KISSsoft

Cylindrical gear pair, helical

06 Helical (DIN 3990)

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Description	KISSsoft example
	Non commercial version for demo and support purposes only ! (914)
	KISSsoft Release 2024

Contents

1 Messages

Calculation is consistent.

2 Overview

Calculation method		DIN 3990:1987 Method B	
Drawing or article number:			
Gear 1:		0.000.0	
Gear 2:		0.000.0	
		------- Gear 1 ----------	Gear 2 -------
Power (kW)	[P]	12.500	
Speed (1/min)	[n]	2950.0	765.9
Number of load cycles (in mio.)	[NL]	3540.000	919.038
Torque (Nm)	[T]	40.5	155.9
Application factor	[KA]	1.25	
Required service life (h)	[H]	20000.00	
Gear driving (+) / driven (-)		+	-
Working flank Gear 1:		Right flank	
Gear 1 direction of rotation:		Clockwise	

3 Tooth geometry

Geometry calculation according to ISO 21771:2007

		------- Gear 1 ----------	Gear 2 -------
Center distance (mm)	[a]	101.845	
Center distance tolerance		ISO 286:2010 Measure js7	
Normal module (mm)	[mn]	1.5000	
Transverse module (mm)	[mt]	1.5459	
Normal Diametral Pitch (1/in)	[Pnd]	16.93333	
Transverse Diametral Pitch (1/in)	[Ptd]	16.43034	
Normal pressure angle (°)	[αn]	20.0000	
Helix angle at reference circle (°)	[β]	14.0000	
Number of teeth	[z]	27	104
Facewidth (mm)	[b]	21.00	20.00
Hand of gear		left	right
Accuracy grade	[Q-DIN 3961:1978]	6	6
Inner diameter (mm)	[di]	0.00	146.39
Inner diameter of gear rim (mm)	[dbi]	0.00	0.00

4 Materials

Gear 1
31 CrMoV9, Nitriding steel, gas-nitrided, ISO 6336-5 Figure 13a/14a (MQ)

Gear 2
42 CrMo 4 (3), Through hardened steel, nitrided, ISO 6336-5 Figure 13b/14b (MQ)

		------- Gear 1 ----------	Gear 2 -------
Surface hardness		HV 800	HV 550
Infinite life strength for tooth root stress (N/mm²)	[σFlim]	425.00	370.00
Infinite life strength for Hertzian pressure (N/mm²)	[σHlim]	1250.00	1000.00
Young's modulus (N/mm²)	[E]	206000	206000
Poisson's ratio	[v]	0.300	0.300
Tensile strength (N/mm²)	[σB]	1100.00	1100.00
Yield point (N/mm²)	[σS]	900.00	900.00

4.1 Gear roughness

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

4.2 Lubrication

Lubrication type	Oil bath lubrication	
Type of oil	Mobilgear 600 XP 150	
Lubricant base	Mineral-oil base	
Oil nominal kinematic viscosity at 40°C (mm²/s)	[v40]	150.00
Oil nominal kinematic viscosity at 100°C (mm²/s)	[v100]	14.70
Specific density at 15°C (kg/dm³)	[ρ]	0.890
Oil temperature (°C)	[TS]	75.000

5 Geometry

5.1 Reference profiles

Reference profile Gear 1

Reference profile	1.25 / 0.38 / 1.0 ISO 53:1998 Profil A	
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]	0.606 /0.608

Reference profile Gear 2

Reference profile	1.25 / 0.38 / 1.0 ISO 53:1998 Profil A	
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]	0.591 /0.593

5.1.1 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:	for high load capacity gearboxes		
Tip relief (µm)	[Ca L/R]	5.0 /5.0	5.0 /5.0

5.2 Basic data

Overall transmission ratio	[itot]	-3.852
Gear ratio	[u]	3.852
Transverse module (mm)	[mt]	1.546
Transverse pressure angle (°)	[αt]	20.562

Working pressure angle (°)	[αwt]	21.425
(°)	[αwt.e/i]	21.450 /21.400
Working pressure angle at normal section (°)	[αwn]	20.838
Base helix angle (°)	[βb]	13.140
Helix angle at operating pitch circle (°)	[βw]	14.078
Reference center distance (mm)	[ad]	101.258
Sum of profile shift coefficients	[Σxi]	0.3994

		------- Gear 1	---------- Gear 2 -------
Profile shift coefficient	[x]	0.3255	0.0739
Generating profile shift coefficient	[xE.e/i]	0.2852/0.2669	0.0006/-0.0452
Virtual gear no. of teeth	[zn]	29.343	113.025
Involute length (mm)	[l_dFa-l_dFf]	3.079	3.104

5.3 Diameters and their allowances

		------- Gear 1	---------- Gear 2 -------
Reference diameter (mm)	[d]	41.740	160.776
Base diameter (mm)	[db]	39.081	150.533
Tip alteration (mm)	[k*mn]	-0.012	-0.012
Tip diameter (mm)	[da]	45.692	163.973
(mm)	[da.e/i]	45.692 /45.682	163.973 /163.963
Tip diameter allowances (mm)	[Ada.e/i]	0.000 /-0.010	0.000 /-0.010
Tip form diameter (mm)	[dFa]	45.692	163.973
(mm)	[dFa.e/i]	45.692 /45.682	163.973 /163.963
Active tip diameter (mm)	[dNa]	45.692	163.973
(mm)	[dNa.e/i]	45.692 /45.682	163.973 /163.963
V-Circle diameter (mm)	[dv]	42.716	160.997
(mm)	[dv.e/i]	42.595 /42.541	160.778 /160.640
Operating pitch diameter (mm)	[dw]	41.982	161.708
(mm)	[dw.e/i]	41.989 /41.975	161.736 /161.680
Root diameter (mm)	[df]	38.966	157.247
(mm)	[df.e/i]	38.845 /38.791	157.028 /156.890
Active root diameter (mm)	[dNf]	40.193	158.852
(mm)	[dNf.e/i]	40.221 /40.171	158.888 /158.821
Root form diameter (mm)	[dFf]	40.081	158.171
(mm)	[dFf.e/i]	40.006 /39.973	157.980 /157.862

5.4 Tip clearances and tooth heights

		------- Gear 1	---------- Gear 2 -------
Theoretical tip clearance (mm)	[c]	0.375	0.375
Effective tip clearance (mm)	[c.e/i]	0.576 /0.468	0.486 /0.418
Reserve (dNf-dFf)/2 (mm)	[cF.e/i]	0.124 /0.082	0.513 /0.421
Addendum, $m_n(h_{aP}^*+x+k)$ (mm)	[ha]	1.976	1.599
(mm)	[ha.e/i]	1.976 /1.971	1.599 /1.594
Dedendum, $m_n(h_{fP}^*-x)$ (mm)	[hf]	1.387	1.764
(mm)	[hf.e/i]	1.447 /1.475	1.874 /1.943
Tooth height (mm)	[h]	3.363	3.363

5.5 Roll angle

		------- Gear 1	---------- Gear 2 -------
Roll angle at dFa (°)	[ξFa.e/i]	34.709 /34.681	24.746 /24.736
Roll angle to dNf (°)	[ξNf.e/i]	13.943 /13.626	19.353 /19.272
Roll angle at dFf (°)	[ξFf.e/i]	12.541 /12.312	18.243 /18.094

5.6 Tooth thickness and pitch

		------- Gear 1	---------- Gear 2 -------
Tooth thickness on reference circle, arc, in module	[sn*]	1.8077	1.6246
Normal tooth thickness at tip circle (mm)	[san]	0.973	1.218
(mm)	[san.e/i]	0.931 /0.903	1.141 /1.086
Normal tooth thickness at tip form circle (mm)	[sFan]	0.973	1.218
(mm)	[sFan.e/i]	0.931 /0.903	1.141 /1.086
Normal space width at root circle (mm)	[efn]	0.000	1.077
(mm)	[efn.e/i]	0.000 /0.000	1.090 /1.099
Pitch on reference circle (mm)	[pt]	4.857	4.857
Base pitch (mm)	[pbt]	4.547	4.547
Transverse pitch on contact-path (mm)	[pet]	4.547	4.547
Lead height (mm)	[pz]	525.932	2025.813
Axial pitch (mm)	[px]	19.479	19.479

5.7 Sliding

		------- Gear 1	---------- Gear 2 -------
Max. sliding velocity at tip (m/s)	[vga]	1.622	1.157
Specific sliding at the tip	[ζa]	0.444	0.444
Specific sliding at the root	[ζf]	-0.798	-0.798
Mean specific sliding	[ζm]	0.444	
Sliding factor on tip	[Kga]	0.250	0.178
Sliding factor on root	[Kgf]	-0.178	-0.250

5.8 Contact ratios

		---------- Pair ----------
Minimal length of contact line (mm)	[Lmin]	31.954
Transverse contact ratio	[εα]	1.571
	[εα.e/m/i]	1.581 /1.568/ 1.555
Overlap ratio	[εβ]	1.027
Total contact ratio	[εγ]	2.597
	[εγ.e/m/i]	2.608 /2.595/ 2.582
Length of path of contact (mm)	[ga]	7.142
(mm)	[ga.e/i]	7.190 /7.072

		------- Gear 1	---------- Gear 2 -------
Addendum contact ratio	[ε]	0.917	0.654
	[ε.e/i]	0.919 /0.913	0.662 /0.643
Length T1-A and T2-A (mm)	[T1A,T2A]	4.695	32.508
(mm)	[.e/i]	4.647 / 4.755	32.508 /32.495
Length T1-B and T2-B (mm)	[T1B,T2B]	7.290	29.912
(mm)	[.e/i]	7.290 / 7.280	29.864 /29.970
Length T1-C and T2-C (mm)	[T1C,T2C]	7.668	29.535
(mm)	[.e/i]	7.658 / 7.678	29.497 /29.573
Length T1-D and T2-D (mm)	[T1D,T2D]	9.242	27.960
(mm)	[.e/i]	9.194 / 9.303	27.960 /27.948
Length T1-E and T2-E (mm)	[T1E,T2E]	11.837	25.365
(mm)	[.e/i]	11.837 /11.828	25.317 /25.423
Length T1-T2 (mm)	[T1T2]	37.202	
(mm)	[.e/i]	37.154 /37.250	
Diameter of single contact point B (mm)	[d-B]	41.712	161.986
(mm)	[d-B.e/i]	41.712 /41.705	161.950 /162.028
Diameter of single contact point D (mm)	[d-D]	43.232	160.585
(mm)	[d-D.e/i]	43.191 /43.283	160.585 /160.576

6 General influence factors

6.1 Forces and circumferential speed

		------- Gear 1	---------- Gear 2 -------
Nominal circum. force at pitch circle (N)	[Ft]	1938.82	
Axial force (N)	[Fa]	483.40	483.40
Radial force (N)	[Fr]	727.28	727.28
Normal force (N)	[Fnorm]	2126.42	2126.42
Nominal circumferential force per mm (N/mm)	[w]	96.94	
Only as information: Forces at operating pitch circle:			
Nominal circumferential force (N)	[Ftw]	1927.65	
Axial force (N)	[Faw]	483.40	483.40
Radial force (N)	[Frw]	756.41	
Circumferential speed reference circle (m/s)	[v]	6.45	
Circumferential speed operating pitch circle (m/s)	[v(dw)]	6.48	

6.2 Contact stiffness

Running-in value (µm)	[yp]	0.6	
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, bs/b, sr/mn]	0.931	(0.500,3.500)
Basic rack factor	[CB]	0.975	
Material coefficient	[E/Est]	1.000	
Single stiffness (N/mm/µm)	[c']	13.625	
Theoretical single stiffness (N/mm/µm)	[c'th]	19.334	
Meshing stiffness (N/mm/µm)	[cγ]	19.458	
Reduced mass (kg/mm)	[mRed]	0.00525	
Resonance speed (min-1)	[nE1]	21531	
Resonance ratio (-)	[N]	0.137	
Subcritical range			

6.3 Calculation of K factors

Running-in value (µm)	[yα]	0.3	
Bearing distance l of pinion shaft (mm)	[l]	42.000	
Distance s of pinion shaft (mm)	[s]	4.200	
Outside diameter of pinion shaft (mm)	[dsh]	21.000	
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			
Effective flank line deviation (µm)	[Fβy]	4.65	
from deformation of shaft (µm)	[fsh*B1]	0.40	
fsh (µm)	[fsh]	0.80	
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]	4.50	
B_2=0.50			
Tooth trace deviation, theoretical (µm)	[Fβx]	5.47	
Running-in value (µm)	[yβ]	0.82	

6.4 K factors

Dynamic factor	[Kv]	1.063
Face load factors		
- Flank	[KHβ]	1.351
- Tooth root	[KFβ]	1.283
- Scuffing	[KBβ]	1.351
Transverse load factors		
- Flank	[KHα]	1.084
- Tooth root	[KFα]	1.084
- Scuffing	[KBα]	1.084
Application factor	[KA]	1.250

Mesh load factor	[Kγ]	1.000

7 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]	0.2852	0.0006
Tooth form factor	[YF]	1.194	1.350
Stress correction factor	[YS]	2.196	2.124
Load application angle (°)	[αFen]	21.275	20.268
Load application diameter, virtual spur gear (mm)	[d_{en}]	45.301	170.573
Load application diameter (mm)	[d_{en}]	43.027	161.811
Bending moment arm (mm)	[hFe]	1.426	1.739
(-)	[hFe*]	0.951	1.160
Tooth root thickness at critical cross section (mm)	[sFn]	3.265	3.402
(-)	[sFn*]	2.177	2.268
Root fillet radius at critical cross section (mm)	[ρF]	0.700	0.689
(-)	[ρF*]	0.466	0.459
Tangent contact point, virtual spur gear (mm)	[x,y]	1.633 /19.629	
Tangent contact point, virtual spur gear (mm)	[x,y]		1.701 /78.794
Diameter at critical cross section (mm)	[d_{sFn}]	39.393	157.625
Tangent at critical cross section (°)	[α_{sFn}]	30.000	30.000
Notch parameter	[q_s]	2.334	2.469
Contact ratio factor	[Yε]	1.000	
Helix angle factor	[Yβ]	0.883	
Effective facewidth (mm)	[beff]	21.00	20.00
Nominal stress at tooth root (N/mm²)	[σF0]	142.53	163.71
Tooth root stress (N/mm²)	[σF]	263.39	302.51
Permissible bending stress at root of Test-gear			
Notch sensitivity factor	[YδrelT]	0.993	0.999
Surface factor	[YRrelT]	0.990	0.990
Size factor, tooth root	[YX]	1.000	1.000
Life factor	[YNT]	1.000	1.000
$Y_{\delta relT} \cdot Y_{RrelT} \cdot Y_X \cdot Y_{NT}$		0.983	0.989
Alternating bending factor, mean stress influence coefficient			
	[YM]	1.000	1.000
Stress correction factor	[YST]	2.00	
$Y_{ST} \cdot \sigma_{Flim}$ (N/mm²)	[σFE]	850.00	740.00
Permissible tooth root stress σFG/SFmin (N/mm²)	[σFP]	642.62	562.78
Limit strength tooth root (N/mm²)	[σFG]	835.41	731.62

7.1 Safety factors

		Gear 1	Gear 2
Required safety	[SFmin]	1.30	1.30
Safety for tooth root stress	[SF=σFG/σF]	3.17	2.42
Transmittable power (kW)	[kWRating]	30.50	23.25

8 Calculation of flank strength (pitting)

		Gear 1	Gear 2
Zone factor	[ZH]	2.379	
Elasticity coefficient (√N/mm)	[ZE]	189.812	
Contact ratio factor	[Zε]	0.798	
Helix angle factor	[Zβ]	0.985	
Effective facewidth (mm)	[beff]	20.00	
Nominal contact stress (N/mm²)	[σH0]	607.16	
Contact stress at operating pitch circle (N/mm²)	[σHw]	846.82	
Single tooth contact factor	[ZB,ZD]	1.00	1.00
Contact stress (N/mm²)	[σHB, σHD]	846.82	846.82
Lubricant coefficient for N_L	[ZL]	0.988	0.988
Speed factor at N_L	[ZV]	0.981	0.981
Roughness factor for N_L	[ZR]	0.797	0.797
Material hardening factor for N_L	[ZW]	1.000	1.000
Life factor	[ZNT]	1.000	1.000
Size factor (flank)	[ZX]	1.000	1.000
$Z_L \cdot Z_V \cdot Z_R \cdot Z_{NT} \cdot Z_X$		0.772	0.772

Limited pitting is permissible: No

Permissible contact stress, σHG/SHmin (N/mm²)	[σHP]	1016.23	812.99
Pitting stress limit (N/mm²)	[σHG]	965.42	772.34

8.1 Safety factors

		------- Gear 1	---------- Gear 2 -------
Required safety	[SHmin]	0.95	0.95
Safety factor for contact stress on operating pitch circle	[SHw]	1.14	0.91
Safety against pressure, σHG/σHBD Single contact	[SHBD]	1.14	0.91
Safety regarding transmittable torque	[SHBD²]	1.30	0.83
Transmittable power (kW)	[kWRating]	18.00	11.52

9 Micropitting

Calculation method according to ISO/TS 6336-22:2018
Lubricant load according to FVA Info sheet 54/7 10, Mobilgear 600 XP 150
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]	128.037
Contact temperature (°C)	[θBRef,A]	253.806
Lubrication gap thickness (µm)	[hRef,A]	0.043
Specific film thickness in test	[λGFT]	0.085

		------- Gear 1	---------- Gear 2 -------
Calculation of permissible specific film thickness			
Material coefficient	[WW]	1.000	
Permissible specific film thickness	[λGFP]	0.120	

Interim results in accordance with ISO/TS 6336-22:2018

Coefficient of friction	[μ_m]	0.107
Lubricant factor	[XL]	1.000
Roughness factor	[XR]	1.831
Lubrication coefficient for lubrication type	[XS]	1.000
Tooth mass temperature (°C)	[θM]	78.424
Tip relief factor	[XCa(A)]	1.817
Loss factor	[HV]	0.105
Equivalent Young's modulus (N/mm²)	[Er]	226373.626
Pressure-viscosity coefficient (m²/N)	[α38]	0.02051
Dynamic viscosity (Ns/m²)	[ηtM]	23.756
Roughness average value (µm)	[Ra]	3.000

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		1	1
Calculation at point (0:A, 1:AB, 2:B, 3:C, 4:D, 5:DE, 6:E, -1:No Point)		1	
Diameter (mm)	[dy]	40.877	162.962
Relative radius of curvature (mm)	[ρred]	5.162	
Load sharing factor	[XY]	0.658	
X_Y interpolated between the values $X_Y(\varepsilon_b=0.8)$ and $X_Y(\varepsilon_b=1.2)$ according to ISO/TC60/WG6.			
Contact stress (N/mm²)	[pH]	689.325	
Contact stress (N/mm²)	[pdyn]	961.418	
Minimal specific film thickness	[λGFY]	0.061	(h_Y=0.182 µm)
Safety against micropitting	[Sλ(B)]	0.507	
For interim results, refer to file:	Micropitting_12.tmp		

10 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]	5.00	5.00
Optimal tip relief (µm)	[Ceff]	6.23	
C_a taken as optimal in the calculation. 0=no, 1=yes		1	1

		Pair	
Helical load factor for scuffing	[KBγ]	1.240	
Lubrication coefficient for lubrication type	[XS]	1.000	
Scuffing test, load stage	[FZGtest]	FZG - Test A / 8.3 / 90 (ISO 14635 - 1), 12	
Relative structural factor, scuffing	[XWrelT]	1.500	
Effective facewidth (mm)	[beff]	20.000	
Applicable circumferential force/facewidth (N/mm)	[wBt]	233.761	
Angle factor	[Xαβ]	0.993	
ε_1 =0.917, ε_2 =0.654			

10.1 Flash temperature-criteria

		Pair	
Tooth mass temperature (°C)	[θMB]	89.30	
$\theta_{MB} = \theta_{oil} + X_S \cdot 0.47 \cdot \theta_{flamax}$			
Maximum flash temperature (°C)	[θflamax]	30.43	
Scuffing temperature (°C)	[θS]	522.88	
Γ coordinates (point of highest temperature)	[Γ]	0.277	
[Γ.A]= -0.388, [Γ.E]= 0.544			
Maximum contact temperature (°C)	[θB]	119.74	
Flash factor (°K·N^-.75·s^.5·m^-.5·mm)	[XM]	50.058	
Geometry factor	[XB]	0.128	
Load sharing factor	[XΓ]	0.819	
Dynamic viscosity (mPa*s)	[ηM]	16.93	(89.3 °C)
Coefficient of friction	[μ_m]	0.122	
Required safety	[SBmin]	2.000	
Margin of safety for scuffing, flash temperature	[SB]	10.009	

10.2 Integral temperature-criteria

		Pair	
Tooth mass temperature (°C)	[θMC]	85.43	
$\theta_{MC} = \theta_{oil} + X_S \cdot 0.70 \cdot \theta_{flaint}$			
Integral scuffing temperature (°C)	[θSint]	522.88	
Flash factor (°K·N^-.75·s^.5·m^-.5·mm)	[XM]	50.058	
Contact ratio factor	[Xε]	0.244	
Dynamic viscosity (mPa*s)	[ηOil]	26.82	(75.0 °C)
Mean coefficient of friction	[μ_m]	0.116	
Geometry factor	[XBE]	0.236	
Meshing factor	[XQ]	1.000	
Tip relief factor	[XCa]	1.068	
Mean flash temperature (°C)	[θflaint]	14.90	
Integral tooth flank temperature (°C)	[θint]	107.78	
Required safety	[SSmin]	1.800	
Safety factor for scuffing (intg.-temp.)	[SSint]	4.851	
Safety factor for transmitted moment (int.-T.)	[SSL]	13.662	

11 Measurements for tooth thickness

11.1 Tooth thickness tolerances

		Gear 1	Gear 2
Tooth thickness tolerance		DIN 3967 d24	DIN 3967 d25
Tooth thickness allowance (normal section) (mm)	[Asn.e/i]	-0.044 /-0.064	-0.080 /-0.130

11.2 Base tangent lengths

		Gear 1	Gear 2
Number of teeth spanned	[k]	4.000	13.000
Base tangent length (no backlash) (mm)	[Wk]	16.451	57.809
Base tangent length with allowance (mm)	[Wk.e/i]	16.410 /16.391	57.734 /57.687
(mm)	[ΔWk.e/i]	-0.041 /-0.060	-0.075 /-0.122
Diameter of measuring circle (mm)	[dMWk.m]	42.218	160.682

11.3 Measurement over balls and pins

		Gear 1	Gear 2
Theoretical diameter of ball/pin (mm)	[DM]	2.713	2.527
Effective diameter of ball/pin (mm)	[DMeff]	2.750	2.750
Radial single-ball measurement, no backlash (mm)	[MrK]	23.341	82.625
Radial single-ball measurement (mm)	[MrK.e/i]	23.294 /23.273	82.522 /82.458

Diameter of measuring circle (mm)	[dMMr.m]	42.672	161.251
Diametral measurement over two balls, no backlash (mm)	[MdK]	46.607	165.251
Diametral measurement over two balls (mm)	[MdK.e/i]	46.514 /46.471	165.045 /164.916
Diametral measurement over pins, no backlash (mm)	[MdR]	46.681	165.251
Measurement over pins according to DIN 3960 (mm)	[MdR.e/i]	46.588 /46.545	165.045 /164.916
Measurement over 2 pins, free, AGMA 2002 (mm)	[dk2f.e/i]	46.508 /46.466	0.000 /0.000
Measurement over 2 pins, transverse, AGMA 2002 (mm)	[dk2t.e/i]	46.660 /	46.617 0.000 /0.000
Measurement over 3 pins, axial, AGMA 2002 (mm)	[dk3A.e/i]	46.588 /46.545	165.045 /164.916

11.4 Tooth thickness

		------- Gear 1	---------- Gear 2 -------
Medium tip diameter (mm)	[da.m]	45.687	163.968
Reference chordal height from da.m (mm)	[hac]	2.015	1.605
Tooth thickness at height hac, chord (mm)	[sc]	2.710	2.437
(mm)	[sc.e/i]	2.667 /2.647	2.357 /2.307
Tooth thickness on reference circle, arc (mm)	[sn]	2.712	2.437
(mm)	[sn.e/i]	2.668 /2.648	2.357 /2.307

11.5 Backlash

		---------- Pair ----------
Circumferential backlash from Aa (mm)	[jtw_Aa.e/i]	0.014 /-0.014
Radial backlash (mm)	[jrw.e/i]	0.276 /0.147
Circumferential backlash (transverse section) (mm)	[jtw.e/i]	0.215 /0.115
Normal backlash (mm)	[jnw.e/i]	0.194 /0.105
Center distance allowances (mm)	[Aa.e/i]	0.018 /-0.018
Backlash free center distance (mm)	[aControl.e/i]	101.680 /101.587
Backlash free center distance, allowances (mm)	[jta]	-0.165 /-0.258

		------- Gear 1	---------- Gear 2 -------
dNf.i with aControl (mm)	[dNf0.i]	39.884	158.402
Reserve (dNf0.i-dFf.e)/2 (mm)	[cF0.i]	-0.061	0.211
Tip clearance (mm)	[c0.i(aControl)]	0.227	0.177

Torsional angle Gear 2 with fixed Gear 1:		
Total torsional angle (°)	[j.tSys]	0.1522/0.0814 (0°9'8"/ 0°4'53")
Torsional angle Gear 1 with fixed Gear 2:		
Total torsional angle (°)	[j.tSys]	0.5864/0.3134 (0°35'11"/ 0°18'48")

12 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]	5.50	4.00
Helix slope deviation (µm)	[fHβ]	9.00	8.00
Total helix deviation (µm)	[Fβ]	10.00	9.00
Normal base pitch deviation (µm)	[fpe]	7.00	8.00
Single pitch deviation (µm)	[fp]	7.00	8.00
Adjacent pitch difference (µm)	[fu]	8.00	10.00
Total cumulative pitch deviation (µm)	[Fp]	19.00	29.00
Pitch span deviation (µm)	[Fpz/8]	12.00	18.00
Runout (µm)	[Fr]	14.00	19.00
Tooth Thickness Variation (µm)	[Rs]	8.00	11.00
Single flank composite, total (µm)	[Fi']	22.00	30.00
Single flank composite, tooth-to-tooth (µm)	[fi']	10.00	11.00
Radial composite, total (µm)	[Fi"]	17.00	24.00
Radial composite, tooth-to-tooth (µm)	[fi"]	6.00	10.00
According DIN 58405:1972 (Precision Mechanics)			
Tooth-to-tooth composite error (µm)	[fi"]	7.00	9.00
Composite error (µm)	[Fi"]	20.00	25.00
Axis alignment error (µm)	[fp]	17.31	17.31
Flank direction error (µm)	[fβ]	5.00	5.00

Runout (µm)	[Trk, Fr]	21.00	28.00

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

Maximum value for deviation error of axis (µm)	[fΣβ]	13.65	(F_β=13.00)
Maximum value for inclination error of axes (µm)	[fΣδ]	27.30	

13 Modifications and determination of the tooth form

13.1 Profile and flank line modifications

Gear 1
Symmetric (both flanks)
- Tip relief, linear

Caa = 5.000 µmLCa = 0.865 ·mn dCa = 44.403 mm

Gear 2
Symmetric (both flanks)
- Tip relief, linear

Caa = 5.000 µmLCa = 0.865 ·mn dCa = 162.962 mm

13.1.1 Tip relief verification

		------- Gear 1 ----------	Gear 2 -------
Diameter (mm)	[dcheck]	45.652	163.933
Tip relief left/right (µm)	[Ca L/R]	4.9 /4.9	4.8 /4.8
Diameter (mm)	[dNa.i]	45.682	163.963
Tip relief left/right (µm)	[Ca L/R]	5.0 /5.0	5.0 /5.0

13.2 Data for the tooth form calculation

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

14 Supplementary data

Maximal possible center distance (eps_a=1.0)	[aMAX]	102.821

14.1 Masses, stiffnesses and moments of inertia

		------- Gear 1 ----------	Gear 2 -------
Mass (kg)	[m]	0.231	0.537
Total mass (kg)	[Σm]	0.768	
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]	5.183e-05	0.00317
System (da+df)/2...di (kg*m²)	[J]	0.0002655	

14.2 Wear, power loss, sound pressure level

Torsional stiffness at driving gear with fixed driven gear:		
Torsional stiffness (MNm/rad)	[cr]	0.148
Torsion when subjected to nominal torque (°)	[δcr]	0.016
Average coefficient of friction according to Niemann	[μ_m]	0.101
Wear sliding coefficient by Niemann	[ζw]	0.697
Loss factor	[HV]	0.105
Gear power loss (kW)	[PVZ]	0.133
Meshing efficiency (%)	[ηz]	98.937
Sound pressure level based on Masuda, without PPTE/δs	[dB(A)]	61.660

14.3 Indications for the manufacturing by wire cutting

		------- Gear 1 ----------	Gear 2 -------
Deviation from theoretical tooth trace (µm)	[WireErr]	148.8	38.7
Permissible deviation (µm)	[Fb/2]	5.0	4.5

15 Service life, damage

Required safety for tooth root	[S_{Fmin}]	1.3000	
Required safety for tooth flank	[S_{Hmin}]	0.9500	
Required service life	[H]	20000.0000	

Service life (calculated with required safeties):

System service life (h)	[H_{att}]	34.4251	
		------- Gear 1 ----------	Gear 2 -------
Tooth root service life (h)	[H_{Fatt}]	1e+06	1e+06
Tooth flank service life (h)	[H_{Hatt}]	1e+06	34.43

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

15.1 Damage

Damage relative to the required service life (H, 20000.0 h)

F_1 (%)	F_2 (%)	H_1 (%)	H_2 (%)
0.0000	0.0000	0.0000	9999.9999

Damage relative to the system service life (H_{att}, 34.4 h)

F_1 (%)	F_2 (%)	H_1 (%)	H_2 (%)
0.0000	0.0000	0.0000	100.0000

16 Reliability calculation

16.1 Calculation method

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

16.2 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)
$R(t) = 100 \cdot Exp(-((t \cdot fac - t_0)/(T - t_0))^{\beta})$ (%)

Gear	Type	fac	β	t_0	T	R(H)
		cycles/h		cycles	cycles	%
1	Tooth root	177000	1.700e+00	9.654e+29	1.484e+30	100.0000
1	Tooth flank	177000	1.300e+00	9.014e+29	4.295e+30	100.0000
2	Tooth root	45952	1.700e+00	9.654e+29	1.484e+30	100.0000
2	Tooth flank	45952	1.300e+00	1.426e+06	6.794e+06	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

16.3 Resulting reliabilities and service lives

Required service life (h)	[H_{min}]	20000.0000
Reliability R, tooth roots subsystem (%)	[R_{subF}]	100.0000
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}]	> 1'000'000
Service life H, tooth flanks subsystem (h)	[H_{subH}]	34.4251

Service life H, gears subsystem (h)	[H_{subG}]	34.4251

17 Remarks

17.1 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.

17.2 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

End of report (lines: 726)