Planetary gearbox FSE.12

Power inputs:

_O.Gearbox.input

Speed	[1/min]	20000
Torque	[Nm]	19
Power	[kW]	39.7935

Power outputs:

_O.Gearbox.output

Speed	[1/min]	-1744.868
Torque	[Nm]	217.7815
Power	[kW]	39.7935

Inhalt

_O.Gearbox.CarrierShaft.Planet.Planet_calc

1 Input data

Coordinate system shaft: see picture W-002

1.1 Shafts

1.1.1 Shaft 'PinShaft'

Drawing		
Initial position (mm)		85.000
Length (mm)		39.000
Speed (1/min)		0.000
Direction of rotation:	clockwise	
Material	C45 (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 (g)		23.984
Mass of shaft, including additional masses (g)		23.984
Mass moment of inertia (kg*mm²)		0.300
Momentum of mass GD2 (Nm²)		0.000

1.1.2 Shaft 'PlanetGearBody'

Drawing		
Initial position (mm)		77.500
Length (mm)		53.000
Speed (1/min)		9032.258
Direction of rotation:	counterclockwise	
Material	C45 (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 (g)		32.593
Mass of shaft, including additional masses (g)		32.593
Mass moment of inertia (kg*mm²)		0.407
Momentum of mass GD2 (Nm²)		0.000

1.2 Weight force

Weight towards	0.000		
Weight towards		0.000	
Weight towards			-1.000

1.3 Shaft modeling

1.4 Shear deformations

Consider deformations due to shearing
Shear correction factor 1.100

1.5 Rolling bearings

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

1.6 Housing

Reference temperature (°C) 20.000

1.7 Load applications

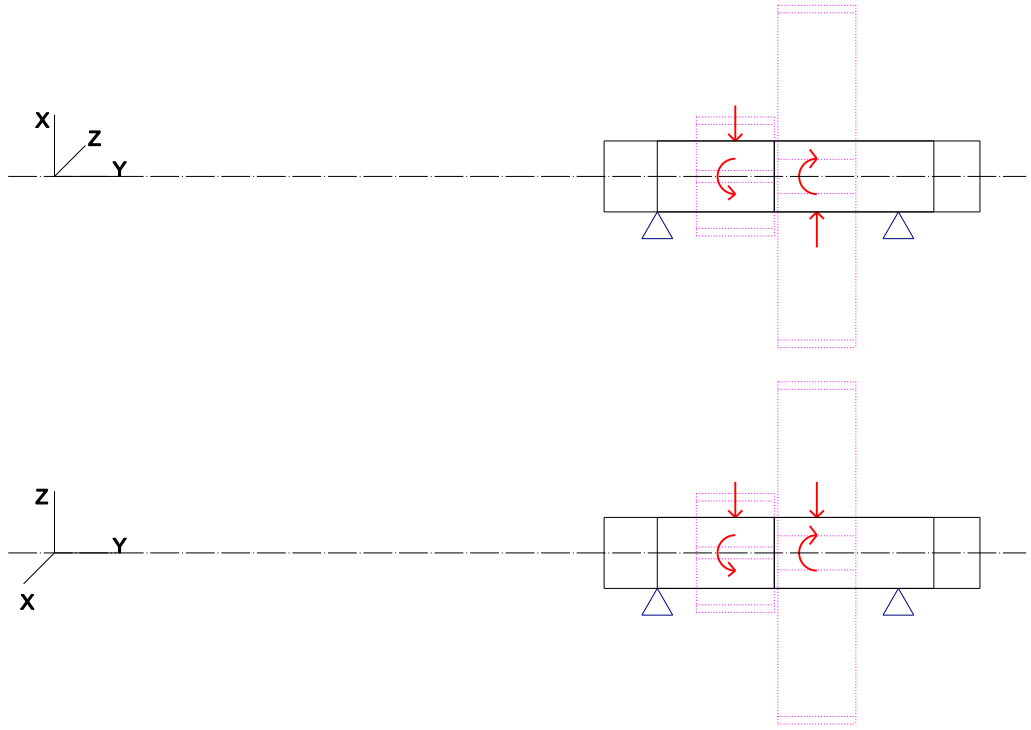


Figure: Load applications

2 Shaft definition (PinShaft)

2.1 Outer contour

2.1.1 Cylinder (Zylinder), 0.000mm ...39.000mm

Diameter (mm)	[d]	10.0000
Length (mm)	[l]	39.0000
Surface roughness (µm)	[Rz]	8.0000

2.2 Forces

2.2.1 Coupling (CouplingPin(PinCarrier))

Position on shaft (mm)	[y_{local}]	43.0000
Position in global system (mm)	[y_{global}]	128.0000
Effective diameter (mm)		15.0000
Radial force factor (-)		0.0000

Direction of the radial force (°)	0.0000
Axial force factor (-)	0.0000
Length of load application (mm)	5.0000
Power (kW)	0.0000
Torque (Nm)	-0.0000
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

2.3 Bearing

2.3.1 Support6 (Free bearing)

Bearing position (mm)	[y_{lokal}]	0.000
Bearing position (mm)	[y_{global}]	85.000

Degrees of freedom
X: fixed; Y: free; Z: fixed;
Rx: free; Ry: free; Rz: free;

2.3.2 Support7 (Fixed bearing adjusted on both sides)

Bearing position (mm)	[y_{lokal}]	34.000
Bearing position (mm)	[y_{global}]	119.000

Degrees of freedom
X: fixed; Y: fixed; Z: fixed;
Rx: free; Ry: free; Rz: free;

3 Shaft definition (PlanetGearBody)

3.1 Outer contour

3.1.1 Cylinder (Zylinder), 0.000mm ...24.000mm

Diameter (mm)	[d]	10.0000
Length (mm)	[l]	24.0000
Surface roughness (µm)	[Rz]	8.0000

3.1.2 Cylinder (Zylinder), 24.000mm ...53.000mm

Diameter (mm)	[d]	10.0000
Length (mm)	[l]	29.0000
Surface roughness (µm)	[Rz]	8.0000

3.2 Forces

3.2.1 Cylindrical gear (PlanetGear1)

Position on shaft (mm)	[y_{local}]	30.0000
Position in global system (mm)	[y_{global}]	107.5000
Operating pitch diameter (mm)		48.2222
Spur gear		
Working pressure angle at normal section (°)		25.0238
Position of contact (°)		180.0000
Length of load application (mm)		11.0000
Power (kW)		13.2645 driven (input)

Torque (Nm)	-14.0238
Axial force (N)	0.0000
Shearing force X (N)	271.5139
Shearing force Z (N)	-581.6327
Bending moment X (Nm)	-0.0000
Bending moment Z (Nm)	-0.0000

3.2.2 Cylindrical gear (PlanetGear2)

Position on shaft (mm)	[y_{local}]	18.5000
Position in global system (mm)	[y_{global}]	96.0000
Operating pitch diameter (mm)		16.7606
Spur gear		
Working pressure angle at normal section (°)		17.6140
Position of contact (°)		-0.0000
Length of load application (mm)		11.0000
Power (kW)		13.2645 driving (output)
Torque (Nm)		14.0238
Axial force (N)		-0.0000
Shearing force X (N)		-531.2929
Shearing force Z (N)		-1673.4294
Bending moment X (Nm)		-0.0000
Bending moment Z (Nm)		-0.0000

4 Connections

4.1 CB1 (SKF K 10X14X10 TN)

Bearing type		Needle cage
Position (mm)		118.500
Shaft 'PinShaft' <-> Shaft 'PlanetGearBody'		
Free bearing		
Inner diameter (mm)	[d]	10.000
External diameter (mm)	[D]	14.000
Width (mm)	[b]	10.000
Corner radius (mm)	[r]	0.000
Basic dynamic load rating (kN)	[C]	5.610
Basic static load rating (kN)	[C_0]	6.100
Fatigue load limit (kN)	[C_u]	0.695
Basic dynamic load rating (kN)	[C_{theo}]	5.981
Basic static load rating (kN)	[C_{0theo}]	6.100
Correction factor Basic dynamic load rating	[f_C]	1.000
Correction factor Basic static load rating	[f_{C0}]	1.000

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

Nominal diametral clearance* (µm)	[Pd0]	0.000

(*) Own input

4.2 CB2 (SKF K 10X14X10 TN)

Bearing type		Needle cage
Position (mm)		85.000
Shaft 'PinShaft' <-> Shaft 'PlanetGearBody'		
Free bearing		
Inner diameter (mm)	[d]	10.000
External diameter (mm)	[D]	14.000

Width (mm)	[b]	10.000
Corner radius (mm)	[r]	0.000
Basic dynamic load rating (kN)	[C]	5.610
Basic static load rating (kN)	[C_0]	6.100
Fatigue load limit (kN)	[C_u]	0.695
Basic dynamic load rating (kN)	[C_{theo}]	5.981
Basic static load rating (kN)	[C_{0theo}]	6.100
Correction factor Basic dynamic load rating	[f_C]	1.000
Correction factor Basic static load rating	[f_{C0}]	1.000

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

Nominal diametral clearance* (µm)	[Pd0]	0.000

(*) Own input

5 Gears

Gears are considered only as load application.

6 Results

6.1 Shafts

Maximum deflection 19.270(µm) (PlanetGearBody pos = 100.125 mm)

Mass center of gravity
PinShaft (mm) 19.500
PlanetGearBody (mm) 26.500

Total axial load
PinShaft (N) 0.000
PlanetGearBody (N) 0.000

Torsion of the shafts under torque
(Difference between left and right shaft end)
PinShaft (°) -0.000
PlanetGearBody (°) -0.119

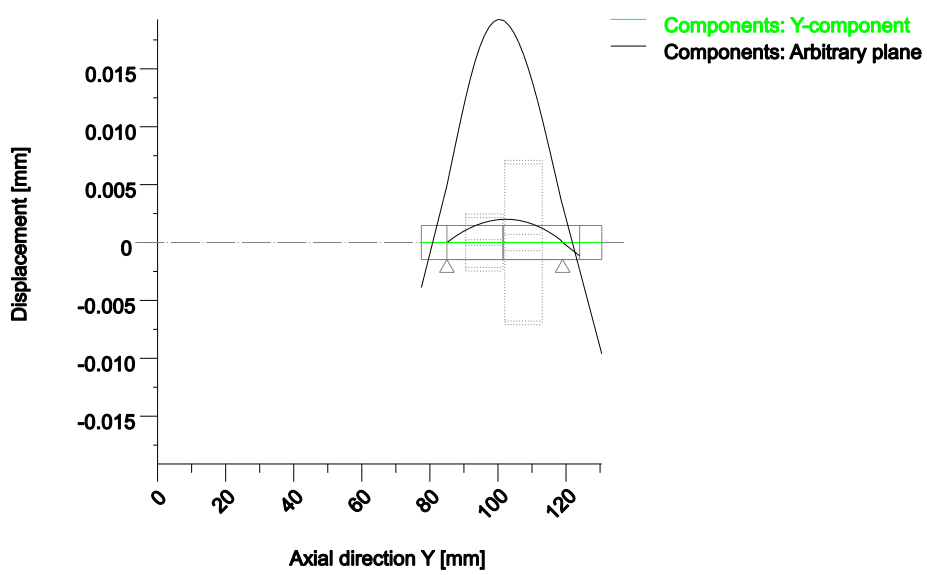
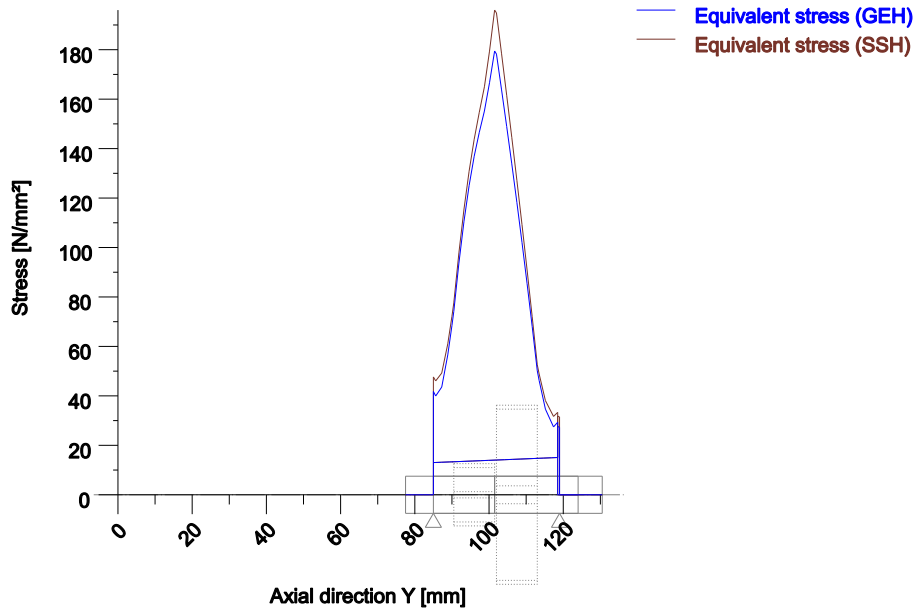


Figure: Deformation (bending etc.) (Arbitrary plane 262.9876651 127)



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

6.2 Bearing

Probability of failure	[n]	10.00	%
Axial clearance (ISO 281)	[u_A]	10.00	µm
Lubricant	ISO-VG 220		
Lubricant - service temperature	[T_B]	70.00	°C

Rolling bearing stiffness calculated from internal geometry

6.3 'PinShaft' Bearing 'Support6'

Position (Y-coordinate)	[y]	0.00	mm
Bearing reaction force	[F_x]	0.268	kN
Bearing reaction force	[F_y]	0.000	kN
Bearing reaction force	[F_z]	1.329	kN
Bearing reaction force	[F_r]	1.356	kN
Inclination angle	[α_{Fr}]	78.617	°
Displacement of bearing	[u_x]	-0.000	µm
Displacement of bearing	[u_y]	0.000	µm
Displacement of bearing	[u_z]	-0.000	µm
Displacement of bearing	[u_r]	0.000	µm
Misalignment of bearing	[r_x]	-0.226	mrad
Misalignment of bearing	[r_z]	0.026	mrad
Misalignment of bearing	[r_r]	0.227	mrad

6.4 'PinShaft' Bearing 'Support7'

Position (Y-coordinate)	[y]	34.00	mm
Bearing reaction force	[F_x]	-0.008	kN
Bearing reaction force	[F_y]	-0.000	kN
Bearing reaction force	[F_z]	0.927	kN
Bearing reaction force	[F_r]	0.927	kN

Inclination angle	[α_{Fr}]	90.482	°
Displacement of bearing	[u_x]	0.000	µm
Displacement of bearing	[u_y]	0.000	µm
Displacement of bearing	[u_z]	-0.000	µm
Displacement of bearing	[u_r]	0.000	µm
Misalignment of bearing	[r_x]	0.229	mrad
Misalignment of bearing	[r_z]	-0.016	mrad
Misalignment of bearing	[r_r]	0.230	mrad

6.5 Rolling bearing 'CB1'

Position (Y-coordinate)	[y]	118.50	mm
Dynamic equivalent load	[P]	0.93	kN
Static equivalent load	[P_0]	0.93	kN
Minimum EHL lubricant film thickness		[h_{min}]	0.127 µm
Life modification factor for reliability	[a_1]	1.000	

6.5.1 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]	0.000	µm

6.5.2 Results according to ISO 281

Lubricant	ISO-VG 220		
Load ratio	[C/P]	6.013	
Operating viscosity	[v]	48.884	mm²/s
Reference viscosity	[v_1]	0.000	mm²/s
Viscosity ratio	[κ]	0.000	
Basic rating life	[L_{10h}]	729.467	h
Bearing rating life	[L_{nh}]	729.467	h
Static safety factor	[S_0]	6.538	

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

Contamination factor	[e_C]	0.000	
Fatigue load limit	[C_u]	0.695	kN
Dynamic equivalent reference load	[P_{ref}]	0.000	kN
Basic reference rating life	[L_{10rh}]	1096.245	h
Reference rating life	[L_{nrh}]	1096.245	h
Maximum contact stress	[p_{max}]	1928.852	N/mm²
Static equivalent load	[P_{0ref}]	0.000	kN
Effective static safety factor	[S_{0w}]	9999.990	
Static safety factor	[S_{0ref}]	9999.990	

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

6.5.4 Bearing reactions

Bearing reaction force	[F_x]	0.012	kN
Bearing reaction force	[F_y]	0.000	kN
Bearing reaction force	[F_z]	-0.933	kN
Bearing reaction force	[F_r]	0.933	kN
Inclination angle	[α_{Fr}]	-89.261	°
Bearing reaction moment	[M_x]	1.015	Nm
Bearing reaction moment	[M_z]	-0.061	Nm
Bearing reaction moment	[M_r]	1.017	Nm
Inclination angle	[α_{Mr}]	-3.425	°
Displacement of bearing	[u_x]	-0.056	µm
Displacement of bearing	[u_y]	0.000	µm
Displacement of bearing	[u_z]	3.584	µm
Displacement of bearing	[u_r]	3.585	µm
Inclination angle	[α_{ur}]	90.899	°
Misalignment of bearing	[r_x]	-0.879	mrad
Misalignment of bearing	[r_z]	0.101	mrad
Misalignment of bearing	[r_r]	0.885	mrad

6.5.5 Friction and power loss

Oil level	[H]	0.000	mm
Load-independent moment of friction		[M_0]	0.003 Nm
Load-dependent moment of friction	[M_1]	0.003	Nm
Moment of friction, cylindrical roller bearing		[M_2]	0.000 Nm

Moment of friction for seals determined according to SKF main catalog 4000/IV T DE:1994

Friction moment	[M_{loss}]	0.006	Nm
Power loss	[P_{loss}]	6.020	W

The moment of friction is calculated according to the details in SKF Catalog 1994.
The factors used to calculate the torque loss have been assumed for this bearing.

6.6 Rolling bearing 'CB2'

Position (Y-coordinate)	[y]	85.00	mm
Dynamic equivalent load	[P]	1.35	kN
Static equivalent load	[P_0]	1.35	kN
Minimum EHL lubricant film thickness		[h_{min}]	0.122 µm
Life modification factor for reliability	[a_1]	1.000	

6.6.1 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]	0.000	µm

6.6.2 Results according to ISO 281

Lubricant	ISO-VG 220		
Load ratio	[C/P]	4.155	
Operating viscosity	[v]	48.884	mm²/s
Reference viscosity	[v_1]	0.000	mm²/s
Viscosity ratio	[κ]	0.000	
Basic rating life	[L_{10h}]	212.827	h
Bearing rating life	[L_{nh}]	212.827	h
Static safety factor	[S_0]	4.518	

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

Contamination factor	[e_C]	0.000	
Fatigue load limit	[C_u]	0.695	kN
Dynamic equivalent reference load	[P_{ref}]	0.000	kN
Basic reference rating life	[L_{10rh}]	315.841	h
Reference rating life	[L_{nrh}]	315.841	h
Maximum contact stress	[p_{max}]	2195.723	N/mm²
Static equivalent load	[P_{0ref}]	0.000	kN
Effective static safety factor	[S_{0w}]	9999.990	
Static safety factor	[S_{0ref}]	9999.990	

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

6.6.4 Bearing reactions

Bearing reaction force	[F_x]	-0.272	kN
Bearing reaction force	[F_y]	0.000	kN
Bearing reaction force	[F_z]	-1.322	kN
Bearing reaction force	[F_r]	1.350	kN
Inclination angle	[α_{Fr}]	-101.614	°
Bearing reaction moment	[M_x]	-1.263	Nm
Bearing reaction moment	[M_z]	0.199	Nm
Bearing reaction moment	[M_r]	1.279	Nm
Inclination angle	[α_{Mr}]	171.047	°
Displacement of bearing	[u_x]	0.983	µm
Displacement of bearing	[u_y]	0.000	µm
Displacement of bearing	[u_z]	4.822	µm
Displacement of bearing	[u_r]	4.921	µm
Inclination angle	[α_{ur}]	78.479	°
Misalignment of bearing	[r_x]	0.937	mrad
Misalignment of bearing	[r_z]	-0.119	mrad
Misalignment of bearing	[r_r]	0.944	mrad

6.6.5 Friction and power loss

Oil level	[H]	0.000	mm
Load-independent moment of friction		[M_0]	0.003 Nm
Load-dependent moment of friction	[M_1]	0.005	Nm
Moment of friction, cylindrical roller bearing		[M_2]	0.000 Nm

Moment of friction for seals determined according to SKF main catalog 4000/IV T DE:1994

Friction moment	[M_{loss}]	0.008	Nm
Power loss	[P_{loss}]	7.440	W

The moment of friction is calculated according to the details in SKF Catalog 1994.
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.
In some situations, this may result in significant variations in roller bearing stiffness.

6.7 Damage relative to the required service life (L_{req} = 0 h)

Wälzlagerschäden pro Lastkollektiv-Element (%)		
Load bin	**B1**	**B2**
1	0.00	0.00
Σ	0.00	0.00

Note: Damage = L_{req}/L_h

B1 : CB1(SKF K 10X14X10 TN, Connecting rolling bearing)
B2 : CB2(SKF K 10X14X10 TN, Connecting rolling bearing)

6.8 Utilization relative to the required service life (L_{req} = 0 h)

Rolling bearings	**B1**	**B2**
Utilization (%)	0.00	0.00

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

B1 : CB1(SKF K 10X14X10 TN, Connecting rolling bearing)
B2 : CB2(SKF K 10X14X10 TN, Connecting rolling bearing)

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

Calculation method: Bertsche

Bearing	p	fac	b	t0	T	R(H)%
1	Bearing	0	135	2e-10	4.437e-09	100.00
2	Bearing	0	135	2e-10	4.437e-09	100.00

Reliability of the configuration for required service life (%)99.00

_O.Gearbox.MainLine_calc

1 Input data

Coordinate system shaft: see picture W-002

1.1 Shafts

1.1.1 Shaft 'CarrierShaft'

Drawing		
Initial position (mm)		95.000
Length (mm)		50.000
Speed (1/min)		0.000
Direction of rotation:	clockwise	
Material	C45 (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 (g)		97.903
Mass of shaft, including additional masses (g)		97.903
Mass moment of inertia (kg*mm²)		4.280
Momentum of mass GD2 (Nm²)		0.000

1.1.2 Shaft 'RingShaft'

Drawing		
Initial position (mm)		60.000
Length (mm)		10.400
Speed (1/min)		1744.868
Direction of rotation:	counterclockwise	
Material	C45 (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)		0.233
Mass of shaft, including additional masses (kg)		0.233
Mass moment of inertia (kg*mm²)		761.768
Momentum of mass GD2 (Nm²)		0.030

1.1.3 Shaft 'SunShaft'

Drawing		
Initial position (mm)		-100.000
Length (mm)		182.000
Speed (1/min)		20000.000
Direction of rotation:	clockwise	
Material	C45 (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)		0.219

Mass of shaft, including additional masses (kg)	0.219		
Mass moment of inertia (kg*mm²)	5.375		
Momentum of mass GD2 (Nm²)	0.000		

1.2 Weight force

Weight towards	0.000		
Weight towards		0.000	
Weight towards			-1.000

1.3 Shaft modeling

1.4 Shear deformations

Consider deformations due to shearing
Shear correction factor 1.100

1.5 Rolling bearings

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

1.6 Housing

Reference temperature (°C) 20.000

1.7 Load applications

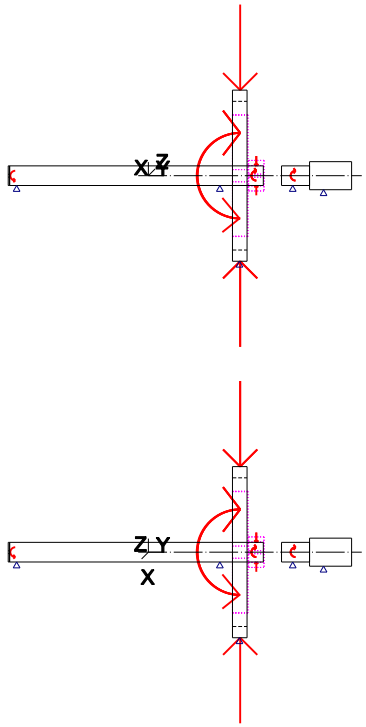


Figure: Load applications

2 Shaft definition (CarrierShaft)

2.1 Outer contour

2.1.1 Cylinder (Cylinder), 0.000mm ...20.000mm

Diameter (mm)	[d]	14.0000
Length (mm)	[l]	20.0000
Surface roughness (µm)	[Rz]	8.0000

2.1.2 Cylinder (Cylinder), 20.000mm ...50.000mm

Diameter (mm)	[d]	20.0000
Length (mm)	[l]	30.0000
Surface roughness (µm)	[Rz]	8.0000

2.2 Forces

2.2.1 Coupling (CarrierElement(PinCarrier))

Position on shaft (mm)	[y_{local}]	10.0000
Position in global system (mm)	[y_{global}]	105.0000
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)		0.0000
Power (kW)		0.0000
Torque (Nm)		-0.0000
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

2.2.2 Coupling (CarrierElement(Planet2Ring))

Position on shaft (mm)	[y_{local}]	10.0000
Position in global system (mm)	[y_{global}]	105.0000
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)		0.0000
Power (kW)		0.0000
Torque (Nm)		-175.7101
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

2.2.3 Coupling (CarrierElement(SunPlanet1))

Position on shaft (mm)	[y_{local}]	10.0000
Position in global system (mm)	[y_{global}]	105.0000
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)	0.0000
Power (kW)	0.0000
Torque (Nm)	-61.0714
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

2.3 Bearing

2.3.1 Support1 (Free bearing)

Bearing position (mm)	[y_{lokal}]	8.000
Bearing position (mm)	[y_{global}]	103.000

Degrees of freedom
X: fixed; Y: fixed; Z: fixed;
Rx: fixed; Ry: fixed; Rz: fixed;

2.3.2 Support2 (Fixed bearing adjusted on both sides)

Bearing position (mm)	[y_{lokal}]	30.000
Bearing position (mm)	[y_{global}]	125.000

Degrees of freedom
X: fixed; Y: fixed; Z: fixed;
Rx: free; Ry: free; Rz: free;

3 Shaft definition (RingShaft)

3.1 Outer contour

3.1.1 Cylinder (Zylinder), 0.000mm ...10.400mm

Diameter (mm)	[d]	122.0000
Length (mm)	[l]	10.4000
Surface roughness (µm)	[Rz]	8.0000

3.2 Inner contour

3.2.1 Cylindrical bore (Zylindrische Bohrung), 0.000mm ...10.400mm

Diameter (mm)	[d]	106.0000
Length (mm)	[l]	10.4000
Surface roughness (µm)	[Rz]	8.0000

3.3 Forces

3.3.1 Cylindrical gear (RingGear(0.0))

Position on shaft (mm)	[y_{local}]	5.5000
Position in global system (mm)	[y_{global}]	65.5000
Operating pitch diameter (mm)		-86.7606

Spur gear

Working pressure angle at normal section (°)	17.6140

Position of contact (°)	0.0000
Length of load application (mm)	11.0000
Power (kW)	13.2645 driven (input)
Torque (Nm)	-72.5938
Axial force (N)	0.0000
Shearing force X (N)	531.2929
Shearing force Z (N)	1673.4294
Bending moment X (Nm)	-0.0000
Bending moment Z (Nm)	0.0000

3.3.2 Cylindrical gear (RingGear(120.0))

Position on shaft (mm) [y_{local}]	5.5000
Position in global system (mm) [y_{global}]	65.5000
Operating pitch diameter (mm)	-86.7606
Spur gear	
Working pressure angle at normal section (°)	17.6140
Position of contact (°)	120.0000
Length of load application (mm)	11.0000
Power (kW)	13.2645 driven (input)
Torque (Nm)	-72.5938
Axial force (N)	0.0000
Shearing force X (N)	-1714.8788
Shearing force Z (N)	-376.6016
Bending moment X (Nm)	-0.0000
Bending moment Z (Nm)	-0.0000

3.3.3 Cylindrical gear (RingGear(240.0))

Position on shaft (mm) [y_{local}]	5.5000
Position in global system (mm) [y_{global}]	65.5000
Operating pitch diameter (mm)	-86.7606
Spur gear	
Working pressure angle at normal section (°)	17.6140
Position of contact (°)	240.0000
Length of load application (mm)	11.0000
Power (kW)	13.2645 driven (input)
Torque (Nm)	-72.5938
Axial force (N)	0.0000
Shearing force X (N)	1183.5859
Shearing force Z (N)	-1296.8278
Bending moment X (Nm)	0.0000
Bending moment Z (Nm)	-0.0000

3.3.4 Coupling (output(output))

Position on shaft (mm) [y_{local}]	5.0000
Position in global system (mm) [y_{global}]	65.0000
Effective diameter (mm)	140.0000
Radial force factor (-)	0.0000
Direction of the radial force (°)	0.0000
Axial force factor (-)	0.0000
Length of load application (mm)	10.0000
Power (kW)	39.7935 driving (output)
Torque (Nm)	217.7815
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

3.4 Bearing

3.4.1 Support3 (Own input)

Bearing position (mm)	[y_{lokal}]	5.000
Bearing position (mm)	[y_{global}]	65.000
Degrees of freedom		
X: fixed; Y: fixed; Z: fixed;		
Rx: fixed; Ry: free; Rz: fixed;		

4 Shaft definition (SunShaft)

4.1 Outer contour

4.1.1 Cylinder (Zylinder), 0.000mm ...182.000mm

Diameter (mm)	[d]	14.0000
Length (mm)	[l]	182.0000
Surface roughness (µm)	[Rz]	8.0000

4.2 Inner contour

4.2.1 Cylindrical bore (Cylindrical bore), 0.000mm ...1.000mm

Diameter (mm)	[d]	2.0000
Length (mm)	[l]	1.0000
Surface roughness (µm)	[Rz]	8.0000

4.3 Forces

4.3.1 Cylindrical gear (SunGear(0.0))

Position on shaft (mm)	[y_{local}]	177.0000
Position in global system (mm)	[y_{global}]	77.0000
Operating pitch diameter (mm)		21.7778
Spur gear		
Working pressure angle at normal section (°)		25.0238
Position of contact (°)		0.0000
Length of load application (mm)		11.0000
Power (kW)		13.2645 driving (output)
Torque (Nm)		-6.3333
Axial force (N)		0.0000
Shearing force X (N)		-271.5139
Shearing force Z (N)		581.6326
Bending moment X (Nm)		-0.0000
Bending moment Z (Nm)		0.0000

4.3.2 Cylindrical gear (SunGear(120.0))

Position on shaft (mm)	[y_{local}]	177.0000
Position in global system (mm)	[y_{global}]	77.0000
Operating pitch diameter (mm)		21.7778
Spur gear		
Working pressure angle at normal section (°)		25.0238
Position of contact (°)		120.0000
Length of load application (mm)		11.0000
Power (kW)		13.2645 driving (output)
Torque (Nm)		-6.3333
Axial force (N)		0.0000
Shearing force X (N)		-367.9517

Shearing force Z (N)	-525.9543
Bending moment X (Nm)	-0.0000
Bending moment Z (Nm)	-0.0000

4.3.3 Cylindrical gear (SunGear(240.0))

Position on shaft (mm)	[y_{local}]	177.0000
Position in global system (mm)	[y_{global}]	77.0000
Operating pitch diameter (mm)		21.7778
Spur gear		
Working pressure angle at normal section (°)		25.0238
Position of contact (°)		240.0000
Length of load application (mm)		11.0000
Power (kW)		13.2645 driving (output)
Torque (Nm)		-6.3333
Axial force (N)		0.0000
Shearing force X (N)		639.4656
Shearing force Z (N)		-55.6783
Bending moment X (Nm)		0.0000
Bending moment Z (Nm)		-0.0000

4.3.4 Coupling (input(input))

Position on shaft (mm)	[y_{local}]	5.0000
Position in global system (mm)	[y_{global}]	-95.0000
Effective diameter (mm)		20.0000
Radial force factor (-)		0.0000
Direction of the radial force (°)		0.0000
Axial force factor (-)		0.0000
Length of load application (mm)		10.0000
Power (kW)		39.7935 driven (input)
Torque (Nm)		19.0000
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

4.4 Bearing

4.4.1 Support4 (Fixed bearing adjusted on both sides)

Bearing position (mm)	[y_{lokal}]	6.000
Bearing position (mm)	[y_{global}]	-94.000

Degrees of freedom
X: fixed; Y: fixed; Z: fixed;
Rx: fixed; Ry: free; Rz: fixed;

4.4.2 Support5 (Free bearing)

Bearing position (mm)	[y_{lokal}]	151.000
Bearing position (mm)	[y_{global}]	51.000

Degrees of freedom
X: fixed; Y: free; Z: fixed;
Rx: free; Ry: free; Rz: free;

5 Gears

Gears are considered only as load application.

6 Results

6.1 Shafts

Maximum deflection 0.065(µm) (SunShaft pos = -12.891 mm)

Mass center of gravity	
CarrierShaft (mm)	28.844
RingShaft (mm)	5.200
SunShaft (mm)	91.010
Total axial load	
CarrierShaft (N)	0.000
RingShaft (N)	0.000
SunShaft (N)	0.000
Torsion of the shafts under torque (Difference between left and right shaft end)	
CarrierShaft (°)	-0.091
RingShaft (°)	-0.000
SunShaft (°)	-0.627

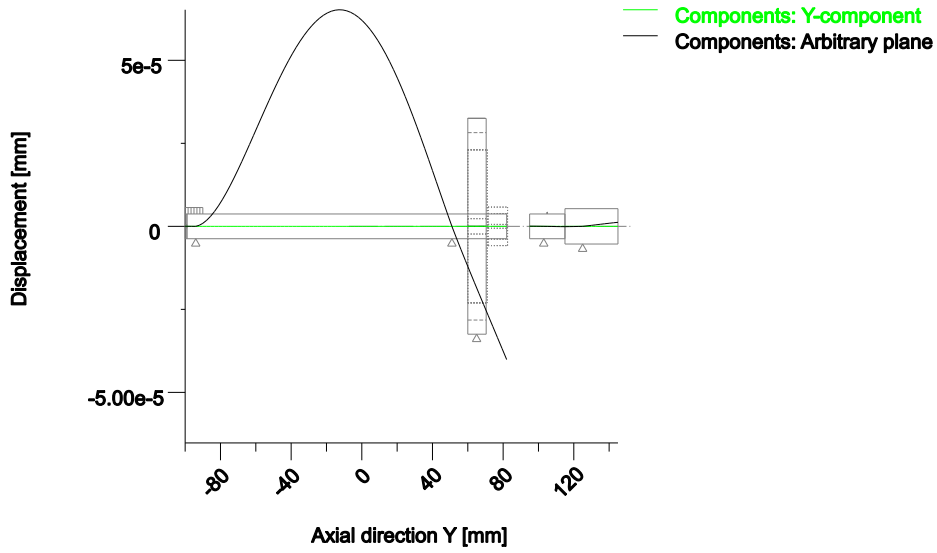
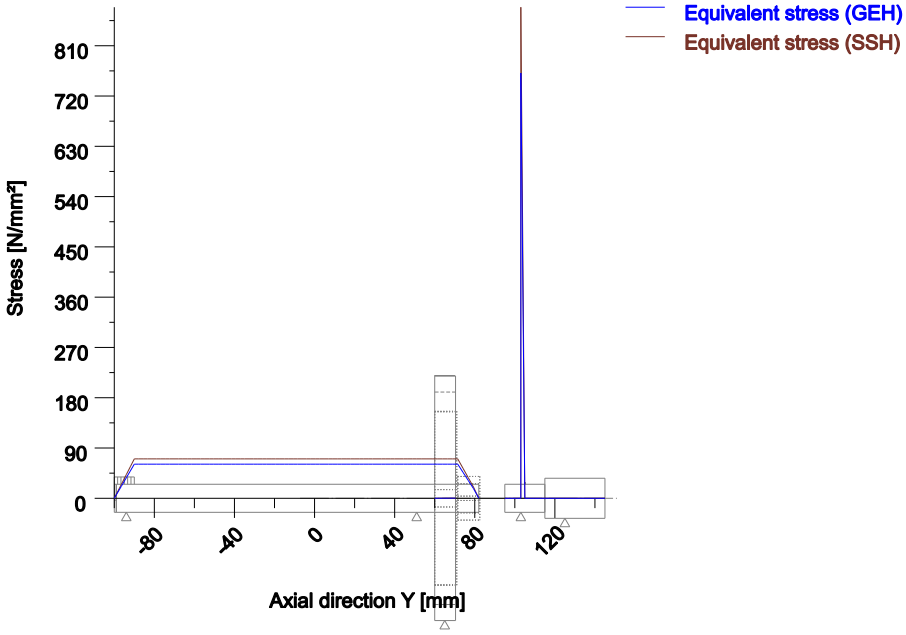


Figure: Deformation (bending etc.) (Arbitrary plane 270 127)



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

6.2 Bearing

6.3 'CarrierShaft' Bearing 'Support1'

Position (Y-coordinate)	[y]	8.00	mm
Bearing reaction force	[F_x]	0.000	kN
Bearing reaction force	[F_y]	0.000	kN
Bearing reaction force	[F_z]	0.000	kN
Bearing reaction force	[F_r]	0.000	kN
Inclination angle	[α_{Fr}]	90.000	°
Bearing reaction moment	[M_x]	-0.001	Nm
Bearing reaction moment	[M_z]	0.000	Nm
Bearing reaction moment	[M_r]	0.001	Nm
Inclination angle	[α_{Mr}]	180.000	°
Displacement of bearing	[u_x]	0.000	µm
Displacement of bearing	[u_y]	0.000	µm
Displacement of bearing	[u_z]	-0.000	µm
Displacement of bearing	[u_r]	0.000	µm
Misalignment of bearing	[r_x]	0.000	mrad
Misalignment of bearing	[r_z]	0.000	mrad
Misalignment of bearing	[r_r]	0.000	mrad

6.4 'CarrierShaft' Bearing 'Support2'

Position (Y-coordinate)	[y]	30.00	mm
Bearing reaction force	[F_x]	0.000	kN
Bearing reaction force	[F_y]	0.000	kN
Bearing reaction force	[F_z]	0.001	kN
Bearing reaction force	[F_r]	0.001	kN
Inclination angle	[α_{Fr}]	90.000	°
Displacement of bearing	[u_x]	0.000	µm

Displacement of bearing	[u_y]	0.000	µm
Displacement of bearing	[u_z]	-0.000	µm
Displacement of bearing	[u_r]	0.000	µm
Misalignment of bearing	[r_x]	-0.000	mrad
Misalignment of bearing	[r_z]	0.000	mrad
Misalignment of bearing	[r_r]	0.000	mrad

6.5 'RingShaft' Bearing 'Support3'

Position (Y-coordinate)	[y]	5.00	mm
Bearing reaction force	[F_x]	0.000	kN
Bearing reaction force	[F_y]	0.000	kN
Bearing reaction force	[F_z]	0.002	kN
Bearing reaction force	[F_r]	0.002	kN
Inclination angle	[α_{Fr}]	90.000	°
Bearing reaction moment	[M_x]	0.000	Nm
Bearing reaction moment	[M_z]	-0.000	Nm
Bearing reaction moment	[M_r]	0.000	Nm
Inclination angle	[α_{Mr}]	0.000	°
Displacement of bearing	[u_x]	-0.000	µm
Displacement of bearing	[u_y]	0.000	µm
Displacement of bearing	[u_z]	-0.000	µm
Displacement of bearing	[u_r]	0.000	µm
Misalignment of bearing	[r_x]	-0.000	mrad
Misalignment of bearing	[r_z]	0.000	mrad
Misalignment of bearing	[r_r]	0.000	mrad

6.6 'SunShaft' Bearing 'Support4'

Position (Y-coordinate)	[y]	6.00	mm
Bearing reaction force	[F_x]	-0.000	kN
Bearing reaction force	[F_y]	0.000	kN
Bearing reaction force	[F_z]	0.001	kN
Bearing reaction force	[F_r]	0.001	kN
Inclination angle	[α_{Fr}]	90.000	°
Bearing reaction moment	[M_x]	0.028	Nm
Bearing reaction moment	[M_z]	0.000	Nm
Bearing reaction moment	[M_r]	0.028	Nm
Inclination angle	[α_{Mr}]	0.000	°
Displacement of bearing	[u_x]	0.000	µm
Displacement of bearing	[u_y]	0.000	µm
Displacement of bearing	[u_z]	-0.000	µm
Displacement of bearing	[u_r]	0.000	µm
Misalignment of bearing	[r_x]	-0.000	mrad
Misalignment of bearing	[r_z]	-0.000	mrad
Misalignment of bearing	[r_r]	0.000	mrad

6.7 'SunShaft' Bearing 'Support5'

Position (Y-coordinate)	[y]	151.00	mm
Bearing reaction force	[F_x]	0.000	kN
Bearing reaction force	[F_y]	0.000	kN
Bearing reaction force	[F_z]	0.001	kN
Bearing reaction force	[F_r]	0.001	kN
Inclination angle	[α_{Fr}]	90.000	°
Displacement of bearing	[u_x]	-0.000	µm
Displacement of bearing	[u_y]	0.000	µm
Displacement of bearing	[u_z]	-0.000	µm
Displacement of bearing	[u_r]	0.000	µm
Misalignment of bearing	[r_x]	0.001	mrad
Misalignment of bearing	[r_z]	0.000	mrad
Misalignment of bearing	[r_r]	0.001	mrad

_O.Gearbox.Planet2Ring.Planet2Ring_calc

1 Overview

Calculation method		DIN 3990:1987 Method B (YF Method C)	
Drawing or article number:			
Gear 1:		PlanetGear2(Planet2Ring)	
Gear 2:		RingGear(Planet2Ring)	
		------- Gear 1 ----------	Gear 2 -------
Power (kW)	[P]	13.265	
Speed (1/min)	[n]	9032.3	1744.9
Number of load cycles (in mio.)	[NL]	379.355	219.853
Torque (Nm)	[T]	14.0	72.6
Application factor	[KA]	1.50	
Required service life (h)	[H]	1000.00	
Power-on time (%)	[ED]	70.00	
Operating time	[Heff]	700.00	
Gear driving (+) / driven (-)		+	-
Working flank Gear 1:		Left flank	
Gear 1 direction of rotation:		Counterclockwise	

2 Tooth geometry

Geometry calculation according to		DIN 3960 (withdrawn)	
		------- Gear 1 ----------	Gear 2 -------
Center distance (mm)	[a]	-35.000	
Center distance tolerance		ISO 286:2010 Measure js7	
Normal module (mm)	[mn]	1.0000	
Normal pressure angle (°)	[αn]	20.0000	
Helix angle at reference circle (°)	[β]	0.0000	
Number of teeth	[z]	17	-88
Facewidth (mm)	[b]	11.00	11.00
Hand of gear		Spur gear	
Accuracy grade	[Q-DIN 3961:1978]	6	6
Inner diameter (mm)	[di]	0.00	
External diameter (mm)	[di]		120.00
Inner diameter of gear rim (mm)	[dbi]	0.00	
Outer diameter of gear rim (mm)	[dbi]		0.00

3 Materials

Gear 1
18CrNiMo7-6, Case hardening steel, case-hardened, ISO 6336-5 Figure 9/10 (MQ), Core hardness >=25HRC Jominy J=12mm<HRC28

Gear 2
18CrNiMo7-6, Case hardening steel, case-hardened, ISO 6336-5 Figure 9/10 (MQ), Core hardness >=25HRC Jominy J=12mm<HRC28

		------- Gear 1 ----------	Gear 2 -------
Surface hardness		HRC 61	HRC 61
Infinite life strength for tooth root stress (N/mm²)	[σFlim]	430.00	430.00
Fatigue strength for Hertzian pressure (N/mm²)	[σHlim]	1500.00	1500.00
Young's modulus (N/mm²)	[E]	206000	206000
Poisson's ratio	[v]	0.300	0.300
Tensile strength (N/mm²)	[σB]	1200.00	1200.00
Yield point (N/mm²)	[σS]	850.00	850.00

3.1 Gear roughness

		------- Gear 1	---------- Gear 2 -------
Arithmetic mean roughness value R_a, flank (µm)	[RAH]	0.60	0.60
Arithmetic mean roughness value R_a, root (µm)	[RAF]	3.00	3.00
Mean peak-to-valley roughness R_z, flank (µm)	[RZH]	4.80	4.80
Mean peak-to-valley roughness R_z, root (µm)	[RZF]	20.00	20.00

3.2 Lubrication

Lubrication type	Oil bath lubrication	
Type of oil	Klübersynth GE 4 75 W 90 (API GL 5)	
Lubricant base	Synthetic oil based on Polyalphaolefin	
Oil nominal kinematic viscosity at 40°C (mm²/s)	[v40]	130.00
Oil nominal kinematic viscosity at 100°C (mm²/s)	[v100]	18.00
Specific density at 15°C (kg/dm³)	[ρ]	0.860
Oil temperature (°C)	[TS]	70.000

4 Geometry

4.1 Reference profiles

Reference profile Gear 1

Reference profile, own input		
Dedendum coefficient	[hfP*]	1.250
Root radius factor	[ρfP*]	0.380
	[ρfPmax*]	0.472
Addendum coefficient	[haP*]	1.000
Tip radius factor	[ρaP*]	0.000
Protuberance height coefficient	[hprP*]	0.000
Protuberance angle	[αprP]	0.000
Tip form height coefficient	[hFaP*]	0.000
Ramp angle	[αKP]	0.000
	not topping	
Smallest radius of curvature, root rounding (mm)	[ρmin.e/i]	0.405 /0.409

Constructed involute of Gear 2

Dedendum coefficient	[hfP*]	1.250
Root radius factor	[ρf*]	0.380
Corresponding root radius in the reference profile	[ρfP*]	0.380
Addendum coefficient	[haP*]	1.000
Tip radius factor	[ρaP*]	0.000

4.1.1 Information on final machining

		------- Gear 1	---------- Gear 2 -------
Dedendum reference profile	[hfP*]	1.250	1.250
Tooth root radius reference profile	[ρfP*]	0.380	0.380
Addendum reference profile	[haP*]	1.000	1.000
Protuberance height coefficient	[hprP*]	0.000	0.000
Protuberance angle (°)	[αprP]	0.000	0.000
Tip form height coefficient	[hFaP*]	0.000	0.000
Ramp angle (°)	[αKP]	0.000	0.000
Type of profile modification:	none (only running-in)		
Tip relief by running in (µm)	[Ca L/R]	2.0 /2.0	2.0 /2.0

4.2 Basic data

Overall transmission ratio	[itot]	5.176
Gear ratio	[u]	-5.176
Transverse module (mm)	[mt]	1.000
Transverse pressure angle (°)	[αt]	20.000
Working pressure angle (°)	[αwt]	17.614
(°)	[αwt.e/i]	17.549 /17.678
Working pressure angle at normal section (°)	[αwn]	17.614
Base helix angle (°)	[βb]	0.000
Helix angle at operating pitch circle (°)	[βw]	0.000
Reference center distance (mm)	[ad]	-35.500
Sum of profile shift coefficients	[Σxi]	0.4720

		------- Gear 1	---------- Gear 2 -------
Profile shift coefficient	[x]	0.4740	-0.0020
Generating profile shift coefficient	[xE.e/i]	0.3998/0.3586	-0.0982/-0.1531
Virtual gear no. of teeth	[zn]	17.000	-88.000
Involute length (mm)	[l_dFa-l_dFf]	2.116	2.149

4.3 Diameters and their allowances

		------- Gear 1	---------- Gear 2 -------
Reference diameter (mm)	[d]	17.000	-88.000
Base diameter (mm)	[db]	15.975	-82.693
Tip alteration (mm)	[k*mn]	0.000	0.000
Tip diameter (mm)	[da]	19.948	-86.004
(mm)	[da.e/i]	19.948 /19.938	-86.004 /-86.014
Tip diameter allowances (mm)	[Ada.e/i]	0.000 /-0.010	0.000 /-0.010
Tip form diameter (mm)	[dFa]	19.948	-86.004
(mm)	[dFa.e/i]	19.948 /19.938	-86.004 /-86.014
Active tip diameter (mm)	[dNa]	19.948	-86.004
(mm)	[dNa.e/i]	19.948 /19.938	-86.004 /-86.014
V-Circle diameter (mm)	[dv]	17.948	-88.004
(mm)	[dv.e/i]	17.800 /17.717	-88.196 /-88.306
Operating pitch diameter (mm)	[dw]	16.761	-86.761
(mm)	[dw.e/i]	16.755 /16.767	-86.730 /-86.792
Root diameter (mm)	[df]	15.448	-90.504
Generated root diameter with xE (mm)	[df.e/i]	15.300 /15.217	-90.696 /-90.806
Active root diameter (mm)	[dNf]	16.162	-89.082
(mm)	[dNf.e/i]	16.180 /16.150	-89.045 /-89.113
Root form diameter (mm)	[dFf]	16.208	-90.042
(mm)	[dFf.e/i]	16.140 /16.108	-90.238 /-90.350

4.4 Tip clearances and tooth heights

		------- Gear 1	---------- Gear 2 -------
Theoretical tip clearance (mm)	[c]	0.278	0.278
Effective tip clearance (mm)	[c.e/i]	0.447 /0.362	0.411 /0.340
Reserve (dNf-dFf)/2 (mm)	[cF.e/i]	0.036 /0.005	0.652 /0.562
Addendum, $m_n(h_{aP}^*+x+k)$ (mm)	[ha]	1.474	0.998
(mm)	[ha.e/i]	1.474 /1.469	0.998 /0.993
Dedendum, $m_n(h_{fP}^*-x)$ (mm)	[hf]	0.776	1.252
(mm)	[hf.e/i]	0.850 /0.891	1.348 /1.403
Tooth height (mm)	[h]	2.250	2.250

4.5 Roll angle

		------- Gear 1	---------- Gear 2 -------
Roll angle at dFa (°)	[ξFa.e/i]	42.849 /42.790	16.375 /16.401
Roll angle to dNf (°)	[ξNf.e/i]	9.222 /8.499	22.885 /23.011
Roll angle at dFf (°)	[ξFf.e/i]	8.267 /7.403	25.028 /25.221

4.6 Tooth thickness and pitch

		------- Gear 1	---------- Gear 2 -------
Tooth thickness on reference circle, arc, in module	[sn*]	1.9158	1.5693
Normal tooth thickness at tip circle (mm)	[san]	0.436	0.890
(mm)	[san.e/i]	0.380 /0.338	0.825 /0.783
Normal tooth thickness at tip form circle (mm)	[sFan]	0.436	0.890
(mm)	[sFan.e/i]	0.380 /0.338	0.825 /0.783

Normal space width at root circle (mm)	[efn]	0.000	0.588
(mm)	[efn.e/i]	0.000 /0.000	0.575 /0.567
Pitch on reference circle (mm)	[pt]	3.142	3.142
Base pitch (mm)	[pbt]	2.952	2.952
Transverse pitch on contact-path (mm)	[pet]	2.952	2.952

4.7 Sliding

		------- Gear 1	---------- Gear 2 -------
Max. sliding velocity at tip (m/s)	[vga]	2.623	1.000
Specific sliding at the tip	[ζa]	0.464	0.463
Specific sliding at the root	[ζf]	-0.862	-0.867
Mean specific sliding	[ζm]	0.464	
Sliding factor on tip	[Kga]	0.331	0.126
Sliding factor on root	[Kgf]	-0.126	-0.331

4.8 Contact ratios

		---------- Pair ----------
Minimal length of contact line (mm)	[Lmin]	11.000
Transverse contact ratio	[εα]	1.608
	[εα.e/m/i]	1.622 /1.604/ 1.585
Overlap ratio	[εβ]	0.000
Total contact ratio	[εγ]	1.608
	[εγ.e/m/i]	1.622 /1.604/ 1.585
Length of path of contact (mm)	[ga]	4.748
(mm)	[ga.e/i]	4.789 /4.680

		------- Gear 1	---------- Gear 2 -------
Addendum contact ratio	[ε]	1.164	0.444
	[ε.e/i]	1.161 /1.165	0.461 /0.420
Length T1-A and T2-A (mm)	[T1A,T2A]	1.226	-11.817
(mm)	[.e/i]	1.185 / 1.286	-11.817 /-11.835
Length T1-B and T2-B (mm)	[T1B,T2B]	3.021	-13.612
(mm)	[.e/i]	3.021 / 3.013	-13.654 /-13.563
Length T1-C and T2-C (mm)	[T1C,T2C]	2.536	-13.127
(mm)	[.e/i]	2.546 / 2.526	-13.178 /-13.076
Length T1-D and T2-D (mm)	[T1D,T2D]	4.178	-14.769
(mm)	[.e/i]	4.137 / 4.238	-14.769 /-14.787
Length T1-E and T2-E (mm)	[T1E,T2E]	5.973	-16.565
(mm)	[.e/i]	5.973 / 5.965	-16.606 /-16.515
Length T1-T2 (mm)	[T1T2]	-10.591	
(mm)	[.e/i]	-10.632 /-10.550	
Diameter of single contact point B (mm)	[d-B]	17.079	-87.059
(mm)	[d-B.e/i]	17.079 /17.074	-87.085 /-87.028
Diameter of single contact point D (mm)	[d-D]	18.028	-87.810
(mm)	[d-D.e/i]	17.990 /18.084	-87.810 /-87.822

5 General influence factors

5.1 Forces and circumferential speed

		------- Gear 1	---------- Gear 2 -------
Nominal circum. force at pitch circle (N)	[Ft]	1649.9	
Axial force (N)	[Fa]	0.0	0.0
Radial force (N)	[Fr]	600.5	600.5
Normal force (N)	[Fnorm]	1755.7	1755.7
Nominal circumferential force per mm (N/mm)	[w]	149.99	
Only as information: Forces at operating pitch circle:			
Nominal circumferential force (N)	[Ftw]	1673.4	
Axial force (N)	[Faw]	0.0	0.0
Radial force (N)	[Frw]	531.3	
Circumferential speed reference circle (m/s)	[v]	8.04	
Circumferential speed operating pitch circle (m/s)	[v(dw)]	7.93	

5.2 Contact stiffness

Running-in value (µm)	[yp]	0.5
Running-in value (µm)	[yf]	0.4
Tolerances f_{pe}, f_f and $f_{H\beta}$, matching the tolerances in section 7		
Correction factor	[CM]	0.800
Gear blank factor	[CR]	1.000
Basic rack factor	[CB]	0.975
Material coefficient	[E/Est]	1.000
Single stiffness (N/mm/µm)	[c']	15.201
Meshing stiffness (N/mm/µm)	[cγ]	22.135
Reduced mass (kg/mm)	[mRed]	0.00116
Resonance speed (min-1)	[nE1]	77553
Resonance ratio (-)	[N]	0.116
Subcritical range		

5.3 Calculation of K factors

Running-in value (µm)	[yα]	0.5
Bearing distance l of pinion shaft (mm)	[l]	22.000
Distance s of pinion shaft (mm)	[s]	2.200
Outside diameter of pinion shaft (mm)	[dsh]	11.000
Load according to Figure 6.8, DIN 3990-1:1987 0:6.8a, 1:6.8b, 2:6.8c, 3:6.8d, 4:6.8e	[-]	4
Coefficient K' according to Figure 6.8, DIN 3990-1:1987	[K']	-1.00
Without stiffening		
Tooth trace deviation (active) (µm)	[Fβy]	4.38
from deformation of shaft (µm)	[fsh*B1]	0.63
fsh (µm)	[fsh]	1.27
B1	[B1]	0.50
fHβ5 (µm)	[fHβ5]	6.00
Flank line:	crowned	[$C_\beta = 0.5*(f_{m\alpha}+f_{sh})$]
Position of contact pattern:	favorable	
from production tolerances (µm)	[fmα*B2]	4.00
B_2=0.50		
Tooth trace deviation, theoretical (µm)	[Fβx]	5.16
Running-in value (µm)	[yβ]	0.77

5.4 K factors

Dynamic factor	[Kv]	1.054
Face load factors		
- Flank	[KHβ]	1.205
- Tooth root	[KFβ]	1.159
- Scuffing	[KBβ]	1.205
Transverse load factors		
- Flank	[KHα]	1.000
- Tooth root	[KFα]	1.000
- Scuffing	[KBα]	1.000
Application factor	[KA]	1.500
Mesh load factor	[Kγ]	1.000

6 Calculation of tooth root strength (fracture)

Calculation of Tooth form coefficients according method: C
Internal toothing: Form milled

		------- Gear 1	---------- Gear 2 -------
Calculated with generating profile shift coefficient	[xE.e]	0.3998	-0.0982
Tooth form factor	[YF]	2.41	2.06
Stress correction factor	[YS]	1.70	1.97
Load application angle (°)	[αFen]	35.72	20.00
Load application diameter (mm)	[d_{en}]	19.948	-86.004
Bending moment arm (mm)	[hF]	2.10	1.91
Tooth thickness at root (mm)	[sFn]	2.13	2.36
Tooth root radius (mm)	[ρF]	0.45	0.38
Bending moment arm (-)	[hF/mn]	2.104	1.906

Tooth thickness at root (-)	[sFn/mn]	2.126	2.356
Tooth root radius (-)	[ρF/mn]	0.451	0.380
Calculation cross section diameter (mm)	[d_{sFn}]	15.613	0.000
Tangents on calculation cross section (°)	[α_{sFn}]	30.000	30.000
Notch parameter	[q_s]	2.354	3.100
Contact ratio factor	[Yε]	0.716	
Helix angle factor	[Yβ]	1.000	
Effective facewidth (mm)	[beff]	11.00	11.00
Nominal stress at tooth root (N/mm²)	[σF0]	441.47	435.41
Tooth root stress (N/mm²)	[σF]	809.09	797.99
Permissible bending stress at root of Test-gear			
Notch sensitivity factor	[YδrelT]	0.999	1.005
Surface factor	[YRrelT]	0.957	0.957
Size factor, tooth root	[YX]	1.000	1.000
Life factor	[YNT]	1.000	1.000
$Y_{\delta relT}*Y_{RrelT}*Y_X*Y_{NT}$		0.955	0.962
Alternating bending factor, mean stress influence coefficient			
	[YM]	1.000	1.000
Stress correction factor	[YST]	2.00	
$Y_{ST}*\sigma_{Flim}$ (N/mm²)	[σFE]	860.00	860.00
Permissible tooth root stress σFG/SFmin (N/mm²)	[σFP]	586.89	590.89
Limit strength tooth root (N/mm²)	[σFG]	821.65	827.24

6.1 Safety factors

		------- Gear 1	---------- Gear 2 -------
Required safety	[SFmin]	1.40	1.40
Safety for tooth root stress	[SF=σFG/σF]	1.02	1.04
Transmittable power (kW)	[kWRating]	9.62	9.82

7 Calculation of flank strength (pitting)

		------- Gear 1	---------- Gear 2 -------
Zone factor	[ZH]	2.671	
Elasticity coefficient (√N/mm)	[ZE]	189.812	
Contact ratio factor	[Zε]	0.893	
Helix angle factor	[Zβ]	1.000	
Effective facewidth (mm)	[beff]	11.00	
Nominal contact stress (N/mm²)	[σH0]	1207.77	
Contact stress at operating pitch circle (N/mm²)	[σHw]	1666.94	
Single tooth contact factor	[ZB,ZD]	1.00	1.00
Contact stress (N/mm²)	[σHB, σHD]	1666.94	1666.94
Lubricant coefficient for N_L	[ZL]	0.982	0.982
Speed factor at N_L	[ZV]	0.994	0.994
Roughness factor for N_L	[ZR]	0.946	0.946
Material hardening factor for N_L	[ZW]	1.000	1.000
Life factor	[ZNT]	1.000	1.000
	[ZL*ZV*ZR*ZNT]	0.924	0.924
Limited pitting is permissible: No			
Size factor (flank)	[ZX]	1.000	1.000
Permissible contact stress, σHG/SHmin (N/mm²)	[σHP]	1386.11	1386.11
Pitting stress limit (N/mm²)	[σHG]	1386.11	1386.11

7.1 Safety factors

		------- Gear 1	---------- Gear 2 -------
Required safety	[SHmin]	1.00	1.00
Safety factor for contact stress on operating pitch circle	[SHw]	0.83	0.83
Safety against pressure, σHG/σHBD Single contact	[SHBD]	0.83	0.83
Safety regarding transmittable torque	[SHBD²]	0.69	0.69
Transmittable power (kW)	[kWRating]	9.17	9.17

8 Scuffing load capacity

Calculation method according to		DIN 3990:1987	
		------- Gear 1 ----------	Gear 2 -------
Thermal contact coefficient (N/mm/s^.5/K)	[BM]	13.780	13.780
Relevant tip relief (µm)	[Ca]	2.00	2.00
Optimal tip relief (µm)	[Ceff]	14.80	
C_a taken as optimal in the calculation. 0=no, 1=yes		0	0
		---------- Pair ----------	
Helical load factor for scuffing	[KBγ]	1.000	
Lubrication coefficient for lubrication type	[XS]	1.000	
Scuffing test, load stage	[FZGtest]	FZG - Test A / 8.3 / 90 (ISO 14635 - 1),	14
Relative structural factor, scuffing	[XWrelT]	1.000	
Effective facewidth (mm)	[beff]	11.000	
Applicable circumferential force/facewidth (N/mm)	[wBt]	285.711	
Angle factor	[Xαβ]	0.941	
ε_1 =1.164, ε_2 =0.444			

8.1 Flash temperature-criteria

		---------- Pair ----------	
Tooth mass temperature (°C)	[θMB]	89.63	
$\theta_{MB} = \theta_{oil} + X_S*0.47*\theta_{flamax}$			
Maximum flash temperature (°C)	[θflamax]	41.76	
Scuffing temperature (°C)	[θS]	551.53	
Γ coordinates (point of highest temperature)	[Γ]	0.648	
[Γ.A]= -0.517, [Γ.E]= 1.356			
Maximum contact temperature (°C)	[θB]	131.39	
Flash factor (°K*N^-.75*s^.5*m^-.5*mm)	[XM]	50.058	
Geometry factor	[XB]	0.132	
Load sharing factor	[XΓ]	1.000	
Dynamic viscosity (mPa*s)	[ηM]	19.17	(89.6 °C)
Coefficient of friction	[μ_m]	0.083	
Required safety	[SBmin]	2.000	
Margin of safety for scuffing, flash temperature	[SB]	7.843	

8.2 Integral temperature-criteria

		---------- Pair ----------	
Tooth mass temperature (°C)	[θMC]	82.65	
$\theta_{MC} = \theta_{oil} + X_S*0.70*\theta_{flaint}$			
Integral scuffing temperature (°C)	[θSint]	551.53	
Flash factor (°K*N^-.75*s^.5*m^-.5*mm)	[XM]	50.058	
Contact ratio factor	[Xε]	0.254	
Dynamic viscosity (mPa*s)	[ηOil]	33.86	(70.0 °C)
Mean coefficient of friction	[μ_m]	0.091	
Geometry factor	[XBE]	0.217	
Meshing factor	[XQ]	1.000	
Tip relief factor	[XCa]	1.057	
Mean flash temperature (°C)	[θflaint]	18.07	
Integral tooth flank temperature (°C)	[θint]	109.76	
Required safety	[SSmin]	1.800	
Safety factor for scuffing (intg.-temp.)	[SSint]	5.025	
Safety factor for transmitted moment (int.-T.)	[SSL]	12.110	

9 Measurements for tooth thickness

9.1 Tooth thickness tolerances

		------- Gear 1 ----------	Gear 2 -------
Tooth thickness tolerance		DIN 3967 cd25	DIN 3967 cd25
Tooth thickness allowance (normal section) (mm)	[Asn.e/i]	-0.054 /-0.084	-0.070 /-0.110

9.2 Base tangent lengths

		------- Gear 1	---------- Gear 2 -------
Number of teeth spanned	[k]	3.000	-10.000
For internal toothing: k = measurement gap number			
Base tangent length (no backlash) (mm)	[Wk]	7.943	-29.279
Base tangent length with allowance (mm)	[Wk.e/i]	7.892 /7.864	-29.345 /-29.382
(mm)	[ΔWk.e/i]	-0.051 /-0.079	-0.066 /-0.103
Diameter of measuring circle (mm)	[dMWk.m]	17.812	-87.752

9.3 Measurement over balls and pins

		------- Gear 1	---------- Gear 2 -------
Theoretical diameter of ball/pin (mm)	[DM]	2.043	1.661
Effective diameter of ball/pin (mm)	[DMeff]	2.000	1.750
Radial single-ball measurement backlash free (mm)	[MrK]	10.443	-42.711
Radial single-ball measurement (mm)	[MrK.e/i]	10.395 /10.368	-42.814 /-42.872
Diameter of measuring circle (mm)	[dMMr.m]	17.796	-88.020
Diametral measurement over two balls, no backlash (mm)	[MdK]	20.806	-85.423
Diametral measurement over two balls (mm)	[MdK.e/i]	20.710 /20.657	-85.628 /-85.744
Diametral measurement over pins without clearance (mm)	[MdR]	20.806	-85.423
Measurement over pins according to DIN 3960 (mm)	[MdR.e/i]	20.710 /20.657	-85.628 /-85.744
Measurement over 3 pins without play (mm)	[Md3R]	20.725	0.000
Measurement over 3 pins (mm)	[Md3R.e/i]	20.631 /20.577	0.000 /0.000

9.4 Tooth thickness

		------- Gear 1	---------- Gear 2 -------
Medium tip diameter (mm)	[da.m]	19.943	-86.009
Reference chordal height from da.m (mm)	[hac]	1.525	0.988
Tooth thickness at height hac, chord (mm)	[sc]	1.912	1.569
(mm)	[sc.e/i]	1.860 /1.831	1.499 /1.459
Tooth thickness on reference circle, arc (mm)	[sn]	1.916	1.569
(mm)	[sn.e/i]	1.862 /1.832	1.499 /1.459

9.5 Backlash

		---------- Pair ----------
Circumferential backlash from Aa (mm)	[jtw_Aa.e/i]	0.008 /-0.008
Radial backlash (mm)	[jrw.e/i]	0.302 /0.175
Circumferential backlash (transverse section) (mm)	[jtw.e/i]	0.199 /0.114
Normal backlash (mm)	[jnw.e/i]	0.191 /0.108
Center distance allowances (mm)	[Aa.e/i]	0.013 /-0.013
Backlash free center distance (mm)	[aControl.e/i]	-35.188 /-35.290
Backlash free center distance, allowances (mm)	[jta]	-0.188 /-0.290

		------- Gear 1	---------- Gear 2 -------
dNf.i with aControl (mm)	[dNf0.i]	15.986	-89.784
Reserve (dNf0.i-dFf.e)/2 (mm)	[cF0.i]	-0.077	0.227
Tip clearance (mm)	[c0.i(aControl)]	0.084	0.062

Torsional angle on input with output fixed:		
Total torsional angle (°)	[j.tSys]	1.3620/0.7816 (1°21'43"/ 0°46'54")

10 Toothing tolerances

		------- Gear 1	---------- Gear 2 -------
According to DIN 3961:1978			
Accuracy grade	[Q-DIN3961]	6	6
Profile form deviation (µm)	[ff]	6.00	6.00
Profile slope deviation (µm)	[fHα]	5.00	5.00
Total profile deviation (µm)	[Ff]	8.00	8.00
Helix form deviation (µm)	[fβf]	4.00	4.00
Helix slope deviation (µm)	[fHβ]	8.00	8.00
Total helix deviation (µm)	[Fβ]	9.00	9.00
Normal base pitch deviation (µm)	[fpe]	7.00	7.00

Single pitch deviation (µm)	[fp]	7.00	7.00
Adjacent pitch difference (µm)	[fu]	8.00	9.00
Total cumulative pitch deviation (µm)	[Fp]	19.00	25.00
Pitch span deviation (µm)	[Fpz/8]	12.00	15.00
Runout (µm)	[Fr]	14.00	16.00
Tooth Thickness Variation (µm)	[Rs]	8.00	10.00
Single flank composite, total (µm)	[Fi']	22.00	26.00
Single flank composite, tooth-to-tooth (µm)	[fi']	10.00	11.00
Radial composite, total (µm)	[Fi"]	17.00	20.00
Radial composite, tooth-to-tooth (µm)	[fi"]	6.00	8.00

According DIN 58405:1972 (Precision Mechanics)

Tooth-to-tooth composite error (µm)	[fi"]	6.00	8.00
Composite error (µm)	[Fi"]	18.00	22.00
Axis alignment error (µm)	[fp]	5.95	5.95
Flank direction error (µm)	[fβ]	5.00	5.00
Runout (µm)	[Trk, Fr]	18.00	24.00

Axis alignment tolerances recommendation acc. to ISO TR 10064-3:1996, Quality 6

Maximum value for deviation error of axis (µm)	[fΣβ]	11.00	(F_β=11.00)
Maximum value for inclination error of axes (µm)	[fΣδ]	22.00	

11 Modifications and determination of the tooth form

11.1 Data for the tooth form calculation

Data not available.
Please run the calculation in the "Tooth form" tab and open the main report again.

12 Supplementary data

Maximal possible center distance (eps_a=1.0)	[aMAX]	-34.499

12.1 Masses, stiffnesses and moments of inertia

		------- Gear 1	---------- Gear 2 -------
Mass (g)	[m]	21.19	447.23
Total mass (g)	[mGes]	468.41	
Moment of inertia for system, relative to the input:			
calculation without consideration of the exact tooth shape			
Gears individually ((da+df)/2...di) (kg*m²)	[J]	8.296e-07	0.00124
System (da+df)/2...di (kg*m²)	[J]	4.712e-05	

12.2 Wear, power loss, sound pressure level

Torsional stiffness at driving gear with fixed driven gear:			
Torsional stiffness (MNm/rad)	[cr]	0.016	
Torsion when subjected to nominal torque (°)	[δcr]	0.051	
Average coefficient of friction according to Niemann	[μ_m]	0.076	
Wear sliding coefficient by Niemann	[ζw]	0.746	
Loss factor	[HV]	0.141	
Gear power loss (kW)	[PVZ]	0.142	
Meshing efficiency (%)	[ηz]	98.928	
Sound pressure level based on Masuda, without PPTE/δs	[dB(A)]	65.451	

13 Service life, damage

Required safety for tooth root	[S_{Fmin}]	1.4000
Required safety for tooth flank	[S_{Hmin}]	1.0000
Required service life	[H]	1000.0000
Power-on time (%)	[ED]	70.0000
Service life (calculated with required safeties):		
System service life (h)	[H_{att}]	0.6733

		------- Gear 1	---------- Gear 2 -------
Tooth root service life (h)	[H_{Fatt}]	0.6733	1.704

Tooth flank service life (h)	[H_{Hatt}]	16.33	28.17

13.1 Damage

Damage relative to the required service life (H, 1000.0 h)

F_1 (%)	F_2 (%)	H_1 (%)	H_2 (%)
9999.9999	9999.9999	6124.7994	3549.5996

Damage relative to the system service life (H_{att}, 0.67329 h)

F_1 (%)	F_2 (%)	H_1 (%)	H_2 (%)
100.0000	39.5182	4.1238	2.3899

14 Reliability calculation

14.1 Calculation method

Calculation method according to B. Bertsche, Reliability in Automotive and Mechanical Engineering, Springer-Verlag Berlin Heidelberg 2008

14.2 Factors

Reliability of material data for σ_{Hlim} (%)	[$R\sigma_{Hlim}$]	99.00
Reliability of material data for σ_{Flim} (%)	[$R\sigma_{Flim}$]	99.00

Calculation of coefficients for reliability R(t)
$R(t) = 100 * Exp(-((t*fac - t_0)/(T - t_0))^{\beta})$ (%)

Gear	Type	fac	β	t_0	T	R(H)
		cycles/h		cycles	cycles	%
1	Tooth root	379355	1.700e+00	2.466e+05	3.789e+05	0.0000
1	Tooth flank	379355	1.300e+00	5.583e+06	2.660e+07	0.0000
2	Tooth root	219853	1.700e+00	3.616e+05	5.557e+05	0.0000
2	Tooth flank	219853	1.300e+00	5.583e+06	2.660e+07	0.0000

fac = Number of load cycles per hour
β = Weibull shape parameter
t_0 = Failure-free number of load cycles
T = Characteristic service life (in load cycles) for 63.2% failure probability
R(H) = Reliability for required service life

14.3 Resulting reliabilities and service lives

Required service life (h)	[H_{min}]	1000.0000
Reliability R, tooth roots subsystem (%)	[R_{subF}]	0.0000
Reliability R, tooth flanks subsystem (%)	[R_{subH}]	0.0000
Reliability R, gears subsystem (%)	[R_{subG}]	0.0000
Required reliability (%)	[R_{min}]	99.0000
Service life H, tooth roots subsystem (h)	[H_{subF}]	0.6733
Service life H, tooth flanks subsystem (h)	[H_{subH}]	16.3271
Service life H, gears subsystem (h)	[H_{subG}]	0.6733

15 Remarks

15.1 Conventions

- Specifications with **.e/i** mean: Maximum value **.e** and Minimum value **.i**, taking all tolerances into account.
- Specifications with **.m** mean: Mean value within tolerance.

- The center distance tolerances and the tooth thickness allowance are taken into account for the backlash tolerance. The maximum and minimum clearance corresponding to the largest and smallest allowances are shown. The calculation is performed for the operating pitch circle.

15.2 Calculations and factors

- Details of calculation method:
  c_γ according to Method B
  K_v according to Method B
  $K_{H\beta}$ and $K_{F\beta}$ according to Method C
  $K_{H\alpha}$, $K_{F\alpha}$ according to Method B

_O.Gearbox.SunPlanet1.SunPlanet1_calc

1 Overview

Calculation method		DIN 3990:1987 Method B	
Drawing or article number:			
Gear 1:		SunGear(SunPlanet1)	
Gear 2:		PlanetGear1(SunPlanet1)	
		------- Gear 1 ----------	Gear 2 -------
Power (kW)	[P]	13.265	
Speed (1/min)	[n]	20000.0	9032.3
Number of load cycles (in mio.)	[NL]	3600.000	541.935
Torque (Nm)	[T]	6.333	14.024
Application factor	[KA]	1.50	
Required service life (h)	[H]	1000.00	
Gear driving (+) / driven (-)		+	-
Working flank Gear 1:		Right flank	
Gear 1 direction of rotation:		Clockwise	

2 Tooth geometry

Geometry calculation according to		DIN 3960 (withdrawn)	
		------- Gear 1 ----------	Gear 2 -------
Center distance (mm)	[a]	35.000	
Center distance tolerance		ISO 286:2010 Measure js7	
Normal module (mm)	[mn]	1.5000	
Normal pressure angle (°)	[αn]	20.0000	
Helix angle at reference circle (°)	[β]	0.0000	
Number of teeth	[z]	14	31
Facewidth (mm)	[b]	11.00	11.00
Hand of gear		Spur gear	
Accuracy grade	[Q-DIN 3961:1978]	6	6
Inner diameter (mm)	[di]	0.00	0.00
Inner diameter of gear rim (mm)	[dbi]	0.00	0.00

3 Materials

Gear 1
18CrNiMo7-6, Case hardening steel, case-hardened, GOST 21354 ground with possible overheating or grinding notch, rolled, Yg=0.6, Yd=1, Yz=0.9

Gear 2
18CrNiMo7-6, Case hardening steel, case-hardened, GOST 21354 ground with possible overheating or grinding notch, rolled, Yg=0.6, Yd=1, Yz=0.9

		------- Gear 1 ----------	Gear 2 -------
Surface hardness		HRC 61	HRC 61
Infinite life strength for tooth root stress (N/mm²)	[σFlim]	221.00	221.00
Fatigue strength for Hertzian pressure (N/mm²)	[σHlim]	1403.00	1403.00
Young's modulus (N/mm²)	[E]	206000	206000
Poisson's ratio	[v]	0.300	0.300
Tensile strength (N/mm²)	[σB]	1200.00	1200.00
Yield point (N/mm²)	[σS]	850.00	850.00

3.1 Gear roughness

		------- Gear 1	---------- Gear 2 -------
Arithmetic mean roughness value R_a, flank (µm)	[RAH]	0.60	0.60
Arithmetic mean roughness value R_a, root (µm)	[RAF]	3.00	3.00
Mean peak-to-valley roughness R_z, flank (µm)	[RZH]	4.80	4.80
Mean peak-to-valley roughness R_z, root (µm)	[RZF]	20.00	20.00

3.2 Lubrication

Lubrication type	Oil bath lubrication	
Type of oil	Klübersynth LEG 4 75 W 90 (API GL 5)	
Lubricant base	Synthetic oil based on Polyalphaolefin	
Oil nominal kinematic viscosity at 40°C (mm²/s)	[v40]	90.00
Oil nominal kinematic viscosity at 100°C (mm²/s)	[v100]	15.00
Specific density at 15°C (kg/dm³)	[ρ]	0.850
Oil temperature (°C)	[TS]	70.000

4 Geometry

4.1 Reference profiles

Tool reference profile from Gear 1

pinion-type cutter, own input

Number of teeth	[z]	25
Profile shift coefficient	[x*]	0.000
Base diameter (mm)	[db0]	35.238
Addendum coefficient	[haP0*]	1.215
Tip diameter (mm)	[da0]	41.145
Tip form: Radius	[ρaP0*]	0.380
Dedendum coefficient	[hfP0*]	1.435
Root diameter (mm)	[df0]	33.195
Root radius factor	[ρfP0*]	0.001
Tooth thickness on reference circle, arc (mm)	[sn]	2.356
Tip form diameter (mm)	[dFa0]	40.557
Root form diameter (mm)	[dFf0]	35.239
	not topping	
Addendum coefficient reference profile Gear	[haP*]	1.000
Manufacturing center distance (mm)	[a0]	29.911

Tool reference profile from Gear 2

pinion-type cutter, own input

Number of teeth	[z]	31
Profile shift coefficient	[x*]	0.000
Base diameter (mm)	[db0]	43.696
Addendum coefficient	[haP0*]	1.228
Tip diameter (mm)	[da0]	50.184
Tip form: Radius	[ρaP0*]	0.380
Dedendum coefficient	[hfP0*]	1.422
Root diameter (mm)	[df0]	42.234
Root radius factor	[ρfP0*]	0.001
Tooth thickness on reference circle, arc (mm)	[sn]	2.356
Tip form diameter (mm)	[dFa0]	49.572
Root form diameter (mm)	[dFf0]	43.830
	not topping	
Addendum coefficient reference profile Gear	[haP*]	1.000
Manufacturing center distance (mm)	[a0]	47.159

4.1.1 Information on final machining

		------- Gear 1	---------- Gear 2 -------
Dedendum reference profile	[hfP*]	1.250	1.250
Tooth root radius reference profile	[ρfP*]	0.380	0.380
Addendum reference profile	[haP*]	1.000	1.000
Protuberance height coefficient	[hprP*]	0.000	0.000
Protuberance angle (°)	[αprP]	0.000	0.000
Tip form height coefficient	[hFaP*]	0.000	0.000
Ramp angle (°)	[αKP]	0.000	0.000

Type of profile modification: none (only running-in)

Tip relief by running in (µm)	[Ca L/R]	2.4 /2.4	2.4 /2.4

4.2 Basic data

Overall transmission ratio	[itot]	-2.214
Gear ratio	[u]	2.214
Transverse module (mm)	[mt]	1.500
Transverse pressure angle (°)	[αt]	20.000
Working pressure angle (°)	[αwt]	25.024
(°)	[αwt.e/i]	25.068 /24.980
Working pressure angle at normal section (°)	[αwn]	25.024
Base helix angle (°)	[βb]	0.000
Helix angle at operating pitch circle (°)	[βw]	0.000
Reference center distance (mm)	[ad]	33.750
Sum of profile shift coefficients	[Σxi]	0.9372

		------- Gear 1 ----------	Gear 2 -------
Profile shift coefficient	[x]	0.4756	0.4617
Generating profile shift coefficient	[xE.e/i]	0.4261/0.3987	0.4122/0.3847
Virtual gear no. of teeth	[zn]	14.000	31.000
Involute length (mm)	[l_dFa-l_dFf]	3.101	3.057

4.3 Diameters and their allowances

		------- Gear 1 ----------	Gear 2 -------
Reference diameter (mm)	[d]	21.000	46.500
Base diameter (mm)	[db]	19.734	43.696
Tip alteration (mm)	[k*mn]	0.000	0.000
Tip diameter (mm)	[da]	25.427	50.885
(mm)	[da.e/i]	25.427 /25.417	50.885 /50.875
Tip diameter allowances (mm)	[Ada.e/i]	0.000 /-0.010	0.000 /-0.010
Tip form diameter (mm)	[dFa]	25.427	50.885
(mm)	[dFa.e/i]	25.427 /25.417	50.885 /50.875
Active tip diameter (mm)	[dNa]	25.427	50.885
(mm)	[dNa.e/i]	25.427 /25.417	50.885 /50.875
V-Circle diameter (mm)	[dv]	22.427	47.885
(mm)	[dv.e/i]	22.278 /22.196	47.737 /47.654
Operating pitch diameter (mm)	[dw]	21.778	48.222
(mm)	[dw.e/i]	21.786 /21.770	48.239 /48.205
Root diameter (mm)	[df]	18.677	44.134
Generated root diameter with xE (mm)	[df.e/i]	18.547 /18.475	43.999 /43.923
Active root diameter (mm)	[dNf]	20.047	45.756
(mm)	[dNf.e/i]	20.061 /20.037	45.778 /45.738
Root form diameter (mm)	[dFf]	20.045	45.331
(mm)	[dFf.e/i]	19.989 /19.960	45.236 /45.184

4.4 Tip clearances and tooth heights

		------- Gear 1 ----------	Gear 2 -------
Theoretical tip clearance (mm)	[c]	0.220	0.219
Effective tip clearance (mm)	[c.e/i]	0.343 /0.275	0.338 /0.271
Reserve (dNf-dFf)/2 (mm)	[cF.e/i]	0.051 /0.024	0.297 /0.251
Addendum, $m_n(h_{aP}$*+x+k) (mm)	[ha]	2.213	2.192
(mm)	[ha.e/i]	2.213 /2.208	2.192 /2.187
Dedendum, $m_n(h_{fP}$*-x) (mm)	[hf]	1.162	1.183
(mm)	[hf.e/i]	1.226 /1.263	1.251 /1.289
Tooth height (mm)	[h]	3.375	3.375

4.5 Roll angle

		------- Gear 1	---------- Gear 2 -------
Roll angle at dFa (°)	[ξFa.e/i]	46.556 /46.510	34.192 /34.167
Roll angle to dNf (°)	[ξNf.e/i]	10.488 /10.088	17.898 /17.723
Roll angle at dFf (°)	[ξFf.e/i]	9.253 /8.711	15.347 /15.080

4.6 Tooth thickness and pitch

		------- Gear 1	---------- Gear 2 -------
Tooth thickness on reference circle, arc, in module	[sn*]	1.9170	1.9069
Normal tooth thickness at tip circle (mm)	[san]	0.550	0.900
(mm)	[san.e/i]	0.492 /0.448	0.847 /0.808
Normal tooth thickness at tip form circle (mm)	[sFan]	0.550	0.900
(mm)	[sFan.e/i]	0.492 /0.448	0.847 /0.808
Normal space width at root circle (mm)	[efn]	0.000	1.142
(mm)	[efn.e/i]	0.000 /0.000	1.172 /1.190
Pitch on reference circle (mm)	[pt]	4.712	4.712
Base pitch (mm)	[pbt]	4.428	4.428
Transverse pitch on contact-path (mm)	[pet]	4.428	4.428

4.7 Sliding

		------- Gear 1	---------- Gear 2 -------
Max. sliding velocity at tip (m/s)	[vga]	10.371	8.632
Specific sliding at the tip	[ζa]	0.618	0.700
Specific sliding at the root	[ζf]	-2.333	-1.615
Mean specific sliding	[ζm]	0.655	
Sliding factor on tip	[Kga]	0.455	0.378
Sliding factor on root	[Kgf]	-0.378	-0.455

4.8 Contact ratios

		---------- Pair ----------
Minimal length of contact line (mm)	[Lmin]	11.000
Transverse contact ratio	[εα]	1.412
	[εα.e/m/i]	1.418 /1.410/ 1.401
Overlap ratio	[εβ]	0.000
Total contact ratio	[εγ]	1.412
	[εγ.e/m/i]	1.418 /1.410/ 1.401
Length of path of contact (mm)	[ga]	6.251
(mm)	[ga.e/i]	6.280 /6.203

		------- Gear 1	---------- Gear 2 -------
Addendum contact ratio	[ε]	0.770	0.641
	[ε.e/i]	0.772 /0.767	0.646 /0.634
Length T1-A and T2-A (mm)	[T1A,T2A]	1.767	13.038
(mm)	[.e/i]	1.737 / 1.806	13.038 /13.028
Length T1-B and T2-B (mm)	[T1B,T2B]	3.589	11.216
(mm)	[.e/i]	3.589 / 3.581	11.186 /11.253
Length T1-C and T2-C (mm)	[T1C,T2C]	4.606	10.199
(mm)	[.e/i]	4.597 / 4.615	10.178 /10.219
Length T1-D and T2-D (mm)	[T1D,T2D]	6.195	8.610
(mm)	[.e/i]	6.165 / 6.234	8.610 / 8.600
Length T1-E and T2-E (mm)	[T1E,T2E]	8.017	6.788
(mm)	[.e/i]	8.017 / 8.009	6.758 / 6.825
Length T1-T2 (mm)	[T1T2]	14.805	
(mm)	[.e/i]	14.775 /14.834	
Diameter of single contact point B (mm)	[d-B]	20.999	49.117
(mm)	[d-B.e/i]	20.999 /20.993	49.090 /49.151
Diameter of single contact point D (mm)	[d-D]	23.301	46.966
(mm)	[d-D.e/i]	23.269 /23.343	46.966 /46.959

5 General influence factors

5.1 Forces and circumferential speed

		------- Gear 1	---------- Gear 2 -------
Nominal circum. force at pitch circle (N)	[Ft]	603.2	
Axial force (N)	[Fa]	0.0	0.0
Radial force (N)	[Fr]	219.5	219.5
Normal force (N)	[Fnorm]	641.9	641.9
Nominal circumferential force per mm (N/mm)	[w]	54.83	
Only as information: Forces at operating pitch circle:			
Nominal circumferential force (N)	[Ftw]	581.6	
Axial force (N)	[Faw]	0.0	0.0
Radial force (N)	[Frw]	271.5	
Circumferential speed reference circle (m/s)	[v]	21.99	
Circumferential speed operating pitch circle (m/s)	[v(dw)]	22.81	

5.2 Contact stiffness

Running-in value (µm)	[yp]	0.5
Running-in value (µm)	[yf]	0.4
Tolerances f_{pe}, f_f and $f_{H\beta}$, matching the tolerances in section 7		
Correction factor	[CM]	0.800
Gear blank factor	[CR]	1.000
Basic rack factor	[CB]	0.975
Material coefficient	[E/Est]	1.000
Single stiffness (N/mm/µm)	[c']	11.300
Meshing stiffness (N/mm/µm)	[cγ]	14.788
Reduced mass (kg/mm)	[mRed]	0.00152
Resonance speed (min-1)	[nE1]	67255
Resonance ratio (-)	[N]	0.297
Subcritical range		

5.3 Calculation of K factors

Running-in value (µm)	[yα]	0.5
Bearing distance l of pinion shaft (mm)	[l]	22.000
Distance s of pinion shaft (mm)	[s]	2.200
Outside diameter of pinion shaft (mm)	[dsh]	11.000
Load according to Figure 6.8, DIN 3990-1:1987 0:6.8a, 1:6.8b, 2:6.8c, 3:6.8d, 4:6.8e	[-]	4
Coefficient K' according to Figure 6.8, DIN 3990-1:1987	[K']	-1.00
Without stiffening		
Tooth trace deviation (active) (µm)	[Fβy]	4.73
from deformation of shaft (µm)	[fsh*B1]	0.33
fsh (µm)	[fsh]	0.66
B1	[B1]	0.50
fHβ5 (µm)	[fHβ5]	6.00
Flank line:	crowned	[$C_\beta = 0.5*(f_{m\alpha}+f_{sh})$]
Position of contact pattern:	favorable	
from production tolerances (µm)	[fmα*B2]	4.00
B_2=0.50		
Tooth trace deviation, theoretical (µm)	[Fβx]	5.56
Running-in value (µm)	[yβ]	0.83

5.4 K factors

Dynamic factor	[Kv]	1.208
Face load factors		
- Flank	[KHβ]	1.352
- Tooth root	[KFβ]	1.238
- Scuffing	[KBβ]	1.352
Transverse load factors		
- Flank	[KHα]	1.000

- Tooth root	[KFα]	1.000
- Scuffing	[KBα]	1.000
Application factor	[KA]	1.500
Mesh load factor	[Kγ]	1.000

6 Calculation of tooth root strength (fracture)

Calculation of Tooth form coefficients according method: B

		------- Gear 1	---------- Gear 2 -------
Calculated with generating profile shift coefficient	[xE.e]	0.4261	0.4122
Tooth form factor	[YF]	1.51	1.50
Stress correction factor	[YS]	2.02	2.07
Load application angle (°)	[αFen]	27.42	25.10
Load application diameter (mm)	[d_{en}]	23.301	49.117
Bending moment arm (mm)	[hF]	1.75	1.93
Tooth thickness at root (mm)	[sFn]	3.14	3.34
Tooth root radius (mm)	[ρF]	0.67	0.65
Bending moment arm (-)	[hF/mn]	1.170	1.286
Tooth thickness at root (-)	[sFn/mn]	2.095	2.228
Tooth root radius (-)	[ρF/mn]	0.446	0.434
Calculation cross section diameter (mm)	[d_{sFn}]	18.984	44.521
Tangents on calculation cross section (°)	[α_{sFn}]	30.000	30.000
Notch parameter	[q_s]	2.348	2.568
Contact ratio factor	[Yε]	1.000	
Helix angle factor	[Yβ]	1.000	
Effective facewidth (mm)	[beff]	11.00	11.00
Nominal stress at tooth root (N/mm²)	[σF0]	111.39	113.19
Tooth root stress (N/mm²)	[σF]	249.72	253.77
Permissible bending stress at root of Test-gear			
Notch sensitivity factor	[YδrelT]	0.999	1.001
Surface factor	[YRrelT]	0.957	0.957
Size factor, tooth root	[YX]	1.000	1.000
Life factor	[YNT]	1.000	1.000
$Y_{\delta relT}*Y_{RrelT}*Y_X*Y_{NT}$		0.955	0.957
Alternating bending factor, mean stress influence coefficient			
	[YM]	1.000	1.000
Stress correction factor	[YST]	2.00	
$Y_{ST}*\sigma_{Flim}$ (N/mm²)	[σFE]	442.00	442.00
Permissible tooth root stress σFG/SFmin (N/mm²)	[σFP]	301.62	302.25
Limit strength tooth root (N/mm²)	[σFG]	422.26	423.15

6.1 Safety factors

		------- Gear 1	---------- Gear 2 -------
Required safety	[SFmin]	1.40	1.40
Safety for tooth root stress	[SF=σFG/σF]	1.69	1.67
Transmittable power (kW)	[kWRating]	16.02	15.80

7 Calculation of flank strength (pitting)

		------- Gear 1	---------- Gear 2 -------
Zone factor	[ZH]	2.203	
Elasticity coefficient (√N/mm)	[ZE]	189.812	
Contact ratio factor	[Zε]	0.929	
Helix angle factor	[Zβ]	1.000	
Effective facewidth (mm)	[beff]	11.00	
Nominal contact stress (N/mm²)	[σH0]	756.10	
Contact stress at operating pitch circle (N/mm²)	[σHw]	1183.14	
Single tooth contact factor	[ZB,ZD]	1.08	1.00
Contact stress (N/mm²)	[σHB, σHD]	1278.10	1183.14
Lubricant coefficient for N_L	[ZL]	0.960	0.960
Speed factor at N_L	[ZV]	1.023	1.023
Roughness factor for N_L	[ZR]	0.937	0.937
Material hardening factor for N_L	[ZW]	1.000	1.000
Life factor	[ZNT]	1.000	1.000
	[ZL*ZV*ZR*ZNT]	0.920	0.920

Limited pitting is permissible:	No		
Size factor (flank)	[ZX]	1.000	1.000
Permissible contact stress, σHG/SHmin (N/mm²)	[σHP]	1290.38	1290.38
Pitting stress limit (N/mm²)	[σHG]	1290.38	1290.38

7.1 Safety factors

		------- Gear 1	---------- Gear 2 -------
Required safety	[SHmin]	1.00	1.00
Safety factor for contact stress on operating pitch circle	[SHw]	1.09	1.09
Safety against pressure, σHG/σHBD Single contact	[SHBD]	1.01	1.09
Safety regarding transmittable torque	[SHBD²]	1.02	1.19
Transmittable power (kW)	[kWRating]	13.52	15.78

8 Micropitting

Calculation method according to	ISO/TS 6336-22:2018	
Lubricant load according to FVA Info sheet 54/7 10, Klübersynth LEG 4 75 W 90 (API GL 5)		
Reference data FZG-C Test:		
Torque (Nm)	[T1Ref]	265.100
Line load at contact point A (N/mm)	[FbbRef,A]	236.300
Oil temperature (°C)	[θOilRef]	90.000
Tooth mass temperature (°C)	[θMRef]	122.487
Contact temperature (°C)	[θBRef,A]	223.515
Lubrication gap thickness (µm)	[hRef,A]	0.041
Specific film thickness in test	[λGFT]	0.083

		------- Gear 1	---------- Gear 2 -------
Calculation of permissible specific film thickness			
Material coefficient	[WW]	1.000	
Permissible specific film thickness	[λGFP]	0.116	

Interim results in accordance with ISO/TS 6336-22:2018			
Coefficient of friction	[μ_m]	0.053	
Lubricant factor	[XL]	0.800	
Roughness factor	[XR]	1.451	
Lubrication coefficient for lubrication type	[XS]	1.000	
Tooth mass temperature (°C)	[θM]	86.171	
Tip relief factor	[XCa(A)]	1.239	
Loss factor	[HV]	0.193	
Equivalent Young's modulus (N/mm²)	[Er]	226373.626	
Pressure-viscosity coefficient (m²/N)	[α38]	0.01291	
Dynamic viscosity (Ns/m²)	[ηtM]	16.542	
Roughness average value (µm)	[Ra]	0.600	

Calculation of speeds, load distribution and flank curvature according to method B following ISO/TS 6336-22:2018.

C_a taken as optimal in the calculation. 0=no, 1=yes		0	0	
Calculation at point (0:A, 1:AB, 2:B, 3:C, 4:D, 5:DE, 6:E, -1:No Point)		0		
Diameter (mm)	[dy]	20.047	50.885	
Relative radius of curvature (mm)	[ρred]	1.556		
Load sharing factor	[XY]	0.333		
Contact stress (N/mm²)	[pH]	671.123		
Contact stress (N/mm²)	[pdyn]	1050.161		
Minimal specific film thickness	[λGFY]	0.269	(h_Y=0.161 µm)	
Safety against micropitting	[Sλ(B)]	2.318		
For interim results, refer to file:	Micropitting_12.tmp			

9 Scuffing load capacity

Calculation method according to	DIN 3990:1987		

		------- Gear 1	---------- Gear 2 -------
Thermal contact coefficient (N/mm/s^.5/K)	[BM]	13.780	13.780
Relevant tip relief (µm)	[Ca]	2.40	2.40
Optimal tip relief (µm)	[Ceff]	7.28	
C_a taken as optimal in the calculation. 0=no, 1=yes		0	0

		---------- Pair ----------
Helical load factor for scuffing	[KBγ]	1.000
Lubrication coefficient for lubrication type	[XS]	1.000
Scuffing test, load stage	[FZGtest]	FZG - Test A / 8.3 / 90 (ISO 14635 - 1), 14
Relative structural factor, scuffing	[XWrelT]	1.000
Effective facewidth (mm)	[beff]	11.000
Applicable circumferential force/facewidth (N/mm)	[wBt]	134.263
Angle factor	[Xαβ]	1.050
ε_1 =0.770, ε_2 =0.641		

9.1 Flash temperature-criteria

		---------- Pair ----------	
Tooth mass temperature (°C)	[θMB]	94.11	
$\theta_{MB} = \theta_{oil} + X_S*0.47*\theta_{flamax}$			
Maximum flash temperature (°C)	[θflamax]	51.29	
Scuffing temperature (°C)	[θS]	568.85	
Γ coordinates (point of highest temperature)	[Γ]	-0.616	
[Γ.A]= -0.616, [Γ.E]= 0.741			
Maximum contact temperature (°C)	[θB]	145.40	
Flash factor (°K*N^-.75*s^.5*m^-.5*mm)	[XM]	50.058	
Geometry factor	[XB]	0.458	
Load sharing factor	[XΓ]	0.333	
Dynamic viscosity (mPa*s)	[ηM]	13.90	(94.1 °C)
Coefficient of friction	[μ_m]	0.084	
Required safety	[SBmin]	2.000	
Margin of safety for scuffing, flash temperature	[SB]	6.616	

9.2 Integral temperature-criteria

		---------- Pair ----------	
Tooth mass temperature (°C)	[θMC]	86.36	
$\theta_{MC} = \theta_{oil} + X_S*0.70*\theta_{flaint}$			
Integral scuffing temperature (°C)	[θSint]	568.85	
Flash factor (°K*N^-.75*s^.5*m^-.5*mm)	[XM]	50.058	
Contact ratio factor	[Xε]	0.283	
Dynamic viscosity (mPa*s)	[ηOil]	25.91	(70.0 °C)
Mean coefficient of friction	[μ_m]	0.057	
Geometry factor	[XBE]	0.364	
Meshing factor	[XQ]	1.000	
Tip relief factor	[XCa]	1.013	
Mean flash temperature (°C)	[θflaint]	23.38	
Integral tooth flank temperature (°C)	[θint]	121.43	
Required safety	[SSmin]	1.800	
Safety factor for scuffing (intg.-temp.)	[SSint]	4.685	
Safety factor for transmitted moment (int.-T.)	[SSL]	9.700	

10 Measurements for tooth thickness

10.1 Tooth thickness tolerances

		------- Gear 1 ----------	Gear 2 -------
Tooth thickness tolerance		DIN 3967 cd25	DIN 3967 cd25
Tooth thickness allowance (normal section) (mm)	[Asn.e/i]	-0.054 /-0.084	-0.054 /-0.084

10.2 Base tangent lengths

		------- Gear 1 ----------	Gear 2 -------
Number of teeth spanned	[k]	3.000	5.000
Base tangent length (no backlash) (mm)	[Wk]	11.853	21.052
Base tangent length with allowance (mm)	[Wk.e/i]	11.802 /11.774	21.001 /20.973
(mm)	[ΔWk.e/i]	-0.051 /-0.079	-0.051 /-0.079
Diameter of measuring circle (mm)	[dMWk.m]	22.986	48.474

10.3 Measurement over balls and pins

		------- Gear 1 ----------	Gear 2 -------
Theoretical diameter of ball/pin (mm)	[DM]	3.211	2.784
Effective diameter of ball/pin (mm)	[DMeff]	3.250	3.000
Radial single-ball measurement backlash free (mm)	[MrK]	13.718	26.277
Radial single-ball measurement (mm)	[MrK.e/i]	13.674 /13.649	26.223 /26.193

Diameter of measuring circle (mm)	[dMMr.m]	22.371	48.089
Diametral measurement over two balls, no backlash (mm)	[MdK]	27.436	52.491
Diametral measurement over two balls (mm)	[MdK.e/i]	27.348 /27.298	52.383 /52.323
Diametral measurement over pins without clearance (mm)	[MdR]	27.436	52.491
Measurement over pins according to DIN 3960 (mm)	[MdR.e/i]	27.348 /27.298	52.383 /52.323
Measurement over 3 pins without play (mm)	[Md3R]	0.000	52.428
Measurement over 3 pins (mm)	[Md3R.e/i]	0.000 /0.000	52.320 /52.260

10.4 Tooth thickness

		------- Gear 1	---------- Gear 2 -------
Medium tip diameter (mm)	[da.m]	25.422	50.880
Reference chordal height from da.m (mm)	[hac]	2.309	2.234
Tooth thickness at height hac, chord (mm)	[sc]	2.867	2.858
(mm)	[sc.e/i]	2.815 /2.786	2.806 /2.776
Tooth thickness on reference circle, arc (mm)	[sn]	2.876	2.860
(mm)	[sn.e/i]	2.822 /2.792	2.806 /2.776

10.5 Backlash

		---------- Pair ----------
Circumferential backlash from Aa (mm)	[jtw_Aa.e/i]	0.012 /-0.012
Radial backlash (mm)	[jrw.e/i]	0.201 /0.108
Circumferential backlash (transverse section) (mm)	[jtw.e/i]	0.186 /0.100
Normal backlash (mm)	[jnw.e/i]	0.166 /0.093
Center distance allowances (mm)	[Aa.e/i]	0.013 /-0.013
Backlash free center distance (mm)	[aControl.e/i]	34.879 /34.811
Backlash free center distance, allowances (mm)	[jta]	-0.121 /-0.189

		------- Gear 1	---------- Gear 2 -------
dNf.i with aControl (mm)	[dNf0.i]	19.908	45.496
Reserve (dNf0.i-dFf.e)/2 (mm)	[cF0.i]	-0.041	0.130
Tip clearance (mm)	[c0.i(aControl)]	0.098	0.095

Torsional angle on input with output fixed:

Total torsional angle (°)	[j.tSys]	0.9781/0.5279 (0°58'41"/ 0°31'41")

11 Toothing tolerances

		------- Gear 1	---------- Gear 2 -------
According to DIN 3961:1978			
Accuracy grade	[Q-DIN3961]	6	6
Profile form deviation (µm)	[ff]	6.00	6.00
Profile slope deviation (µm)	[fHα]	5.00	5.00
Total profile deviation (µm)	[Ff]	8.00	8.00
Helix form deviation (µm)	[fβf]	4.00	4.00
Helix slope deviation (µm)	[fHβ]	8.00	8.00
Total helix deviation (µm)	[Fβ]	9.00	9.00
Normal base pitch deviation (µm)	[fpe]	7.00	7.00
Single pitch deviation (µm)	[fp]	7.00	7.00
Adjacent pitch difference (µm)	[fu]	8.00	8.00
Total cumulative pitch deviation (µm)	[Fp]	19.00	19.00
Pitch span deviation (µm)	[Fpz/8]	12.00	12.00
Runout (µm)	[Fr]	14.00	14.00
Tooth Thickness Variation (µm)	[Rs]	8.00	8.00
Single flank composite, total (µm)	[Fi']	22.00	22.00
Single flank composite, tooth-to-tooth (µm)	[fi']	10.00	10.00
Radial composite, total (µm)	[Fi"]	17.00	17.00
Radial composite, tooth-to-tooth (µm)	[fi"]	6.00	6.00
According DIN 58405:1972 (Precision Mechanics)			
Tooth-to-tooth composite error (µm)	[fi"]	6.00	7.00
Composite error (µm)	[Fi"]	18.00	20.00
Axis alignment error (µm)	[fp]	5.95	5.95
Flank direction error (µm)	[fβ]	5.00	5.00
Runout (µm)	[Trk, Fr]	21.00	24.00

Axis alignment tolerances recommendation acc. to ISO TR 10064-3:1996, Quality 6

Maximum value for deviation error of axis (µm)	[fΣβ]	10.00	(F_β=10.00)
Maximum value for inclination error of axes (µm)	[fΣδ]	20.00	

12 Modifications and determination of the tooth form

12.1 Data for the tooth form calculation

Data not available.
Please run the calculation in the "Tooth form" tab and open the main report again.

13 Supplementary data

Maximal possible center distance (eps_a=1.0)	[aMAX]	35.809

13.1 Masses, stiffnesses and moments of inertia

		------- Gear 1	---------- Gear 2 -------
Mass (g)	[m]	32.90	152.69
Total mass (g)	[mGes]	185.58	
Moment of inertia for system, relative to the input:			
calculation without consideration of the exact tooth shape			
Gears individually ((da+df)/2...di) (kg*m²)	[J]	2e-06	4.308e-05
System (da+df)/2...di (kg*m²)	[J]	1.079e-05	

13.2 Wear, power loss, sound pressure level

Torsional stiffness at driving gear with fixed driven gear:			
Torsional stiffness (MNm/rad)	[cr]	0.015	
Torsion when subjected to nominal torque (°)	[δcr]	0.024	
Average coefficient of friction according to Niemann	[μ_m]	0.058	
Wear sliding coefficient by Niemann	[ζw]	0.925	
Loss factor	[HV]	0.193	
Gear power loss (kW)	[PVZ]	0.149	
Meshing efficiency (%)	[ηz]	98.880	
Sound pressure level based on Masuda, without PPTE/δs	[dB(A)]	66.926	

14 Service life, damage

Required safety for tooth root	[S_{Fmin}]	1.4000
Required safety for tooth flank	[S_{Hmin}]	1.0000
Required service life	[H]	1000.0000

Service life (calculated with required safeties):

System service life (h)	[H_{att}]	> 1000000

		------- Gear 1	---------- Gear 2 -------
Tooth root service life (h)	[H_{Fatt}]	1e+06	1e+06
Tooth flank service life (h)	[H_{Hatt}]	1e+06	1e+06

Note: The entry 1e+006 h means that the Service life > 1,000,000 h.

14.1 Damage

Damage relative to the required service life (H, 1000.0 h)

F_1 (%)	F_2 (%)	H_1 (%)	H_2 (%)
0.0000	0.0000	0.0000	0.0000

15 Reliability calculation

15.1 Calculation method

Calculation method according to B. Bertsche, Reliability in Automotive and Mechanical Engineering, Springer-Verlag Berlin Heidelberg 2008

15.2 Factors

Reliability of material data for σ_{Hlim} (%)	[$R\sigma_{Hlim}$]	99.00
Reliability of material data for σ_{Flim} (%)	[$R\sigma_{Flim}$]	99.00

Calculation of coefficients for reliability R(t)
$R(t) = 100 * Exp(-((t*fac - t_0)/(T - t_0))^{\beta})$ (%)

Gear	Type	fac	β	t_0	T	R(H)
		cycles/h		cycles	cycles	%
1	Tooth root	3600000	1.700e+00	9.654e+29	1.484e+30	100.0000
1	Tooth flank	3600000	1.300e+00	9.014e+29	4.295e+30	100.0000
2	Tooth root	541935	1.700e+00	9.654e+29	1.484e+30	100.0000
2	Tooth flank	541935	1.300e+00	9.014e+29	4.295e+30	100.0000

fac = Number of load cycles per hour
β = Weibull shape parameter
t_0 = Failure-free number of load cycles
T = Characteristic service life (in load cycles) for 63.2% failure probability
R(H) = Reliability for required service life

15.3 Resulting reliabilities and service lives

Required service life (h)	[H_{min}]	1000.0000
Reliability R, tooth roots subsystem (%)	[R_{subF}]	100.0000
Reliability R, tooth flanks subsystem (%)	[R_{subH}]	100.0000
Reliability R, gears subsystem (%)	[R_{subG}]	100.0000
Required reliability (%)	[R_{min}]	99.0000
Service life H, tooth roots subsystem (h)	[H_{subF}]	> 1'000'000
Service life H, tooth flanks subsystem (h)	[H_{subH}]	> 1'000'000
Service life H, gears subsystem (h)	[H_{subG}]	> 1'000'000

16 Remarks

16.1 Conventions

- Specifications with **.e/i** mean: Maximum value **.e** and Minimum value **.i**, taking all tolerances into account.
- Specifications with **.m** mean: Mean value within tolerance.

- The center distance tolerances and the tooth thickness allowance are taken into account for the backlash tolerance. The maximum and minimum clearance corresponding to the largest and smallest allowances are shown. The calculation is performed for the operating pitch circle.

16.2 Calculations and factors

- Details of calculation method:
  c_γ according to Method B
  K_v according to Method B
  $K_{H\beta}$ and $K_{F\beta}$ according to Method C
  $K_{H\alpha}$, $K_{F\alpha}$ according to Method B