KISSsoft

Shaft

01 Shafts

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	Non commercial version for demo and support purposes only ! (914)
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Contents

1 Messages

Calculation is consistent.

In the rolling bearing database, the data for the internal geometry (e.g. number of rolling elements, rolling element diameter, etc.) is not completely available for the bearing "SKF 21308 E".

For calculations based on the bearing internal geometry, the data as available in the database are used. The missing data are estimated and documented in the protocol.

In the rolling bearing database, the data for the internal geometry (e.g. number of rolling elements, rolling element diameter, etc.) is not completely available for the bearing "SKF 21307 CC".

For calculations based on the bearing internal geometry, the data as available in the database are used. The missing data are estimated and documented in the protocol.

Cross section B-B:
The notch factor for light interference fits is no longer defined in DIN 743.

The notch factor for light interference fits (according to FKM) is larger than the notch factor for tight interference fits (according to DIN).

In this case, the notch factor for tight interference fits (according to DIN) is used.

2 Input data

Coordinate system shaft: see picture W-002

2.1 Shafts

2.1.1 Shaft 'Shaft'

Drawing	W-007	
Initial position (mm)		0.000
Length (mm)		235.000
Speed (1/min)		980.000
Direction of rotation:	clockwise	
Material	42 CrMo 4 (1)	
Young's modulus (N/mm²)		206000.000
Poisson's ratio nu		0.300
Density (kg/m³)		7830.000
Coefficient of thermal expansion	(10^-6/K)	11.500
Temperature (°C)		20.000
Mass of shaft (kg)		3.025
Note: mass stands for the shaft only without considering the gears		
Mass of shaft, including additional masses (kg)		8.879
Mass moment of inertia (kg*m²)		0.013
Momentum of mass GD2 (Nm²)		0.519

2.2 Weight force

Position in space (°) 0.000

2.3 Shaft modeling

Gears mounted with stiffness according to ISO

2.4 Shear deformations

Consider deformations due to shearing
Shear correction factor 1.100

2.5 Rolling bearings

Rolling bearing stiffness is calculated from inner bearing geometry
Tolerance field: Mean value

2.6 Housing

Reference temperature (°C) 20.000

2.7 Load applications

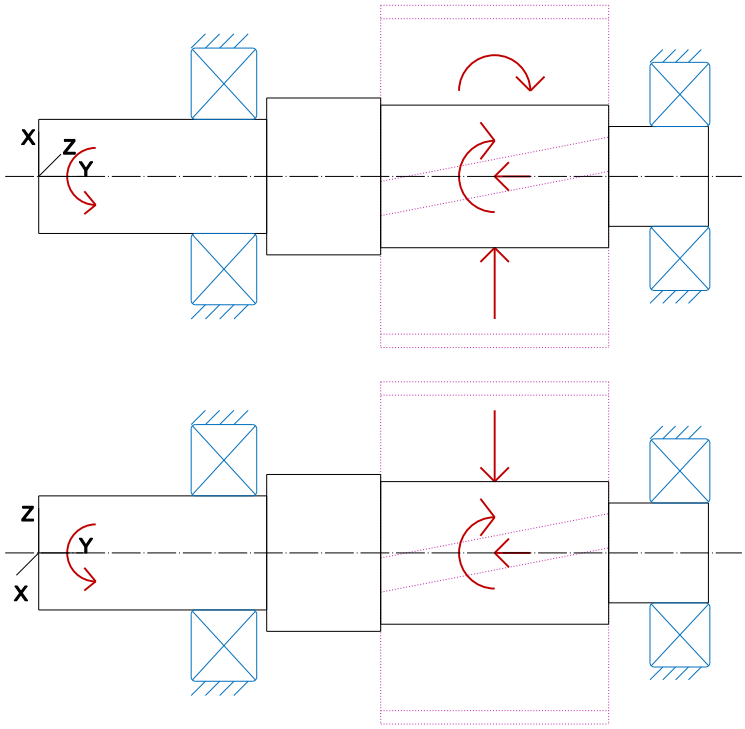


Figure: Load applications

3 Shaft definition (Shaft)

3.1 Outer contour

3.1.1 Cylinder (Cylinder 1), 0.000mm ...80.000mm

Diameter (mm)	[d]	40.0000
Length (mm)	[l]	80.0000
Surface roughness (µm)	[Rz]	4.8000

Key way (Key way) 2.000 mm ... 24.000 mm
l=22.00 (mm), i=1, Rz=16.0, Machined (Ra=3.2µm/125µin)

Interference fit (Interference fit) 0.000 mm ... 40.000 mm
l=40.00 (mm), Typ=0, Machined (Ra=3.2µm/125µin)

Radius right (Radius right)
r=3.00 (mm), Rz=8.0, Machined (Ra=3.2µm/125µin)

3.1.2 Cylinder (Cylinder 2), 80.000mm ...120.000mm

Diameter (mm)	[d]	55.0000
Length (mm)	[l]	40.0000
Surface roughness (µm)	[Rz]	16.0000

3.1.3 Cylinder (Cylinder 3), 120.000mm ...200.000mm

Diameter (mm)	[d]	50.0000
Length (mm)	[l]	80.0000
Surface roughness (µm)	[Rz]	4.8000

Radius left (Radius left)
r=1.00 (mm), Rz=8.0, Machined (Ra=3.2µm/125µin)

Key way (Key way) 130.000 mm ... 190.000 mm
l=60.00 (mm), i=1, Rz=16.0, Machined (Ra=3.2µm/125µin)

3.1.4 Cylinder (Cylinder 4), 200.000mm ...235.000mm

Diameter (mm)	[d]	35.0000
Length (mm)	[l]	35.0000
Surface roughness (µm)	[Rz]	4.8000

Radius left (Radius left)
r=1.00 (mm), Rz=4.8, Machined (Ra=3.2µm/125µin)

3.2 Forces

3.2.1 Coupling (Coupling / Motor)

Position on shaft (mm)	[y_{local}]	20.0000
Position in global system (mm)	[y_{global}]	20.0000
Effective diameter (mm)		0.0000
Radial force factor (-)		0.0000
Direction of the radial force (°)		0.0000
Axial force factor (-)		0.0000
Length of load application (mm)		40.0000
Power (kW)		75.0000 driven (input)
Torque (Nm)		730.8135
Axial force (N)		0.0000
Shearing force X (N)		0.0000
Shearing force Z (N)		0.0000
Bending moment X (Nm)		0.0000
Bending moment Z (Nm)		0.0000
Mass (kg)		0.0000
Mass moment of inertia Jp (kg*m²)		0.0000e+00
Mass moment of inertia Jxx (kg*m²)		0.0000e+00
Mass moment of inertia Jzz (kg*m²)		0.0000e+00
Eccentricity (mm)		0.0000

3.2.2 Cylindrical gear (Cylindrical gear)

Position on shaft (mm)	[y_{local}]	160.0000
Position in global system (mm)	[y_{global}]	160.0000
Operating pitch diameter (mm)		120.0000
Helix angle (°)		15.0000 Helix left hand
Working pressure angle at normal section (°)		20.0000
Position of contact (°)		180.0000
Length of load application (mm)		80.0000
Power (kW)		75.0000 driving (output)
Torque (Nm)		-730.8135
Axial force (N)		-3263.6815
Shearing force X (N)		4589.6272
Shearing force Z (N)		-12180.2252
Bending moment X (Nm)		0.0000
Bending moment Z (Nm)		195.8209

3.3 Bearing

3.3.1 Rolling bearing 1 (SKF 21308 E)

Bearing type		Spherical roller bearings SKF Explorer
Bearing position (mm)	[y_{lokal}]	65.000
Bearing position (mm)	[y_{global}]	65.000
Attachment of external ring		Set fixed bearing left
Inner diameter (mm)	[d]	40.000
External diameter (mm)	[D]	90.000
Width (mm)	[b]	23.000
Corner radius (mm)	[r]	1.500

Calculation was performed using real bearing internal geometry provided by bearing manufacturer. These values are however not available for reports.

Nominal diametral clearance* (µm) (*) ISO 5753-1:2009 C0	[Pd0]	37.500
Basic static load rating (kN)	[C_0]	108.000
Basic dynamic load rating (kN)	[C]	107.000
Fatigue load limit (kN)	[C_u]	12.000
Values for approximated geometry:		
Basic dynamic load rating (kN)	[C_{theo}]	90.296
Basic static load rating (kN)	[C_{0theo}]	108.000
Correction factor Basic dynamic load rating	[f_C]	1.000
Correction factor Basic static load rating	[f_{C0}]	1.000

3.3.2 Rolling bearing 2 (SKF 21307 CC)

Bearing type		Spherical roller bearings SKF Explorer
Bearing position (mm)	[y_{lokal}]	225.000
Bearing position (mm)	[y_{global}]	225.000
Attachment of external ring		Set fixed bearing right
Inner diameter (mm)	[d]	35.000
External diameter (mm)	[D]	80.000
Width (mm)	[b]	21.000
Corner radius (mm)	[r]	1.500

Calculation was performed using real bearing internal geometry provided by bearing manufacturer. These values are however not available for reports.

Nominal diametral clearance* (µm) (*) ISO 5753-1:2009 C0	[Pd0]	37.500
Basic static load rating (kN)	[C_0]	72.000
Basic dynamic load rating (kN)	[C]	79.200
Fatigue load limit (kN)	[C_u]	8.000
Values for approximated geometry:		
Basic dynamic load rating (kN)	[C_{theo}]	67.526
Basic static load rating (kN)	[C_{0theo}]	72.000
Correction factor Basic dynamic load rating	[f_C]	1.000
Correction factor Basic static load rating	[f_{C0}]	1.000

4 Gears

Gears are considered as mass and as stiffness according to ISO 6336-1 (interference fit).

4.1 Shaft 'Shaft': Cylindrical gear 'Cylindrical gear'

Center point	[y]	160.000	mm
Left side of the gear			
Position (Y-coordinate)	[y]	120.000	mm
Second moment of area	[I_{zz}]	2562392.188	mm⁴
Product E·I	[$E \cdot I_{zz}$]	527852.791	Nm²
Right side of the gear			
Position (Y-coordinate)	[y]	200.000	mm
Second moment of area	[I_{zz}]	2562392.188	mm⁴
Product E·I	[$E \cdot I_{zz}$]	527852.791	Nm²
Mass	[m]	5.854	kg
Center of mass	[y_S]	160.000	mm
Polar mass moment of inertia	[J_p]	1.2368e-02	kg·m²
Mass moment of inertia	[J_{xx}]	9.3062e-03	kg·m²
Mass moment of inertia	[J_{zz}]	9.3062e-03	kg·m²

5 Results

5.1 Shafts

Maximum deflection (µm)	36.566
Position of the maximum (mm)	200.000
Mass center of gravity (mm)	119.025
Total axial load (N)	-3263.682
Torsion of the shaft under torque (°) (Difference between left and right shaft end)	-0.151

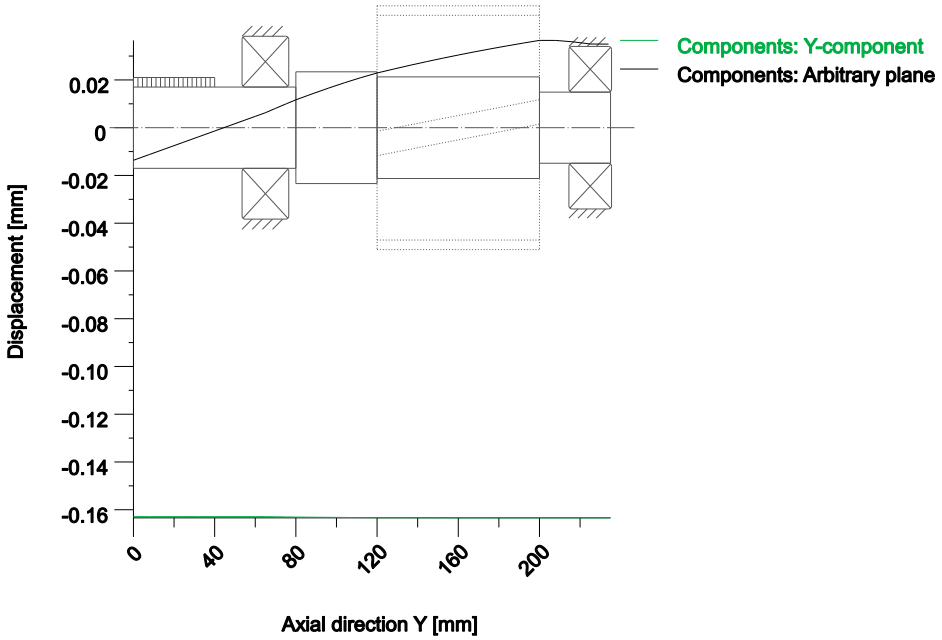
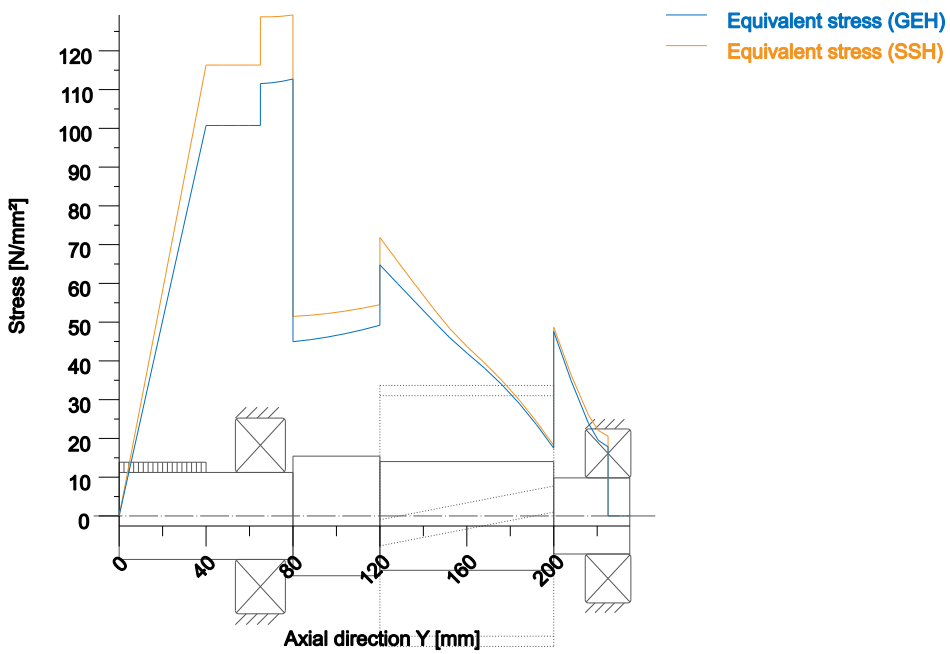


Figure: Deformation (bending etc.) (Arbitrary plane 283.0418113 131)



Nominal stresses, without taking into account stress concentrations
GEH(von Mises): sigV = ((sigB+sigZ,D)^2 + 3*(tauT+tauS)^2)^1/2
SSH(Tresca): sigV = ((sigB-sigZ,D)^2 + 4*(tauT+tauS)^2)^1/2

Figure: Equivalent stress

5.2 Bearing

Probability of failure	[n]	10.00	%
Axial clearance (ISO 281)	[u_A]	10.00	µm
Lubricant	ISO-VG 220		
Lubricant with additive, effect on bearing lifetime confirmed in tests.			
Oil lubrication, on-line filtration, ISO4406 -/17/14, β25=75			
Lubricant - service temperature	[T_B]	30.00	°C
Limit for factor a_{ISO}	[a_{ISOmax}]	50.00	
Oil level	[h_{oil}]	-30.00	mm
Oil bath lubrication			

Rolling bearing rating life according to ISO/TS 16281:2008

5.3 'Shaft' Rolling bearing 'Rolling bearing 1'

Position (Y-coordinate)	[y]	65.00	mm
Dynamic equivalent load	[P]	17.64	kN
Static equivalent load	[P_0]	15.01	kN
Minimum EHL lubricant film thickness	[h_{min}]	0.850	µm
Life modification factor for reliability	[a_1]	1.000	

5.3.1 Operating bearing clearance

Clearance change not considered in the calculation of the operating bearing clearance

Total diametral clearance change	[ΔP_d]	0.000	µm
Operating diametral clearance	[P_d]	37.500	µm

5.3.2 Results according to ISO 281

Lubricant	ISO-VG 220		
Lubricant with additive, effect on bearing lifetime confirmed in tests.			
Lubricant - service temperature	[T_B]	30.00	°C
Oil lubrication, on-line filtration, ISO4406 -/17/14, β25=75			

Contamination factor	[e_C]	0.436	
Load ratio	[C/P]	6.066	
Operating viscosity	[v]	425.092	mm²/s
Reference viscosity	[v_1]	17.562	mm²/s
Viscosity ratio	[κ]	24.205	
Life modification factor	[a_{ISO}]	2.261	
Fatigue load limit	[C_u]	12.000	kN
Basic rating life	[L_{10h}]	6922.309	h
Bearing rating life	[L_{nh}]	6922.309	h
Modified rating life	[L_{nmh}]	15649.175	h
Static safety factor	[S_0]	7.196	

5.3.3 Calculation with proprietary bearing internal geometry data (ISO/TS 16281)

Contamination factor	[e_C]	0.467	
Fatigue load limit	[C_u]	12.000	kN
Dynamic equivalent reference load	[P_{ref}]	11.094	kN
Basic reference rating life	[L_{10rh}]	32476.847	h
Reference rating life	[L_{nrh}]	32476.847	h
Modified reference rating life	[L_{nmrh}]	172666.005	h
Maximum contact stress	[p_{max}]	1733.247	N/mm²
Static equivalent load	[P_{0ref}]	17.343	kN
Effective static safety factor	[S_{0w}]	5.326	
Static safety factor	[S_{0ref}]	6.227	

(S0w = (p0 / pmax)^n, S0ref = C0 / P0ref)

5.3.4 Bearing reactions

Bearing reaction force	[F_x]	-3.088	kN
Bearing reaction force	[F_y]	3.264	kN
Bearing reaction force	[F_z]	4.991	kN
Bearing reaction force	[F_r]	5.869	kN
Inclination angle	[α_{Fr}]	121.748	°
Displacement of bearing	[u_x]	3.498	µm
Displacement of bearing	[u_y]	-162.890	µm
Displacement of bearing	[u_z]	-5.625	µm
Displacement of bearing	[u_r]	6.623	µm
Inclination angle	[α_{ur}]	-58.124	°
Misalignment of bearing	[r_x]	-0.296	mrad
Misalignment of bearing	[r_z]	-0.078	mrad
Misalignment of bearing	[r_r]	0.307	mrad

5.3.5 Friction and power loss

Oil level	[H]	8.750	mm
Rolling frictional moment	[M_{rr}]	0.601	Nm
Sliding frictional moment	[M_{sl}]	1.147	Nm
Frictional moment seals	[M_{seal}]	0.000	Nm

Moment of friction for seals determined according to SKF main catalog 17000/1 EN:2018

Frictional moment drag losses	[M_{drag}]	0.075	Nm
Friction moment	[M_{loss}]	1.823	Nm
Power loss	[P_{loss}]	187.041	W

The moment of friction is calculated according to the details in SKF Catalog 2018.
The calculation is always performed with a coefficient for additives in the lubricant μ_{bl} = 0.15.
The factors used to calculate the torque loss have been assumed for this bearing.

5.4 'Shaft' Rolling bearing 'Rolling bearing 2'

Position (Y-coordinate)	[y]	225.00	mm
Dynamic equivalent load	[P]	7.43	kN
Static equivalent load	[P_0]	7.43	kN
Minimum EHL lubricant film thickness		[h_{min}]	0.709 µm
Life modification factor for reliability	[a_1]	1.000	

5.4.1 Operating bearing clearance

Clearance change not considered in the calculation of the operating bearing clearance

Total diametral clearance change	[ΔP_d]	0.000	µm
Operating diametral clearance	[P_d]	37.500	µm

5.4.2 Results according to ISO 281

Lubricant	ISO-VG 220

Lubricant with additive, effect on bearing lifetime confirmed in tests.

Lubricant - service temperature	[T_B]	30.00	°C
Oil lubrication, on-line filtration, ISO4406 -/17/14, β25=75			
Contamination factor	[e_C]	0.396	
Load ratio	[C/P]	10.660	
Operating viscosity	[v]	425.092	mm²/s
Reference viscosity	[v_1]	19.439	mm²/s
Viscosity ratio	[κ]	21.868	
Life modification factor	[a_{ISO}]	4.116	
Fatigue load limit	[C_u]	8.000	kN
Basic rating life	[L_{10h}]	45345.439	h
Bearing rating life	[L_{nh}]	45345.439	h
Modified rating life	[L_{nmh}]	186628.957	h
Static safety factor	[S_0]	9.691	

5.4.3 Calculation with proprietary bearing internal geometry data (ISO/TS 16281)

Contamination factor	[e_C]	0.399	
Fatigue load limit	[C_u]	8.000	kN
Dynamic equivalent reference load	[P_{ref}]	5.765	kN
Basic reference rating life	[L_{10rh}]	105587.120	h
Reference rating life	[L_{nrh}]	105587.120	h
Modified reference rating life	[L_{nmrh}]	974813.724	h
Maximum contact stress	[p_{max}]	1561.947	N/mm²
Static equivalent load	[P_{0ref}]	8.902	kN
Effective static safety factor	[S_{0w}]	6.558	
Static safety factor	[S_{0ref}]	8.088	
(S0w = (p0 / pmax)^n, S0ref = C0 / P0ref)			

5.4.4 Bearing reactions

Bearing reaction force	[F_x]	-1.501	kN
Bearing reaction force	[F_y]	0.000	kN
Bearing reaction force	[F_z]	7.276	kN
Bearing reaction force	[F_r]	7.429	kN
Inclination angle	[α_{Fr}]	101.658	°
Displacement of bearing	[u_x]	7.138	µm
Displacement of bearing	[u_y]	-163.402	µm
Displacement of bearing	[u_z]	-34.320	µm
Displacement of bearing	[u_r]	35.055	µm
Inclination angle	[α_{ur}]	-78.251	°
Misalignment of bearing	[r_x]	-0.003	mrad
Misalignment of bearing	[r_z]	0.033	mrad
Misalignment of bearing	[r_r]	0.033	mrad

5.4.5 Friction and power loss

Oil level	[H]	4.375	mm
Rolling frictional moment	[M_{rr}]	0.502	Nm
Sliding frictional moment	[M_{sl}]	0.032	Nm
Frictional moment seals	[M_{seal}]	0.000	Nm
Moment of friction for seals determined according to SKF main catalog 17000/1 EN:2018			
Frictional moment drag losses	[M_{drag}]	0.034	Nm
Friction moment	[M_{loss}]	0.568	Nm
Power loss	[P_{loss}]	58.272	W

The moment of friction is calculated according to the details in SKF Catalog 2018.
The calculation is always performed with a coefficient for additives in the lubricant μ_{bl} = 0.15.
The factors used to calculate the torque loss have been assumed for this bearing.

(*) Note about roller bearings with an approximated bearing geometry:
The internal geometry of these bearings has not been input in the database. The geometry is back-calculated as specified in ISO 281, from C and C_0 (details in the manufacturer's catalog). For this reason, the geometry may be different from the actual geometry.
This can lead to differences in the service life calculation and, more importantly, the roller bearing stiffness.

5.5 Bearing frequencies

rolling bearing	n_i (1/min)	n_o (1/min)	n_{rel} (1/min)	FTF (Hz)	BSF (Hz)	BPFI (Hz)	BPFO (Hz)	BPF (Hz)
Rolling bearing 1 (SKF 21308 E)	980.00	0.00	980.00	7.01	55.78	177.15	133.19	111.56
Rolling bearing 2 (SKF 21307 CC)	980.00	0.00	980.00	6.81	47.02	152.36	108.98	94.05

n_i : Inner ring speed
n_o : Outer ring speed
n_{rel} : Relative speed
FTF : Rotational frequency of cage
FTF : Rotational frequency of cage
FTF : Rotational frequency of cage
BSF : Rotational frequency of rolling element
BPFI : Over-rolling frequency of inner ring
BPFO : Over-rolling frequency of outer ring
BPF : Over-rolling frequency of rolling element

5.6 Damage relative to the required service life (L_{req} = 5000 h)

Wälzlagerschäden pro Lastkollektiv-Element (%)		
Load bin	**B1**	**B2**
1	2.90	0.51
Σ	2.90	0.51

Note: Damage = L_{req}/L_h

B1 : Rolling bearing 1 (SKF 21308 E)
B2 : Rolling bearing 2 (SKF 21307 CC)

5.7 Utilization relative to the required service life (L_{req} = 5000 h)

Rolling bearings	**B1**	**B2**
Utilization (%)	34.56	20.56

Note: Utilization = $(L_{req}/L_h)^{(1/k)}$
Ball bearing: k = 3, roller bearing: k = 10/3

B1 : Rolling bearing 1 (SKF 21308 E)
B2 : Rolling bearing 2 (SKF 21307 CC)

5.8 Calculation of the factors required to define reliability R(t) using the Weibull distribution. t in (h)

Reliability not calculated

6 Strength calculation according to DIN 743:2012

6.1 Summary

Shaft

Drawing	W-007
Material	42 CrMo 4 (1)
Material type	Through hardened steel
Material treatment	alloyed, through hardened
Surface treatment	No

Calculation of endurance limit and the static strength

Calculation for load case 2 (σav/σmv = const)

Cross section	Position (Y-Coord) (mm)	
A-A	136.30	Key
B-B	75.40	Interference fit
C-C	200.00	Shoulder
D-D	80.00	Shoulder

Results:

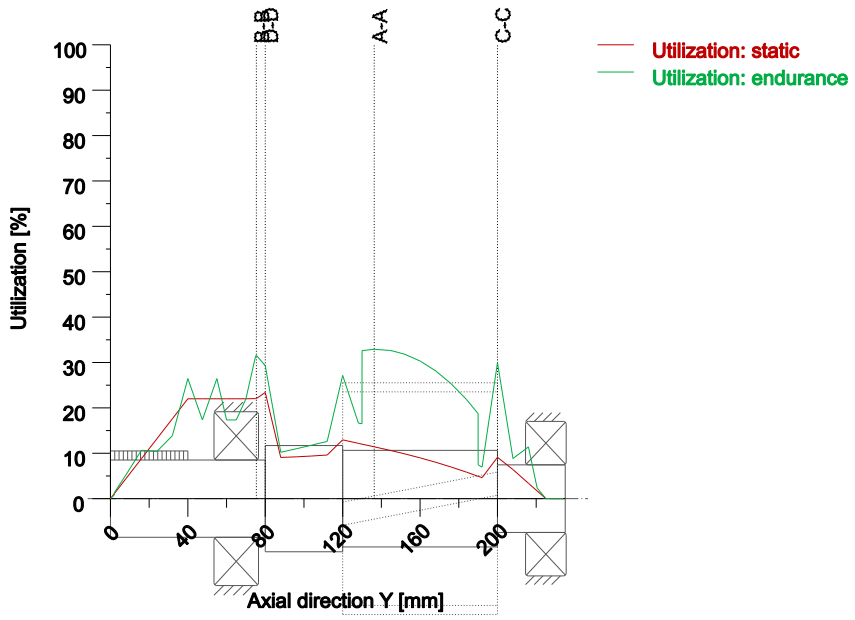
Cross section	βσ	KFσ	K2d	SD	SS
A-A	2.98	1.00	0.87	3.65	10.50
B-B	2.69	1.00	0.89	3.80	5.44
C-C	2.33	0.90	0.90	4.00	13.18
D-D	1.77	0.87	0.89	4.10	5.13
Required safeties:				1.20	1.20

Abbreviations:
βσ: Notch factor, bending
KFσ: Surface factor
K2d: size factor bending
SD: Safety endurance limit
SS: Safety against yield point

6.1.1 Utilization (%)

Cross section	Static (yield point)	Endurance
A-A	11.429	32.903
B-B	22.050	31.564
C-C	9.108	29.974
D-D	23.395	29.301

Maximum utilization (%)	[A]	32.903



Utilization = Smin/S (%)

Figure: Strength (nominal load)

6.2 Calculation details

General statements

Label	Shaft		
Drawing	W-007		
Length (mm)	[l]	235.00	
lcElem = 0			
Speed (1/min)	[n]	980.00	

Material	42 CrMo 4 (1)
Material type	Through hardened steel
Material treatment	alloyed, through hardened
Surface treatment	No

	Tension/Compression		Bending	Torsion	Shearing
Load factor static calculation	1.700	1.700	1.700	1.700	
Stress ratio	0.000	-1.000	0.000	-1.000	
Load factor endurance limit	1.000	1.000	1.000	1.000	

Reference diameter material (mm)	[dB]	16.00
σB according to DIN 743 (at dB) (N/mm²)	[σB]	1100.00
σB according to DIN 743 (at dB) (N/mm²)	[σS]	900.00
[σzdW], bei dB (N/mm²)		440.00
[σbW], bei dB (N/mm²)		550.00
[τtW], bei dB (N/mm²)		330.00
Thickness of raw material (mm)	[dWerkst]	60.00

Material data calculated with K1(d), according to DIN 743/3
Geometric size factor K1d calculated with shaft diameter D
Material strength calculated from shaft diameter
(Requirement: Through hardening of pre-machined shaft)

Notice: The following material values are only valid for
the first cross-section, the next ones are corresponding
to their actual 'Diameter for size factor'.

[σBeff] (N/mm²)	958.47
[σSeff] (N/mm²)	748.58
[σbFK] (N/mm²)	898.29
[τtFK] (N/mm²)	518.63
[σbBRand] (N/mm²)	708.00
[σzdW] (N/mm²)	383.39
[σbW] (N/mm²)	479.24
[τtW] (N/mm²)	287.54

Endurance limit for single stage use

Calculation for load case 2 (σ.av/σ.mv = const)

6.2.1 Cross section 'A-A' Key

Comment	Y= 130.00...190.00mm	
Position (Y-Coordinate) (mm)	[y]	136.300
External diameter (mm)	[da]	50.000
Inner diameter (mm)	[di]	0.000
Diameter for size factors (mm)	[deff]	50.000
Notch effect	Key	
Number of keys	[n]	1

Groove with manufactured with end milling cutter
Standard: DIN 6885.1:1968 Default

[b, t] (mm)	14.000 5.600	
Mean roughness (µm)	[Rz]	16.000

		Tension/Compression	Bending	Torsion	Shearing
Load: (N) (Nm)					
Mean value	[Fzdm, Mbm, Tm, Fqm]	-1299.4	0.0	291.0	0.0
Amplitude	[Fzda, Mba, Ta, Fqa]	1299.4	376.5	291.0	3284.6
Maximum value	[Fzdmax, Mbmax, Tmax, Fqmax]	-2598.7	376.5	581.9	3284.6
Maximum value (static safety)		-4417.8	640.0	989.2	5583.8
Cross section, moment of resistance: (mm²)					
[A, Wb, Wt]		1963.5	12271.8	24543.7	

		Tension/Compression	Bending	Torsion
Stresses: (N/mm²)				
[σzdm, σbm, τm, τqm] (N/mm²)		-0.662	0.000	11.855	0.000
[σzda, σba, τa, τqa] (N/mm²)		0.662	30.677	11.855	2.230
[σzdmax,σbmax,τmax,τqmax] (N/mm²)		-2.250	52.151	40.306	3.792
Technological size influence	[K1(σB)]			0.871	
	[K1(σS)]			0.832	

		Tension/Compression	Bending	Torsion
Notch effect coefficient	[ß(dB)]	2.958	2.958	1.800
[dB] (mm) = 40.0				
Geometrical size influence	[K3(d)]	0.940	0.940	0.968
Geometrical size influence	[K3(dB)]	0.947	0.947	0.971
Notch effect coefficient	[ß]	2.981	2.981	1.807
Geometrical size influence	[K2(d)]	1.000	0.873	0.873
Influence coefficient surface roughness	[KF]	1.000	1.000	1.000

Roughness factor is included into the notch effect coefficient

Surface treatment factor	[KV]	1.000	1.000	1.000
Total influence coefficient	[K]	2.981	3.413	2.069

Present safety for endurance limit:

Equivalent mean stress (N/mm²)	[σmV]	20.522
Equivalent mean stress (N/mm²)	[τmV]	11.848

Fatigue limit of part (N/mm²)	[σWK]	128.630	140.423	138.967
Influence coefficient of mean stress sensitivity.				
	[ψσK]	0.072	0.079	0.078

Permissible amplitude (N/mm²)	[σADK]	23.385	133.371	128.897
Safety against fatigue	[S]			3.647
Required safety against fatigue	[Smin]			1.200
Result (%)	[S/Smin]			303.9

Present safety
for proof against exceed of yield point:

Static notch sensitivity factor	[K2F]	1.000	1.200	1.200
Increase coefficient	[γF]	1.000	1.000	1.000
Yield stress of part (N/mm²)	[σFK]	748.576	898.291	518.629
Safety yield stress	[S]			10.500
Required safety	[Smin]			1.200
Result (%)	[S/Smin]			875.0

6.2.2 Cross section 'B-B' Interference fit

Comment	Y= 54.60... 75.40mm	
Position (Y-Coordinate) (mm)	[y]	75.400
External diameter (mm)	[da]	40.000
Inner diameter (mm)	[di]	0.000
Diameter for size factors (mm)	[deff]	40.000
Notch effect	Interference fit	
Characteristic:	Slight interference fit	

Note: Interference fit types 'Slight interference fit' and 'Interference fit with end relief' are no longer supported in the current FKM Guideline, 7th edition (2020).
The notch effect coefficients are determined on the basis of the old FKM Guideline (2012).
We recommend you use interference fit type 'Interference fit' when developing new products or further developing existing ones.
Mean roughness (µm) [Rz] 4.800

		Tension/Compression	Bending	Torsion	Shearing
Load: (N) (Nm)					
Mean value	[Fzdm, Mbm, Tm, Fqm]	-1631.8	0.0	365.4	0.0
Amplitude	[Fzda, Mba, Ta, Fqa]	1631.8	60.8	365.4	5863.3
Maximum value	[Fzdmax, Mbmax, Tmax, Fqmax]	-3263.7	60.8	730.8	5863.3
Maximum value (static safety)		-5548.3	103.4	1242.4	9967.5
Cross section, moment of resistance: (mm²)					
[A, Wb, Wt]		1256.6	6283.2	12566.4	
Stresses: (N/mm²)					
[σzdm, σbm, τm, τqm] (N/mm²)		-1.299	0.000	29.078	0.000
[σzda, σba, τa, τqa] (N/mm²)		1.299	9.678	29.078	6.221
[σzdmax,σbmax,τmax,τqmax] (N/mm²)		-4.415	16.452	98.866	10.576

Technological size influence	[K1(σB)]		0.897
	[K1(σS)]		0.865

		Tension/Compression	Bending	Torsion
Notch effect coefficient	[ß(dB)]	2.686	2.686	1.786
[dB] (mm) = 40.0				
Geometrical size influence	[K3(d)]	0.952	0.952	0.972
Geometrical size influence	[K3(dB)]	0.952	0.952	0.972
Notch effect coefficient	[ß]	2.686	2.686	1.786
Geometrical size influence	[K2(d)]	1.000	0.888	0.888
Influence coefficient surface roughness	[KF]	1.000	1.000	1.000
Roughness factor is included into the notch effect coefficient				
Surface treatment factor	[KV]	1.000	1.000	1.000
Total influence coefficient	[K]	2.686	3.024	2.011

Present safety for endurance limit:

Equivalent mean stress (N/mm²)	[σmV]			50.348
Equivalent mean stress (N/mm²)	[τmV]			29.068
Fatigue limit of part (N/mm²)	[σWK]	146.853	163.052	147.125

Influence coefficient of mean stress sensitivity.

	[ψσK]	0.080	0.090	0.081
Permissible amplitude (N/mm²)	[σADK]	19.567	111.008	136.154
Safety against fatigue	[S]			3.802
Required safety against fatigue	[Smin]			1.200
Result (%)	[S/Smin]			316.8

Present safety
for proof against exceed of yield point:

Static notch sensitivity factor	[K2F]	1.000	1.200	1.200
Increase coefficient	[γF]	1.000	1.000	1.000
Yield stress of part (N/mm²)	[σFK]	778.230	933.876	539.174
Safety yield stress	[S]			5.442
Required safety	[Smin]			1.200
Result (%)	[S/Smin]			453.5

6.2.3 Cross section 'C-C' Shoulder

Comment	Y= 200.00mm		
Position (Y-Coordinate) (mm)	[y]		200.000
External diameter (mm)	[da]		35.000
Inner diameter (mm)	[di]		0.000
Diameter for size factors (mm)	[deff]		50.000
Notch effect		Shoulder	
[D, r, t] (mm)	50.000	1.000	7.500
Mean roughness (µm)	[Rz]		4.800

		Tension/Compression	Bending	Torsion	Shearing
Load: (N) (Nm)					
Mean value	[Fzdm, Mbm, Tm, Fqm]	0.0	0.0	0.0	0.0
Amplitude	[Fzda, Mba, Ta, Fqa]	0.0	185.7	0.0	7426.8
Maximum value	[Fzdmax, Mbmax, Tmax, Fqmax]	0.0	185.7	0.0	7426.8
Maximum value (static safety)		0.0	315.7	0.0	12625.6
Cross section, moment of resistance: (mm²)					
[A, Wb, Wt]		962.1	4209.2	8418.5	
Stresses: (N/mm²)					
[σzdm, σbm, τm, τqm] (N/mm²)		0.000	0.000	0.000	0.000
[σzda, σba, τa, τqa] (N/mm²)		0.000	44.115	0.000	10.292
[σzdmax,σbmax,τmax,τqmax] (N/mm²)		0.000	74.995	0.000	17.497

Technological size influence	[K1(σB)]		0.871
	[K1(σS)]		0.832

		Tension/Compression	Bending	Torsion
Stress concentration factor	[α]	2.807	2.485	1.772
References stress slope	[G']	2.478	2.478	1.150
Notch sensitivity factor	[n]	1.065	1.065	1.045
Notch effect coefficient	[ß]	2.635	2.333	1.696
Geometrical size influence	[K2(d)]	1.000	0.897	0.897
Influence coefficient surface roughness	[KF]	0.898	0.898	0.941
Surface treatment factor	[KV]	1.000	1.000	1.000
Total influence coefficient	[K]	2.748	2.714	1.953

Present safety for endurance limit:

Equivalent mean stress (N/mm²)	[σmV]			0.000
Equivalent mean stress (N/mm²)	[τmV]			0.000
Fatigue limit of part (N/mm²)	[σWK]	139.492	176.610	147.241
Influence coefficient of mean stress sensitivity.				
	[ψσK]	0.078	0.101	0.083
Permissible amplitude (N/mm²)	[σADK]	139.492	176.610	147.241
Safety against fatigue	[S]			4.003
Required safety against fatigue	[Smin]			1.200
Result (%)	[S/Smin]			333.6

Present safety
for proof against exceed of yield point:

Static notch sensitivity factor	[K2F]	1.000	1.200	1.200
Increase coefficient	[γF]	1.100	1.100	1.000
Yield stress of part (N/mm²)	[σFK]	823.433	988.120	518.629
Safety yield stress	[S]			13.176
Required safety	[Smin]			1.200
Result (%)	[S/Smin]			1098.0

6.2.4 Cross section 'D-D' Shoulder

Comment	Y= 80.00mm			
Position (Y-Coordinate) (mm)	[y]			80.000
External diameter (mm)	[da]			40.000
Inner diameter (mm)	[di]			0.000
Diameter for size factors (mm)	[deff]			55.000
Notch effect		Shoulder		
[D, r, t] (mm)	55.000	3.000	7.500	
Mean roughness (µm)	[Rz]			8.000

		Tension/Compression	Bending	Torsion	Shearing
Load: (N) (Nm)					
Mean value	[Fzdm, Mbm, Tm, Fqm]	-1631.8	0.0	365.4	0.0
Amplitude	[Fzda, Mba, Ta, Fqa]	1631.8	87.8	365.4	5862.9
Maximum value	[Fzdmax, Mbmax, Tmax, Fqmax]	-3263.7	87.8	730.8	5862.9
Maximum value (static safety)		-5548.3	149.2	1242.4	9966.9
Cross section, moment of resistance: (mm²)					
[A, Wb, Wt]		1256.6	6283.2	12566.4	

Stresses: (N/mm²)				
[σzdm, σbm, τm, τqm] (N/mm²)	-1.299	0.000	29.078	0.000
[σzda, σba, τa, τqa] (N/mm²)	1.299	13.970	29.078	6.221
[σzdmax,σbmax,τmax,τqmax] (N/mm²)	-4.415	23.750	98.866	10.575

Technological size influence	[K1(σB)]	0.861
	[K1(σS)]	0.818

		Tension/Compression	Bending	Torsion
Stress concentration factor	[α]	2.030	1.843	1.437
References stress slope	[G']	0.859	0.859	0.383
Notch sensitivity factor	[n]	1.040	1.040	1.027
Notch effect coefficient	[ß]	1.952	1.772	1.399
Geometrical size influence	[K2(d)]	1.000	0.888	0.888
Influence coefficient surface roughness	[KF]	0.866	0.866	0.923
Surface treatment factor	[KV]	1.000	1.000	1.000
Total influence coefficient	[K]	2.107	2.150	1.659

Present safety for endurance limit:

Equivalent mean stress (N/mm²)	[σmV]			50.348
Equivalent mean stress (N/mm²)	[τmV]			29.068
Fatigue limit of part (N/mm²)	[σWK]	179.732	220.195	171.209
Influence coefficient of mean stress sensitivity.				
	[ψσK]	0.105	0.132	0.099
Permissible amplitude (N/mm²)	[σADK]	20.354	149.354	155.731
Safety against fatigue	[S]			4.095
Required safety against fatigue	[Smin]			1.200
Result (%)	[S/Smin]			341.3

Present safety
for proof against exceed of yield point:

Static notch sensitivity factor	[K2F]	1.000	1.200	1.200
Increase coefficient	[γF]	1.100	1.050	1.000

Yield stress of part (N/mm²)	[σFK]	809.501	927.246	509.853
Safety yield stress	[S]			5.129
Required safety	[Smin]			1.200
Result (%)	[S/Smin]			427.4

Remarks:
- The shearing force is not considered in the analysis specified in DIN 743.
- Cross section with interference fit: The notch factors for the 'Slight interference fit' case are no longer defined in DIN 743. The notch factors are taken from the FKM Guideline, except if those for the 'tight interference fit' according to DIN are smaller, in which case they will be used.

End of report (lines: 903)