH (material group 3E0)						
Temp. [°C]	PN 10	PN 16	PN 25	PN 40	PN 63	PN 100
20	10.0	16.0	25.0	40.0	63.0	100.0
100	8.5	13.7	21.4	34.2	54.0	85.7
150	8.3	13.3	20.8	33.3	52.5	83.3
200	7.8	12.5	19.6	31.4	49.5	78.5
250	7.2	11.6	18.2	29.1	45.9	72.8
300	6.4	10.2	16.0	25.7	40.5	64.2
350	6.1	9.9	15.4	24.7	39.0	61.9
400	5.7	9.1	14.2	22.8	36.0	57.1
1.4541 (material group 12E0)						
Temp. [°C]	PN 10	PN 16	PN 25	PN 40	PN 63	PN 100
20	10.0	16.0	25.0	40.0	63.0	100.0
100	9.9	15.8	24.7	39.6	62.4	99.0
150	9.3	14.9	23.3	37.3	58.8	93.3
200	8.8	14.1	22.1	35.4	55.8	88.5
250	8.4	13.4	21.0	33.7	53.1	84.2
300	7.9	12.7	19.8	31.8	50.1	79.5
350	7.6	12.2	19.1	30.6	48.3	76.6
400	7.4	11.8	18.5	29.7	46.8	74.2
1.4571 (material group 15E0)						
Temp. [°C]	PN 10	PN 16	PN 25	PN 40	PN 63	PN 100
20	10.0	16.0	25.0	40.0	63.0	100.0
100	10.0	16.0	25.0	40.0	63.0	100.0
150	9.8	15.6	24.5	39.2	61.8	98.0
200	9.3	14.9	23.3	37.3	58.8	93.3
250	8.8	14.1	22.1	35.4	55.8	88.5
300	8.3	13.3	20.8	33.3	52.5	83.3
350	8.0	12.8	20.1	32.1	50.7	80.4
400	7.8	12.4	19.5	31.2	49.2	78.0
16Mo3 (material group 4E0)						
Temp. [°C]	PN 10	PN 16	PN 25	PN 40	PN 63	PN 100
20	10.0	16.0	25.0	40.0	63.0	100.0
100	10.0	16.0	25.0	40.0	63.0	100.0
150	10.0	16.0	25.0	40.0	63.0	100.0
200	10.0	16.0	25.0	40.0	63.0	100.0
250	9.2	14.8	23.2	37.1	58.5	92.8
300	8.0	12.9	20.2	32.3	51.0	80.9
350	7.6	12.1	19.0	20.4	48.0	76.1
400	7.1	11.4	17.8	28.5	45.0	71.4
1.4462 (material group 16E0)						
Temp. [°C]	PN 10	PN 16	PN 25	PN 40	PN 63	PN 100
20	10.0	16.0	25.0	40.0	63.0	100.0
100	10.0	16.0	25.0	40.0	63.0	100.0
150	10.0	16.0	25.0	40.0	63.0	100.0
200	10.0	16.0	25.0	40.0	63.0	100.0
250	10.0	16.0	25.0	40.0	63.0	100.0

2 Application Range Restrictions for Individual Gaskets and Nominal Diameters

The tightening torques for flat graphite gaskets, spiral-wound and grooved metal gaskets with graphite overlay have been calculated for service temperatures of up to 400 °C. Although gasket characteristics for up to 500 °C are available in individual cases, special bolts will be needed for such applications. Temperatures above 400 °C are therefore no standard application in the chemical and pharmaceutical industries so that such service conditions are not covered by this Guideline.

The calculations according to DIN EN 1591-1 show the following application restrictions where some flanges will be overstressed at high temperatures.

Tabelle 2 — Application restrictions

PN rating	Gasket type	Note
PN 10	Metal-reinforced graphite gasket	DN 600 only up to 250° C DN 800 – DN 1000 only up to 200° C An FE analysis has, however, shown that no unallowable stresses occur even for DN 1000 and 400° C. As the highest stresses occur at DN 1000, DN 800 and 900 will also be covered.
PN 10 T&G	Metal-reinforced graphite gasket	DN 500 only up to 300° C DN 600 only up to 250° C
PN 16	Metal-reinforced graphite gasket	DN 500 only up to 200° C DN 600 – DN 1000: only up to 150° C
	Spiral-wound gasket with graphite filler	DN 500 only up to 250° C
	Grooved metal gasket with graphite filler	DN 500 only up to 350° C
PN 16 T&G	Metal-reinforced graphite gasket	DN 500 only up to 150° C DN 600 only up to 100° C
PN 25	Metal-reinforced graphite gasket	DN 600 only up to 250° C DN 800 only up to 50° C DN 1000 only up to 50° C An FE analysis has, however, shown that no unallowable stresses occur even for DN 1000 and 400° C. As the highest stresses occur at DN 1000, DN 600 to DN 900 will also be covered.
PN 25 T&G	Metal-reinforced graphite gasket	DN 600 only up to 200° C
PN 40 T&G	Metal-reinforced graphite gasket	DN 500 only up to 350° C DN 600 only up to 300° C
	Fibre gaskets	up to 200 °C
	PTFE gasket with 10% glass microspheres	up to 150 °C
	PTFE gasket with 40% glass microspheres	up to 200 °C

For gasket groups A and B, the following PN–DN combinations were used for the evaluation:

2.1 Gasket group A: Flat gaskets

Table 3 — Evaluation for PN–DN¹ ratings, flat gaskets

DN	PN 10		PN 16		PN 25		PN 40		PN 63		PN 100	
	Bolt		Bolt		Bolt		Bolt		Bolt		Bolt	
	Number	Size	Number	Size	Number	Size	Number	Size	Number	Size	Number	Size
25	4	M12	4	M12	4	M12	4	M12	4	M16	4	M16
40	4	M16	4	M16	4	M16	4	M16	4	M20	4	M24
50	4	M16	4	M16	4	M16	4	M16	4	M20	4	M24
80	8	M16	8	M16	8	M16	8	M16	8	M20	8	M27
100	8	M16	8	M16	8	M20	8	M20	8	M24	8	M27
125	8	M16	8	M16	8	M24	8	M24	8	M27	8	M30
150	8	M20	8	M20	8	M24	8	M24	8	M30	8	M30
200	8	M20	12	M20	12	M24	12	M27	12	M33	12	M33
250	12	M20	12	M20	12	M27	12	M30	12	M33	12	M36
300	12	M20	12	M24	16	M27	16	M30	16	M33	16	M39
350	16	M20	16	M24	16	M30	16	M33	16	M36	16	M45
400	16	M24	16	M27	16	M33	16	M36	16	M39	16	M45
450	20	M24	20	M27	20	M33	20	M36				
500	20	M24	20	M30	20	M33	20	M39				
600	20	M27	20	M33	20	M36	20	M45				
700	24	M27	24	M33	24	M39	24	M45				
800	24	M30	24	M36	24	M45	24	M52				
900	28	M30	28	M36	28	M52	28	M52				
1000	28	M33	28	M39	28	M52	28	M52				

without inner flare

with inner flare

DIN and EN flanges of identical dimensions

Flanged joint design with tightness evaluation

2.2 Gasket group B: grooved metal gasket and spiral-wound gaskets

Table 4 — Evaluation for PN–DN¹ ratings, narrow gaskets

DN	PN 10		PN 16		PN 25		PN 40		PN 63		PN 100	
	Bolt		Bolt		Bolt		Bolt		Bolt		Bolt	
	Number	Size	Number	Size	Number	Size	Number	Size	Number	Size	Number	Size
25	4	M12	4	M12	4	M12	4	M12	4	M16	4	M16
40	4	M16	4	M16	4	M16	4	M16	4	M20	4	M24
80	8	M16	8	M16	8	M16	8	M16	8	M20	8	M27
100	8	M16	8	M16	8	M20	8	M20	8	M24	8	M27
125	8	M16	8	M16	8	M24	8	M24	8	M27	8	M30
150	8	M20	8	M20	8	M24	8	M24	8	M30	8	M30
200	8	M20	12	M20	12	M24	12	M27	12	M33	12	M33
250	12	M20	12	M20	12	M27	12	M30	12	M33	12	M36
300	12	M20	12	M24	16	M27	16	M30	16	M33	16	M39
350	16	M20	16	M24	16	M30	16	M33	16	M36	16	M45
400	16	M24	16	M27	16	M33	16	M36	16	M39	16	M45
450	20	M24	20	M27	20	M33	20	M36				
500	20	M24	20	M30	20	M33	20	M39				
600	20	M27	20	M33	20	M36	20	M45				
700	24	M27	24	M33	24	M39	24	M45				
800	24	M30	24	M36	24	M45	24	M52				
900	28	M30	28	M36	28	M52	28	M52				
1000	28	M33	28	M39	28	M52	28	M52				

¹ The tightening torques specified for DN 25 can also be used for nominal diameters < DN 25.

2.3 Gasket group B: Tongue-and-groove flanges, flat gaskets

Table 5 — Evaluation for PN–DN¹ ratings, tongue-and-groove flanges, flat gaskets

DN	PN 10		PN 16		PN 25		PN 40		PN 63		PN 100	
	Bolt		Bolt		Bolt		Bolt		Bolt		Bolt	
	Number	Size	Number	Size	Number	Size	Number	Size	Number	Size	Number	Size
25	4	M12	4	M12	4	M12	4	M12	4	M16	4	M16
40	4	M16	4	M16	4	M16	4	M16	4	M20	4	M24
50	4	M16	4	M16	4	M16	4	M16	4	M20	4	M24
80	8	M16	8	M16	8	M16	8	M16	8	M20	8	M27
100	8	M16	8	M16	8	M20	8	M20	8	M24	8	M27
125	8	M16	8	M16	8	M24	8	M24	8	M27	8	M30
150	8	M20	8	M20	8	M24	8	M24	8	M30	8	M30
200	8	M20	12	M20	12	M24	12	M27	12	M33	12	M33
250	12	M20	12	M20	12	M27	12	M30	12	M33	12	M36
300	12	M20	12	M24	16	M27	16	M30	16	M33	16	M39
350	16	M20	16	M24	16	M30	16	M33	16	M36	16	M45
400	16	M24	16	M27	16	M33	16	M36	16	M39	16	M45
450	20	M24	20	M27	20	M33	20	M36				
500	20	M24	20	M30	20	M33	20	M39				
600	20	M27	20	M33	20	M36	20	M45				
700	24	M27	24	M33	24	M39	24	M45				
800	24	M30	24	M36	24	M45	24	M52				
900	28	M30	28	M36	28	M52	28	M52				
1000	28	M33	28	M39	28	M52	28	M52				

Revision note:

The following changes have been made relative to the previous edition:

- a) Note on Q_{Smax} determination added.

¹ The tightening torques specified for DN 25 can also be used for nominal diameters < DN 25.