

Bolted joint

01 Bolts (VDI 2230 Example 1)

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Description	KISSsoft example
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Non commercial version for demo and support purposes only ! (914)
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1 Messages

 Calculation is consistent.

2 Inputs

Configuration:	Bolted connection under axial load (single bolt)	
Calculation using assembly temperature		
Assembly temperature (°C)	[T _M]	20.00
Thread standard	Standard thread	
Label	M12	
Pitch (mm)	[P]	1.75
Flank angle (°)	[β]	60.00
Reference diameter (mm)	[d]	12.00
Flank diameter (mm)	[d ₂]	10.86
Core diameter (mm)	[d ₃]	9.85
Minor diameter inner thread (mm)	[D ₁]	10.11
Flank diameter inner thread (mm)	[D ₂]	10.86
Nominal cross section of thread (mm ²)	[A _N]	113.10
Core cross section of the thread (mm ²)	[A _{d3}]	76.25
Thread manufacturing	Final heat treated	
Axial force (N)	[F _A]	24900.00
Required clamping force:		
For shearing force transmission (N)	[F _{KQ}]	1000.00
For sealing (N)	[F _{KP}]	0.00
Tightening technique:	Own Input	
Tightening factor	[α _A]	1.80
Minimum tightening factor (scattering coef. of friction)	[α _{min}]	1.00
Load application factor	[n]	0.35
Bolting type: SV 4		
Length of connected solid (mm)	[l _A]	0.00
Distance of connected solid (mm)	[a _k]	3.89
Load application height (mm)	[l _k]	14.53 <...< 42.00
(A more precise estimation can be performed according to VDI 2230, Figure 5.2/5.).		
Coef. of friction in thread	[μ _G]	0.100 /0.100
Coef. of friction at head support	[μ _k]	0.100 /0.100
Bolt type:	Cylindrical screw with socket head bolt DIN EN ISO 4762:2004	
Reference diameter (mm)	[d]	12.00
Bolt length (mm)	[l]	60.00
Shank diameter (mm)	[d ₁]	12.00
Shank length (mm)	[l ₁]	24.00
Thread length (mm)	[b]	36.00
Outer diameter of head support (mm)	[d _w]	17.23
Inner diameter of head support (mm)	[d _a]	13.70
Surface roughness, head bearing area (μm)	[R _z]	16.00
Interface diameter (mm)	[D _{Tr}]	25.00
Stressed cross section of bolt (mm ²)	[A ₀]	84.27
Addendum (mm)	[k]	12.00
Diameter of bolt head (mm)	[d _k]	18.00
Free thread length (mm)	[l ₃]	18.00
Width across flats (mm)	[s]	10.00
Reduction coefficient	[k _r]	0.50
Moment of resistance (mm ³)	[W _b]	109.11
Polar moment of resistance (mm ³)	[W _p]	218.21
Polar moment of resistance (mm ³)	[W _{pp}]	290.95

Strength class	10.9		
Tensile strength (N/mm ²)	[R _m]	1040.00	
Yield point (N/mm ²)	[R _{p0.2}]	940.00	
Maximum yield point (N/mm ²)	[R _{p,max}]	940.00	
Young's modulus bolt (N/mm ²)	[E _s]	205000.00	
Clamped parts:			
	Cylinder		
Outside diameter of bush (mm)	[D _A]	80.00	
Outer diameter for stiffening (mm)	[D _{A'}]	80.00	
Number of parts	[i _P]		1
Part 0			
Material	Own Input		
Depth of Layer (mm)	[h _i]	42.00	
Young's modulus (N/mm ²)	[E _p]	205000.00	
Permissible surface pressure (N/mm ²)	[p _G]	1300.00	
Surface roughness (µm)	[R _z]	4.80	
Thread with pocket hole			
Clamping length (mm)	[l _k]	42.00	
Through hole standard			
	ISO 273:1979/DIN EN 20273:1992 medium		
Diameter through hole (mm)	[d _h]	13.50	
Chamfer at head (mm)	[c _k]	0.00	
No washer below bolt head			
Blind hole			
Material	Own Input		
Counter bore depth (mm)	[t _s]	0.00	
Shearing strength (N/mm ²)	[T _{bmin}]	460.00	
Young's modulus (N/mm ²)	[E _p]	205000.00	
Coefficient of thermal expansion	(10 ⁻⁶ /K)	[α]	11.50
Surface roughness (µm)	[R _z]	16.00	

3 Results

Virtual outer diameter of base body:			
Diameter (mm)	[D _{A'}]	80.00	
Diameter (mm)	[D _A]	80.00	
Diameter limit (mm)	[D _{A,Gr}]	44.87	
Cone angle (°)	[φ]	29.49	
Resilience of flange (mm/N)	[δ _p]		4.219966e-07
Addition for plate resilience (mm/N)	[δ _{pzu}]		1.708004e-07
Resilience of bolt (mm/N)	[δ _s]		2.984655e-06
Load factor for centric load introduction	[Φ _n]	0.0602	
Amount of embedding (mm)	[f _z]	0.0080	
Preload loss (N)	[F _z]	2348.35	
required assembly preload:			
-minimum (N)	[F _{Mmin}]	26749.58	
-maximum (N)	[F _{Mmax}]	48149.24	
Pretension force according table (N)	[F _{Mtab}]	65000.00	
Bolt load excluding torsion at yield point (N)	[F _{M0.2}]	79000.00	
attained assembly preload:			
-maximum (N)	[F _M]	64904.29	
for utilization of yield point (%)	[V _{max}]	90.00	
Pretension force (N)	[F _V]	62555.95	
Additional bolt load (N)	[F _{SA}]	1498.77	
Additional plate load (N)	[F _{PA}]	23401.23	
Fatigue load (N/mm ²)	[σ _a]	8.89	
Fatigue life (N/mm ²)	[σ _{Azul}]	48.88	
Number of load cycles	[N _z]	>=	2000000
Bolt elongation for FM (mm)	[f _s]	0.19372	
for FM/α (mm)	[f _s]	0.10762	0.10762
Part elongation for FM (mm)	[f _r]	0.02739	
for FM/α (mm)	[f _r]	0.01522	0.01522

3.1 Length of engagement, stripping force

Calculation of the minimum nut height according to VDI 2230 (2015)
(also valid for the required length of engagement of a blind hole)

Length of engagement (mm)	[$m_{gesvorh}$]	18.00
Effective length of engagement (mm)	[$m_{effvorh}$]	14.50
Coefficient C1	[C_1]	1.000
Coefficient C2	[C_2]	0.897
Coefficient C3	[C_3]	0.899
Flank diameter tolerance, bolt		ISO 965-1 5e
Bolt minimum flank diameter (mm)	[d_{2min}]	10.674
Bolt minimum flank diameter (mm)	[d_{2max}]	10.792
Core diameter tolerance, internal thread		ISO 965-1 5G
Internal thread maximum core diameter (mm)	[D_{1max}]	10.405
Minimum internal thread core diameter (mm)	[D_{1min}]	10.140
Bolt shear surface (mm ²)	[A_{SGS}]	345.27
Tensile strength of bolt (N/mm ²)	[R_m]	1040.00
Bolt tensile strength coefficient	[R_{mmax}/R_m]	1.20
Maximum tensile strength, bolt (N/mm ²)	[R_{mmax}]	1248.00
Ratio of shearing strength	[T_{BS}/R_m]	0.62
Shearing strength bolt (N/mm ²)	[T_{BS}]	644.80
Minor diameter inner thread (mm)	[D_1]	10.106
Flank diameter inner thread (mm)	[D_2]	10.863
Bolt external diameter tolerance		ISO 965-1 6f
Minimum external diameter, bolt (mm)	[d_{min}]	11.687
Maximum external bolt diameter (mm)	[d_{max}]	11.952
Flank diameter tolerance, internal thread		ISO 965-1 6G
Maximum flank diameter, inner thread (mm)	[D_{2max}]	11.097
Minimum internal thread flank diameter (mm)	[D_{2min}]	10.897
Internal thread shear surface (mm ²)	[A_{SGM}]	478.33
Internal thread shearing strength (N/mm ²)	[T_{BM}]	460.00
RS ratio	[R_s]	0.99
Stripping force, bolt thread (N)	[F_{mGS}]	199763.86
Stripping force, internal thread (N)	[F_{mGM}]	197742.55
Bolt breaking force (N)	[F_{mS}]	87637.17
Safety against stripping force to breaking force	[S_{AE}]	2.26
Assembly pretension force (N)	[F_M]	64904.29
Safety stripping force to preload	[S_{FM}]	3.05
Minimum length of engagement Rm (mm)	[m_{ges}]	10.60
Minimum length of engagement Rmmax (mm)	[m_{gesmin}]	13.50

The bolt thread is more critical to prevent stripping.

3.2 Calculation with maximum attained pretension force

for utilization of yield point (%)	[V_{min}]	90.00
Assembly pretension force (N)	[F_M]	64904.29
Pretension force (N)	[F_V]	62555.95
Thread torque (Nm)	[M_G]	58.78
Torsional stress (N/mm ²)	[T_s]	269.39
Total bolt load (N)	[F_{Smax}]	66403.06
Tensile stress (N/mm ²)	[σ_z]	788.01
Equivalent stress in assembly state (N/mm ²)	[$\sigma_{red.M,zul}$]	846.00
Equivalent stress in working state (N/mm ²)	[$\sigma_{red.B}$]	821.82
Tightening torque (Nm)	[M_A]	109.32
Loose torque (Nm)	[M_L]	70.05
Permissible equivalent stress (N/mm ²)	[σ_{Mzul}]	846.00
Permissible equivalent stress (N/mm ²)	[σ_{Bzul}]	940.00
Surface pressure under bolt head (N/mm ²)	[p_k]	774.36
Support area under bolt head (mm ²)	[A_{pk}]	85.75

4 Results

		Ambient temperature	Operating temperature
Virtual outer diameter of base body:			
Diameter (mm)	[D _A]	80.00	
Diameter (mm)	[D _A]	80.00	
Diameter limit (mm)	[D _{A.Gr}]	44.87	
Cone angle (°)	[Φ]	29.49	
Resilience of flange (mm/N)	[δ _F]	4.219966e-07	4.219966e-07
Addition for plate resilience (mm/N)	[δ _{Pzu}]	1.708004e-07	
Resilience of bolt (mm/N)	[δ _S]	2.984655e-06	2.984655e-06
Load factor for centric load introduction	[Φ _n]	0.0602	0.0602
Amount of embedding (mm)	[f _z]	0.0080	
Preload loss (N)	[F _z]	2348.35	
required assembly preload:			
-minimum (N)	[F _{Mmin}]	26749.58	26749.58
-maximum (N)	[F _{Mmax}]	48149.24	48149.24
Pretension force according table (N)	[F _{Mtab}]	65000.00	
Bolt load excluding torsion at yield point (N)	[F _{M0.2}]	79000.00	0.00
attained assembly preload:			
-maximum (N)	[F _M]	64904.29	64904.29
for utilization of yield point (%)	[v _{max}]	90.00	
Pretension force (N)	[F _V]	62555.95	62555.95
Additional bolt load (N)	[F _{SA}]	1498.77	1498.77
Additional plate load (N)	[F _{PA}]	23401.23	23401.23
Fatigue load (N/mm ²)	[σ _a]	8.89	8.89
Fatigue life (N/mm ²)	[σ _{Azul}]	48.88	48.88
Number of load cycles	[N _D]	>=	2000000
Length of engagement (mm)	[m _{ges}]	18.00	
Minimum length of engagement of bolt (mm)	[m _{gesmin}]	13.50	
Bolt elongation for FM (mm)	[f _s]	0.19372	0.19372
for FM/α (mm)	[f _s]	0.10762	0.10762
Part elongation for FM (mm)	[f _r]	0.02739	0.02739
for FM/α (mm)	[f _r]	0.01522	0.01522

4.1 Length of engagement, stripping force

Calculation of the minimum nut height according to VDI 2230 (2015)
(also valid for the required length of engagement of a blind hole)

Length of engagement (mm)	[m _{gesvorh}]	18.00	
Effective length of engagement (mm)	[m _{effvorh}]	14.50	
Coefficient C1	[C ₁]	1.000	
Coefficient C2	[C ₂]	0.897	
Coefficient C3	[C ₃]	0.899	
Flank diameter tolerance, bolt		ISO 965-1 5e	
Bolt minimum flank diameter (mm)	[d _{2min}]	10.674	
Bolt minimum flank diameter (mm)	[d _{2max}]	10.792	
Core diameter tolerance, internal thread		ISO 965-1 5G	
Internal thread maximum core diameter (mm)	[D _{1max}]	10.405	
Minimum internal thread core diameter (mm)	[D _{1min}]	10.140	
Bolt shear surface (mm ²)	[A _{SGS}]	345.27	
Tensile strength of bolt (N/mm ²)	[R _m]	1040.00	
Bolt tensile strength coefficient	[R _{mmax} /R _m]		1.20
Maximum tensile strength, bolt (N/mm ²)	[R _{mmax}]	1248.00	
Ratio of shearing strength	[T _{BS} /R _m]		0.62
Shearing strength bolt (N/mm ²)	[T _{BS}]	644.80	
Minor diameter inner thread (mm)	[D ₁]	10.106	
Flank diameter inner thread (mm)	[D ₂]	10.863	
Bolt external diameter tolerance		ISO 965-1 6f	
Minimum external diameter, bolt (mm)	[d _{min}]	11.687	
Maximum external bolt diameter (mm)	[d _{max}]	11.952	
Flank diameter tolerance, internal thread		ISO 965-1 6G	
Maximum flank diameter, inner thread (mm)	[D _{2max}]	11.097	
Minimum internal thread flank diameter (mm)	[D _{2min}]	10.897	
Internal thread shear surface (mm ²)	[A _{SGM}]	478.33	

Internal thread shearing strength (N/mm ²)	[T _{BM}]	460.00
RS ratio	[R _S]	0.99
Stripping force, bolt thread (N)	[F _{mGS}]	199763.86
Stripping force, internal thread (N)	[F _{mGM}]	197742.55
Bolt breaking force (N)	[F _{mS}]	87637.17
Safety against stripping force to breaking force	[S _{AE}]	2.26
Assembly pretension force (N)	[F _M]	64904.29
Safety stripping force to preload	[S _{FM}]	3.05
Minimum length of engagement R _m (mm)	[m _{ges}]	10.60
Minimum length of engagement R _{mmax} (mm)	[m _{gesmin}]	13.50

The internal thread is more critical to prevent stripping.

4.2 Calculation with maximum attained pretension force

for utilization of yield point (%)	[V _{min}]	90.00
Assembly pretension force (N)	[F _M]	64904.29 64904.29
Pretension force (N)	[F _V]	62555.95 62555.95
Thread torque (Nm)	[M _G]	58.78 58.78
Torsional stress (N/mm ²)	[T _s]	269.39 269.39
Total bolt load (N)	[F _{Smax}]	66403.06 66403.06
Tensile stress (N/mm ²)	[σ _z]	788.01 788.01
Equivalent stress in assembly state (N/mm ²)	[σ _{red.M,zul}]	846.00
Equivalent stress in working state (N/mm ²)	[σ _{red.B}]	821.82 821.82
Tightening torque (Nm)	[M _A]	109.32
Loose torque (Nm)	[M _L]	70.05
Surface pressure under bolt head (N/mm ²)	[p _K]	774.36 774.36

4.3 Calculating safeties with the minimal required mounting preload, tightening factor 1.0

Assembly pretension force (N)	[F _{Mmin}]	26749.58 26749.58
Thread torque (Nm)	[M _{G_FMmin}]	24.23 24.23
Torsional stress (N/mm ²)	[T _{s_FMmin}]	111.03 111.03
Total bolt load (N)	[F _{Smax_FMmin}]	28248.35 28248.35
Tensile stress (N/mm ²)	[σ _{z_FMmin}]	335.23 335.23
Equivalent stress in assembly state (N/mm ²)	[σ _{red.M,zul_FMmin}]	348.67
Equivalent stress in working state (N/mm ²)	[σ _{red.B_FMmin}]	348.74 348.74
Tightening torque (Nm)	[M _{A_FMmin}]	45.06
Loose torque (Nm)	[M _{L_FMmin}]	27.33
Surface pressure under bolt head (N/mm ²)	[p _{K_FMmin}]	329.42 329.42

4.4 Calculation with the maximum required assembly preload, with tightening factor 1.80

Assembly pretension force (N)	[F _{Mmax}]	48149.24 48149.24
Additional clamp load (spare) (N)	[F _{Kres}]	9308.36
Thread torque (Nm)	[M _{G_FMmax}]	43.61 43.61
Torsional stress (N/mm ²)	[T _{s_FMmax}]	199.85 199.85
Total bolt load (N)	[F _{Smax_FMmax}]	49648.01 49648.01
Tensile stress (N/mm ²)	[σ _{z_FMmax}]	589.18 589.18
Equivalent stress in assembly state (N/mm ²)	[σ _{red.M,zul_FMmax}]	627.61
Equivalent stress in working state (N/mm ²)	[σ _{red.B_FMmax}]	614.07 614.07
Tightening torque (Nm)	[M _{A_FMmax}]	81.10
Loose torque (Nm)	[M _{L_FMmax}]	51.29
Surface pressure under bolt head (N/mm ²)	[p _{K_FMmax}]	578.97 578.97
Permissible equivalent stress (N/mm ²)	[σ _{Mzul}]	846.00
Permissible equivalent stress (N/mm ²)	[σ _{bzul}]	940.00 940.00
Support area under bolt head (mm ²)	[A _{pK}]	85.75
Permissible surface pressure under bolt head (N/mm ²)	[p _{Kzul}]	1300 1300

5 Summary

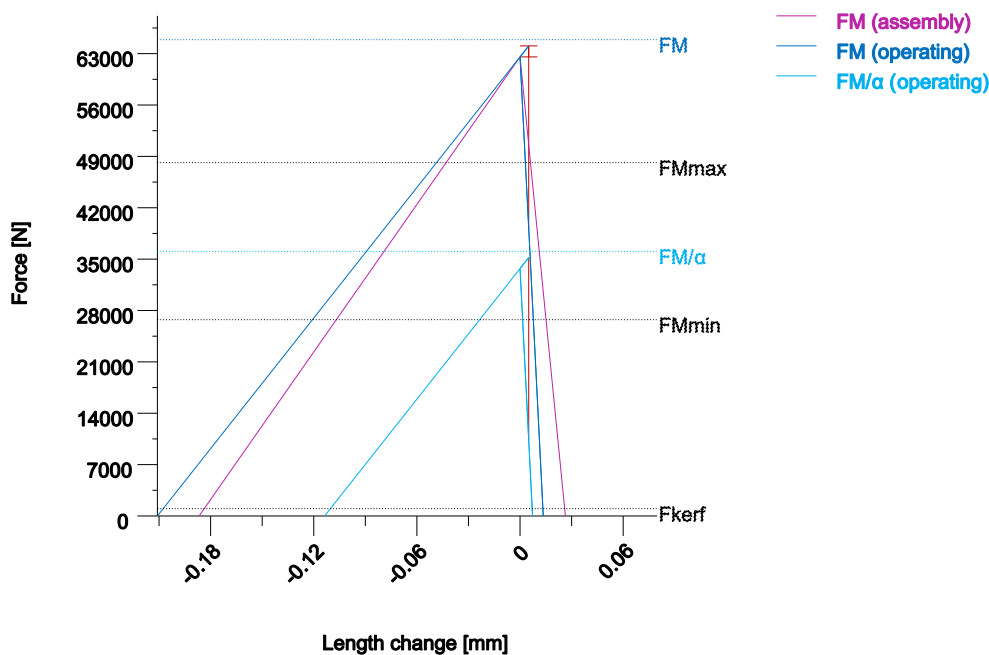
Calculation variant: The yield point must not be exceeded.

5.1 Calculation with maximum attained pretension force

Safety against yield point	[S _F]	1.14	1.14
Safety against fatigue	[S _D]	5.50	5.50
Safety against pressure	[S _P]	1.68	1.68

5.2 Calculation with minimum attained pretension force

Safety against sliding	[S _G]	10.31	10.31
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In the distortion triangle in the assembled state (FM (assembly)), the horizontal axis represents the amount by which the length of the bolt and clamped parts changes.

In the distortion triangle in the working state (FM (operation) and FM/α (operation)), additional parameters such as load application factors or equivalent stiffness of the screw-in area affect the working load distribution and consequently the slope of the lines in the diagram. Consequently, the horizontal values in the diagram can no longer equal the actual changes in the length of the bolt and clamped parts.

Figure: Display of the clamping diagram

6 Remarks

- Safeties (SF, SD, SP) are calculated according to VDI 2230.
- The safety against sliding (SG = FKR/FKerf) is calculated with FM/α.
- The calculation of the normal values for 90% utilization factor (Preload and tightening torque) follows the corresponding equation according to VDI 2230. These values correspond with the values in the tables in the VDI Standard. Small differences may however occur.
- The calculation of the length of engagement is theoretical, according to VDI 2230, and must be checked in real life conditions.
- Note: The minimum length of engagement mgesmin is calculated with Rmmax, dmin and D2max or d2min and D1max and is intended to represent the worst case scenario.

-Total required clamp load according to (R2/4): $FK_{erf} \geq \text{Maxi}(F_{KA} + F_{KP}, F_{KQ})$

End of report (lines: 386)