KISSsoft Release 03/2018 A

KISSsoft evaluation

File

Name : Unnamed
Changed by: J on: 25.01.2019 at: 20:57:06

Important hint: At least one warning has occurred during the calculation:

1-> Undercut Gear 1
(Underneath of the active flank - no reduction of transverse contact ratio)

2-> The difference between the temperature of the lubricant (70.0 °C) and the temperature (90.0 °C) used when the micropitting test process was performed is greater than (15.0 °C).
The results for micropitting should therefore be used with caution.

3-> Note: Wear may occur if the thickness of the lubricant film hC (0.013 µm) in the pitch point is less than (0.100 µm).
For this reason, check the wear risk.

4-> The calculation of micropitting specified in ISO15144 is not designed for use with internal toothing
because it has not yet been subject to sufficient investigation.
The results can only be used for information purposes.

5-> Gear 3: The measurement over rollers is smaller than the tip diameter.
This might produce an incorrect measurement!

CALCULATION OF A SPUR PLANETARY GEAR STAGE

Drawing or article number:
Gear 1: 0.000.0
Gear 2: 0.000.0
Gear 3: 0.000.0

Calculation method DIN 3990:1987 Method B (YF Method C)

		------- Sun	---------- Planets	---------- Internal gear ---
Number of planets	[p]	(1)	3	(1)
Power (W)	[P]		410.338	
Speed (1/min)	[n]	211.7		0.0
Speed difference for planet bearing calculation (1/min)	[n2]		76.5	
Speed planet carrier (1/min)	[nSteg]		31.6	
Torque (Nm)	[T]	18.5	0.0	105.6
Torque Pl.-Carrier (Nm)	[TSteg]		124.140	

Application factor	[KA]		1.10	
Distribution factor	[Kγ]		1.00	
Required service life (h)	[H]	2000.00		
Gear driving (+) / driven (-)		+	-/+	-

Working flank gear 1: Right flank
Sense of rotation gear 1 clockwise
Planet carrier direction of rotation
clockwise

KISSsoft
Drivetrain Design Solutions

1. TOOTH GEOMETRY AND MATERIAL

(geometry calculation according to DIN 3960:1987)

		------- GEAR 1	---------- GEAR 2	---------- GEAR 3 ---
Center distance (mm)	[a]		20.268	
Center distance tolerance	ISO 286:2010 Measure js7			
Normal module (mm)	[mn]		0.7000	
Pressure angle at normal section (°)	[alfn]		20.0000	
Helix angle at reference circle (°)	[beta]		0.0000	
Number of teeth	[z]	17	40	-97
Facewidth (mm)	[b]	12.00	12.00	12.00
Hand of gear	Spur gear			
Planetary axles can be placed in regular pitch.:		120°		
Accuracy grade	[Q-DIN3961:1978]	6	6	6
Inner diameter (mm)	[di]	0.00	20.83	
External diameter (mm)	[di]			76.60
Inner diameter of gear rim (mm)	[dbi]	0.00	0.00	
Outer diameter of gear rim (mm)	[dbi]			0.00

Material

Gear 1:	Steel, Grade 2, HRC58-64(AGMA), Case-carburized steel, case-hardened AGMA 2001-C95
Gear 2:	Steel, Grade 2, HRC58-64(AGMA), Case-carburized steel, case-hardened AGMA 2001-C95
Gear 3:	Steel, Grade 1, HB400(AGMA), Through hardened steel, alloyed, through hardened AGMA 2001-C95

		------- GEAR 1	---------- GEAR 2	---------- GEAR 3 ---
Surface hardness	HRC 60	HRC 60	HBW 400	
Fatigue strength. tooth root stress (N/mm²)	[σFlim]	450.00	450.00	301.00
Fatigue strength for Hertzian pressure (N/mm²)	[σHlim]	1550.00	1550.00	1088.00
Tensile strength (N/mm²)	[σB]	966.00	966.00	1380.00
Yield point (N/mm²)	[σS]	822.00	822.00	1211.00
Young's modulus (N/mm²)	[E]	206843	206843	206843
Poisson's ratio	[v]	0.300	0.300	0.300
Roughness average value DS, flank (µm)	[RAH]	0.63	0.63	2.40
Roughness average value DS, root (µm)	[RAF]	2.40	2.40	2.40
Mean roughness height, Rz, flank (µm)	[RZH]	5.00	5.00	16.00
Mean roughness height, Rz, root (µm)	[RZF]	16.00	16.00	16.00

Gear reference profile	1 :		
Reference profile	1.25 / 0.38 / 1.0 ISO 53:1998 Profil A		
Dedendum coefficient	[hfP*]	1.250	
Root radius factor	[rhofP*]	0.380 (rhofPmax*=0.472)	
Addendum coefficient	[haP*]	1.000	
Tip radius factor	[rhoaP*]	0.000	
Protuberance height coefficient	[hprP*]	0.000	
Protuberance angle	[alfprP]	0.000	
Tip form height coefficient	[hFaP*]	0.000	
Ramp angle	[alfKP]	0.000	
		not topping	

Gear reference profile	2 :
Reference profile	1.25 / 0.38 / 1.0 ISO 53:1998 Profil A

Dedendum coefficient	[hfP*]	1.250
Root radius factor	[rhofP*]	0.380 (rhofPmax*=0.472)
Addendum coefficient	[haP*]	1.000
Tip radius factor	[rhoaP*]	0.000
Protuberance height coefficient	[hprP*]	0.000
Protuberance angle	[alfprP]	0.000
Tip form height coefficient	[hFaP*]	0.000
Ramp angle	[alfKP]	0.000
	not topping	

Gear reference profile	3 :	
Reference profile	1.25 / 0.38 / 1.0 ISO 53:1998 Profil A	
Dedendum coefficient	[hfP*]	1.250
Root radius factor	[rhofP*]	0.380 (rhofPmax*=0.472)
Addendum coefficient	[haP*]	1.000
Tip radius factor	[rhoaP*]	0.000
Protuberance height coefficient	[hprP*]	0.000
Protuberance angle	[alfprP]	0.000
Tip form height coefficient	[hFaP*]	0.000
Ramp angle	[alfKP]	0.000
	not topping	

Summary of reference profile gears:

Dedendum reference profile	[hfP*]	1.250	1.250	1.250
Tooth root radius Refer. profile	[rofP*]	0.380	0.380	0.380
Addendum Reference profile	[haP*]	1.000	1.000	1.000
Protuberance height coefficient	[hprP*]	0.000	0.000	0.000
Protuberance angle (°)	[alfprP]	0.000	0.000	0.000
Tip form height coefficient	[hFaP*]	0.000	0.000	0.000
Ramp angle (°)	[alfKP]	0.000	0.000	0.000

Type of profile modification:	none (only running-in)			
Tip relief (µm)	[Ca]	1.80	1.80	4.40

Lubrication type		Oil bath lubrication
Type of oil		Oil: Mobilgear 600 XP 220
Lubricant base		Mineral-oil base
Kinem. viscosity oil at 40 °C (mm²/s)	[nu40]	220.00
Kinem. viscosity oil at 100 °C (mm²/s)	[nu100]	19.00
Specific density at 15 °C (kg/dm³)	[roOil]	0.890
Oil temperature (°C)	[TS]	70.000

		------- GEAR 1	---------- GEAR 2	---------- GEAR 3 ---	
Overall transmission ratio	[itot]		6.706		
Gear ratio	[u]		2.353	-2.425	
Transverse module (mm)	[mt]		0.700		
Pressure angle at pitch circle (°)	[alft]		20.000		
Working transverse pressure angle (°)	[alfwt]		22.336	22.336	
	[alfwt.e/i]	22.408 /	22.264	22.264 /	22.408
Working pressure angle at normal section (°)	[alfwn]		22.336	22.336	
Helix angle at operating pitch circle (°)	[betaw]		0.000	0.000	
Base helix angle (°)	[betab]		0.000		
Reference center distance (mm)	[ad]		19.950	-19.950	
Sum of profile shift coefficients	[Summexi]		0.4795	-0.4795	
Profile shift coefficient	[x]	0.3288	0.1508	-0.6303	
Tooth thickness (Arc) (module) (module)	[sn*]	1.8101	1.6805	1.1120	
Tip alteration (mm)	[k*mn]	0.000	0.000	0.000	

Reference diameter (mm)	[d]	11.900	28.000	-67.900
Base diameter (mm)	[db]	11.182	26.311	-63.805
Tip diameter (mm)	[da]	13.760	29.611	-67.382
(mm)	[da.e/i]	13.760 / 13.750	29.611 / 29.601	-67.382 / -67.392
Tip diameter allowances (mm)	[Ada.e/i]	0.000 / -0.010	0.000 / -0.010	0.000 / -0.010
Tip form diameter (mm)	[dFa]	13.760	29.611	-67.382
(mm)	[dFa.e/i]	13.760 / 13.750	29.611 / 29.601	-67.382 / -67.392
Active tip diameter (mm)	[dNa.e/i]	13.760 / 13.750	29.611 / 29.601	-67.382 / -67.392
Operating pitch diameter (mm)	[dw]	12.089	28.446 / 28.446	-68.981
(mm)	[dw.e]	12.096	28.460 / 28.431	-68.945
(mm)	[dw.i]	12.083	28.431 / 28.460	-69.017
Root diameter (mm)	[df]	10.610	26.461	-70.532
Generating Profile shift coefficient	[xE.e/i]	0.0776 / -0.0480	-0.2260 / -0.3713	-1.1523 / -1.4663
Manufactured root diameter with xE (mm)	[df.e]	10.259	25.934	-71.263
(mm)	[df.i]	10.083	25.730	-71.703
Theoretical tip clearance (mm)	[c]	0.157	0.157/ 0.193	0.193
Tip clearance upper allowance (mm)	[c.e]	0.538	0.436/ 0.794	0.574
Tip clearance lower allowance (mm)	[c.i]	0.410	0.322/ 0.548	0.446
Active root diameter (mm)	[dNf]	11.330	27.329/ 27.045	-70.082
(mm)	[dNf.e]	11.342	27.348/ 27.066	-70.050
(mm)	[dNf.i]	11.321	27.314/ 27.033	-70.105
Root form diameter (mm)	[dFf]	11.260	27.009	-70.180
(mm)	[dFf.e/i]	11.186 / 11.182	26.703 / 26.608	-70.847 / -71

.220

Internal toothing: Calculation dFf with pinion type cutter (z0= 32, x0= 0.000)

Reserve (dNf-dFf)/2 (mm)	[cF.e/i]	0.080 / 0.067	0.229 / 0.165	0.585 / 0

.371

(undercut taken into account)

Addendum (mm)	[ha = mn * (haP*+x)]	0.930	0.806	0.259
(mm)	[ha.e/i]	0.930 / 0.925	0.806 / 0.801	0.259 /

0.254

Dedendum (mm)	[hf = mn * (hfP*-x)]	0.645	0.769	1.316
(mm)	[hf.e/i]	0.821 / 0.909	1.033 / 1.135	1.682 /

1.901

Roll angle at dFa (°)	[xsi_dFa.e/i]	41.086 / 40.998	29.581 / 29.533	19.453 /

19.481

Roll angle to dNf (°)	[xsi_dNf.e/i]	9.725 / 9.048	16.242 / 15.964	
	[xsi_dNf.e/i]		13.816 / 13.508	25.962 / 26.081
Roll angle at dFf (°)	[xsi_dFf.e/i]	1.510 / 0.077	9.926 / 8.632	27.651 /

28.413

Tooth height (mm)	[h]	1.575	1.575	1.575
Virtual gear no. of teeth	[zn]	17.000	40.000	-97.000
Normal tooth thickness at tip circle (mm)	[san]	0.363	0.510	0.591
(mm)	[san.e/i]	0.222 / 0.141	0.312 / 0.229	0.331 / 0.168
Normal space width at root circle (mm)	[efn]	0.000	0.583	0.351
(mm)	[efn.e/i]	0.000 / 0.000	0.000 / 0.000	0.278 / 0.226
Max. sliding velocity at tip (m/s)	[vga]	0.046	0.037/ 0.007	0.021
Specific sliding at the tip	[zetaa]	0.609	0.685/ 0.120	0.299
Specific sliding at the root	[zetaf]	-2.170	-1.554/ -0.427	-0.136
Sliding factor on tip	[Kga]	0.404	0.327/ 0.057	0.094
Sliding factor on root	[Kgf]	-0.327	-0.404/ -0.094	-0.057
Pitch on reference circle (mm)	[pt]	2.199		
Base pitch (mm)	[pbt]	2.066		
Transverse pitch on contact-path (mm)	[pet]	2.066		
Length of path of contact (mm)	[ga]	3.099	3.663	
(mm)	[ga.e/i]	3.127 / 3.052	3.691 / 3.609	
Length T1-A (mm)	[T1A]	0.911	6.792/ 3.129	-10.832

Length T1-B (mm)	[T1B]	1.943	5.760/ 4.726	-12.428	
Length T1-C (mm)	[T1C]	2.297	5.405/ 5.405	-13.108	
Length T1-D (mm)	[T1D]	2.977	4.726/ 5.196	-12.898	
Length T1-E (mm)	[T1E]	4.009	3.693/ 6.792	-14.495	
Diameter of single contact point B (mm)	[d-B]	11.838	28.723/ 27.957	-68.476	
(mm)	[d-B.e]	11.838	28.700/ 27.957	-68.496	
(mm)	[d-B.i]	11.833	28.752/ 27.950	-68.448	
Diameter of single contact point D (mm)	[d-D]	12.669	27.957/ 28.289	-68.823	
(mm)	[d-D.e]	12.643	27.957/ 28.269	-68.823	
(mm)	[d-D.i]	12.705	27.950/ 28.321	-68.834	

Transverse contact ratio	[eps_a]	1.500	1.773
Transverse contact ratio with allowances	[eps_a.e/i]	1.513 / 1.477	1.786 / 1.746
Overlap ratio	[eps_b]	0.000	0.000
Total contact ratio	[eps_g]	1.500	1.773
Total contact ratio with allowances	[eps_g.e/i]	1.513 / 1.477	1.786 / 1.746

2. FACTORS OF GENERAL INFLUENCE

		------- GEAR 1	---------- GEAR 2	---------- GEAR 3 ---	
Nominal circum. force at pitch circle (N)	[Ft]		1037.092	1037.092	
Axial force (N)	[Fa]	0.0	0.0	0.0	
Axial force (total) (N)	[Fatot=Fa* 3]			0.0	0.0
Radial force (N)	[Fr]		377.471	377.471	
Normal force (N)	[Fnorm]	1103.7	1103.7	1103.7	
Nominal circumferential force per mm (N/mm)	[w]		86.42	86.42	
Only as information: Forces at operating pitch circle:					
Nominal circumferential force (N)	[Ftw]		1020.842	1020.842	
Axial force (N)	[Fa]	0.0	0.0/ 0.0	0.0	
Axial force (total) (N)	[Fatot=Fa* 3]			0.0	0.0
Radial force (N)	[Fr]		419.435	419.435	
Circumferential speed reference circle (m/s)	[v]		0.11	(Planet)	
Running-in value (µm)	[yp]		0.450	0.777	
Running-in value (µm)	[yf]		0.375	0.555	
Gear blank factor	[CR, bs/b]		0.862 (0.250)	0.862 (0.250)	
Correction factor	[CM]		0.800	0.800	
Basic rack factor	[CBS]		0.975	0.975	
Material coefficient	[E/Est]		1.004	1.004	
Singular tooth stiffness (N/mm/µm)	[c']		11.090	12.399	
Meshing stiffness (N/mm/µm)	[cg]		15.245	19.584	
Reduced mass (kg/mm)	[mRed]		0.0002	0.0019	
Resonance speed (min-1)	[nE1]		170706	24187	
Resonance ratio (-)	[N]		0.001	0.003	
Running-in value (µm)	[ya]		0.450	0.777	
Dynamic factor	[KV]		1.00	1.00	
User specified factor KHb:					
Face load factor - flank	[KHb]		1.20	1.10	
- Tooth root	[KFb]		1.17	1.08	
- Scuffing	[KBb]		1.20	1.10	
Transverse load factor - flank	[KHa]		1.00	1.21	
- Tooth root	[KFa]		1.00	1.21	
- Scuffing	[KBa]		1.00	1.21	

Helical load factor scuffing	[Kbg]		1.00	1.00
Number of load cycles (in mio.)	[NL]	64.8	9.2	11.4

3. TOOTH ROOT STRENGTH

Calculation of Tooth form coefficients according method: C

		------- GEAR 1	---------- GEAR 2	---------- GEAR 3 ---
Calculated with manufacturing profile shift	[xE.e]	0.0776	-0.2260	-1.1523
Tooth form factor	[YF]	3.19	3.16/ 3.16	1.38
Stress correction factor	[YS]	1.51	1.51/ 1.51	2.27
Bending moment arm (mm)	[hF]	1.59	1.63/ 1.63	1.28
Load application angle (°)	[alfFen]	34.75	26.71/ 26.71	20.00
Tooth thickness at root (mm)	[sFn]	1.35	1.43/ 1.43	1.97
Tooth root radius (mm)	[roF]	0.39	0.42/ 0.42	0.27

(hF* = 2.273/ 2.323/ 2.323/ 1.823 sFn* = 1.935/ 2.047/ 2.047/ 2.814)
(roF* = 0.553/ 0.601/ 0.601/ 0.380 dsFn = 10.514/ 26.242/ 26.242/ 0.000 alfsFn = 30.0/ 30.0/ 30.0/ 30.0)

Contact ratio factor	[Yeps]		0.75	0.67	
Helix angle factor	[Ybet]		1.00	1.00	
Effective facewidth (mm)	[beff]	12.00	12.00/ 12.00	12.00	
Nominal stress at tooth root (N/mm²)	[sigF0]	446.30	442.40/ 396.97	261.17	
Tooth root stress (N/mm²)	[sigF]	573.16	568.14/ 573.13	377.06	
Permissible bending stress at root of Test-gear					
Notch sensitivity factor	[YdrelT]	0.992	0.992/ 0.992	1.007	
Surface factor	[YRrelT]	0.972	0.972	0.972	
size factor (Tooth root)	[YX]	1.000	1.000	1.000	
Finite life factor	[YNT]	1.000	1.000	1.000	
Alternating bending factor (mean stress influence coefficient)	[YM]		1.000	0.700	1.000
Stress correction factor	[Yst]		2.00		
Yst*sigFlim (N/mm²)	[sigFE]	900.00	900.00	602.00	
Permissible tooth root stress (N/mm²)	[sigFP=sigFG/SFmin]	619.95	433.74/ 433.74	420.87	
Limit strength tooth root (N/mm²)	[sigFG]	867.93	607.24/ 607.24	589.21	
Required safety	[SFmin]	1.40	1.40	1.40	
Safety for tooth root stress	[SF=sigFG/sigF]	1.51	1.07/ 1.06	1.56	
Transmittable power (W)	[WRating]	443.84	313.27/ 310.54	458.00	

4. SAFETY AGAINST PITTING (TOOTH FLANK)

		------- GEAR 1	---------- GEAR 2	---------- GEAR 3 ---
Zone factor	[ZH]		2.35	2.35
Elasticity factor (√N/mm²)	[ZE]		190.20	190.20
Contact ratio factor	[Zeps]		0.913	0.862
Helix angle factor	[Zbet]		1.000	1.000
Effective facewidth (mm)	[beff]		12.00	12.00
Nominal contact stress (N/mm²)	[sigH0]		1311.55	518.23
Contact stress at operating pitch circle (N/mm²)	[sigHw]		1507.31	627.64
Single tooth contact factor	[ZB,ZD]	1.05	1.00/ 1.10	1.00
Contact stress (N/mm²)	[sigHB, sigHD]	1587.80	1507.31/ 689.38	627.64
Lubrication coefficient at NL	[ZL]	1.020	1.015/ 1.019	1.020
Speed coefficient at NL	[ZV]	0.938	0.955/ 0.938	0.935
Roughness coefficient at NL	[ZR]	0.920	0.941/ 0.895	0.890
Material pairing coefficient at NL	[ZW]	1.000	1.000/ 1.000	1.041

Finite life factor	[ZNT]	1.000	1.137	1.119
Limited pitting is permitted:	No			
Size factor (flank)	[ZX]	1.000	1.000	1.000
Permissible contact stress (N/mm²)	[sigHP=sigHG/SHmin]	1364.67	1606.05/1506.26	1075.30
Pitting stress limit (N/mm²)	[sigHG]	1364.67	1606.05/1506.26	1075.30
Required safety	[SHmin]	1.00	1.00	1.00
Safety factor for contact stress at operating pitch circle				
	[SHw]	0.91	1.07/ 2.40	1.71
Safety for stress at single tooth contact	[SHBD=sigHG/sigHBD]	0.86	1.07/ 2.18	1.71
(Safety regarding transmittable torque)	[(SHBD)^2]	0.74	1.14/ 4.77	2.94
Transmittable power (W)	[WRating]	303.11	465.86/1958.93	1204.40

4b. MICROPITTING ACCORDING TO ISO/TR 15144-1:2014

Pairing Gear 1-2:

Calculation of permissible specific film thickness

Lubricant load according to FVA Info sheet 54/7 10 (Oil: Mobilgear 600 XP 220)

Reference data FZG-C Test:

Torque (Nm)	[T1Ref]	265.1
Line load at contact point A (N/mm)	[FbbRef,A]	236.3
Oil temperature (°C)	[theOilRef]	90.0
Tooth mass temperature (°C)	[theMRef]	127.7
Contact temperature (°C)	[theBRef,A]	251.7
Lubrication gap thickness (µm)	[hRef,A]	0.051
Specific film thickness in test (µm)	[lamGFT]	0.102
Material coefficient	[WW]	1.00
Permissible specific film thickness (µm)	[lamGFP]	0.143

Interim results in accordance with ISO/TR 15144:2014

Coefficient of friction	[mym]	0.251	
Lubricant factor	[XL]	1.000	
Roughness factor	[XR]	1.739	
Tooth mass temperature (°C)	[theM]	72.4	
Tip relief factor	[XCa (A)]	1.194	
Loss factor	[HV]	0.168	
Equivalent Young's modulus (N/mm²)	[Er]	227300	
Pressure-viscosity coefficient (m²/N)	[alf38]	0.02162	
Dynamic viscosity (Ns/m²)	[etatM]	40.0	
Roughness average value (µm)	[Ra]	0.6	

Calculation of speeds, load distribution and flank curvature according to method B following ISO/TR 15144-1:2014

Ca 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]	11.330	29.611
Relative radius of curvature (mm)	[ρred]	0.803	
Load sharing factor	[XY]	0.333	
Contact stress (N/mm²)	[pH]	1174.539	
Contact stress (N/mm²)	[pdyn]	1350.710	
Minimal specific film thickness (µm)	[lamGFY]	0.013	(hY=0.008 µm)
Safety against micropitting	[Slam(B)]	0.093	

(For intermediate results refer to file: Micropitting_12.tmp)

Pairing Gear 2-3:

Calculation of permissible specific film thickness

Material coefficient	[WW]	0.75
Permissible specific film thickness (µm)	[lamGFP]	0.107

Interim results in accordance with ISO/TR 15144:2014

Coefficient of friction	[mym]	0.146	
Lubricant factor	[XL]	1.000	
Roughness factor	[XR]	1.402	
Tooth mass temperature (°C)	[theM]	70.4	
Tip relief factor	[XCa (A)]	1.685	
Loss factor	[HV]	0.041	
Equivalent Young's modulus (N/mm²)	[Er]	227300	
Pressure-viscosity coefficient (m²/N)	[alf38]	0.02162	
Dynamic viscosity (Ns/m²)	[etatM]	43.3	
Roughness average value (µm)	[Ra]	1.5	

Calculation of speeds, load distribution and flank curvature according to method B following ISO/TR 15144-1:2014

Ca 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]	27.045	-67.382
Relative radius of curvature (mm)	[pred]	2.428	
Load sharing factor	[XY]	0.333	
Contact stress (N/mm²)	[pH]	675.887	
Contact stress (N/mm²)	[pdyn]	818.592	
Minimal specific film thickness (µm)	[lamGFY]	0.009	(hY=0.014 µm)
Safety against micropitting	[Slam(B)]	0.086	

(For intermediate results refer to file: Micropitting_23.tmp)

The calculation of micropitting specified in ISO15144 is not designed for use with internal toothing because it has not yet been subject to sufficient investigation.
The results can only be used for information purposes.

5. SCUFFING LOAD CAPACITY

Calculation method according to DIN 3990:1987

Lubrication coefficient (for lubrication type)	[XS]	1.000		
Scuffing test and load stage	[FZGtest]	FZG - Test A / 8.3 / 90 (ISO 14635 - 1)		12
Relative structure coefficient (Scuffing)	[XWrelT]	1.000	1.000	
Thermal contact factor (N/mm/s^.5/K)	[BM]	13.780	13.780	13.780
Relevant tip relief (µm)	[Ca]	1.80	1.80	4.40
Optimal tip relief (µm)	[Ceff]	8.57	7.67	
Ca taken as optimal in the calculation (0=no, 1=yes)		0	0/ 0	0
Effective facewidth (mm)	[beff]	12.000	12.000	
Applicable circumferential force/facewidth (N/mm)	[wBt]	114.149	126.772	
Angle factor	[Xalfbet]	1.012	1.012	

Flash temperature-criteria

Tooth mass temperature (°C)	[theMB]	75.67	71.01
(theMB = theoil + XS*0.47*theflamax)			
Maximum flash temperature (°C)	[theflamax]	12.06	2.14
Scuffing temperature (°C)	[theS]	408.58	408.58
Coordinate gamma (point of highest temp.)	[Gamma]	-0.604	-0.421
(1) [Gamma.A]=-0.604 [Gamma.E]=0.745			
(2) [Gamma.A]=-0.421 [Gamma.E]=0.257			
Highest contact temp. (°C)	[theB]	87.73	73.15
Flash factor (°K*N^-.75*s^.5*m^-.5*mm)	[XM]	50.109	50.109
Geometry factor	[XB]	0.441	0.087
Load sharing factor	[XGam]	0.333	0.333
Dynamic viscosity (mPa*s)	[etaM]	35.49	42.36 (70.0 °C)
Coefficient of friction	[mym]	0.294	0.244

Required safety	[SBmin]	2.000	
Safety factor for scuffing (flash temperature)	[SB]	19.086	107.247
Integral temperature-criteria			
Tooth mass temperature (°C)	[theMC]	74.03	70.42
(theMC = theoil + XS*0.70*theflaint)			
Mean flash temperature (°C)	[theflaint]	5.75	0.60
Integral scuffing temperature (°C)	[theSint]	408.58	408.58
Flash factor (°K*N^-.75*s^.5*m^-.5*mm)	[XM]	50.109	50.109
Contact ratio factor	[Xeps]	0.262	0.364
Dynamic viscosity (mPa*s)	[etaOil]	44.06	44.06
Mean coefficient of friction	[mym]	0.223	0.184
Geometry factor	[XBE]	0.357	0.031
Meshing factor	[XQ]	1.000	0.962
Tip relief factor	[XCa]	1.013	1.100
Integral tooth flank temperature (°C)	[theint]	82.66	71.31
Required safety	[SSmin]	1.800	
Safety factor for scuffing (intg.-temp.)	[SSint]	4.94	5.73
Safety referring to transmittable torque	[SSL]	26.74	257.69

6. MEASUREMENTS FOR TOOTH THICKNESS

		------- GEAR 1	---------- GEAR 2	---------- GEAR 3 ---
Tooth thickness deviation		Own Input	Own Input	Own Input
Tooth thickness allowance (normal section) (mm)	[As.e/i]	-0.128/ -0.192	-0.192/ -0.266	-0.266/ -0.426
Number of teeth spanned	[k]	4.000	4.000	-12.000
(Internal toothing: k = (Measurement gap number)				
Base tangent length (no backlash) (mm)	[Wk]	7.557	7.697	-25.017
Actual base tangent length ('span') (mm)	[Wk.e/i]	7.437/ 7.376	7.517/ 7.447	-25.267/ -25
.418				
Diameter of measuring circle (mm)	[dMWk.m]	13.413	27.354	-68.654
Theoretical diameter of ball/pin (mm)	[DM]	1.351	1.209	1.177
Effective diameter of ball/pin (mm)	[DMeff]	1.400	1.400	1.100
Radial single-ball measurement backlash free (mm)	[MrK]	7.244	15.265	-33.732
Radial single-ball measurement (mm)	[MrK.e/i]	7.125/ 7.063	15.048/ 14.959	-34.063/ -34
.254				
Diameter of measuring circle (mm)	[dMMr.m]	12.171	28.087	-69.858
Diametral measurement over two balls without clearance (mm)	[MdK]	14.432	30.531	-67
.455				
Diametral two ball measure (mm)	[MdK.e/i]	14.196/ 14.073	30.096/ 29.918	-68.117/
-68.499				
Measurement over pins according to DIN 3960 (mm)	[MdR.e/i]	14.196/ 14.073	30.096/ 29.918	-68.117/
-68.499				
Measurement over 3 pins (axial) according to AGMA 2002 (mm)				
	[dk3A.e/i]	14.196/ 14.073	30.096/ 29.918	-68.117/
-68.499				
Effective dimensions over 3 pins (mm)	[Md3R.e/i]	14.141/ 14.019	0.000/ 0.000	-68.108/ -68
.490				
Tooth thickness (chordal) in pitch diameter (mm)	[sc]	1.265	1.176	0.778
(mm)	[sc.e/i]	1.137/ 1.073	0.984/ 0.910	0.512/ 0.352
Reference chordal height from da.m (mm)	[ha]	0.961	0.815	0.254
Tooth thickness (Arc) (mm)	[sn]	1.267	1.176	0.778
(mm)	[sn.e/i]	1.139/ 1.075	0.984/ 0.910	0.512/ 0.352

Backlash free center distance (mm)	[aControl.e/i]	19.844/ 19.637	-20.796/ -21.044	
Backlash free center distance, allowances (mm)	[jta]	-0.424/ -0.631	-0.528/ -0.776	
Tip clearance (mm)	[c0.i(aControl)]	-0.210	-0.298	-0.319
Center distance allowances (mm)	[Aa.e/i]	0.011/ -0.011	0.011/ -0.011	
Circumferential backlash from Aa (mm)	[jtw_Aa.e/i]	0.009/ -0.009	0.009/ -0.009	
Radial clearance (mm)	[jrw]	0.641/ 0.413	0.787/ 0.518	
Circumferential backlash (transverse section) (mm)	[jtw]	0.474/ 0.316	0.712/ 0.457	
Normal backlash (mm)	[jnw]	0.445/ 0.297	0.669/ 0.429	
Torsional angle at entry with fixed output:				
Entire torsional angle (°)	[j.tSys]	11.0740/ 7.4918		

7. GEAR ACCURACY

		GEAR 1	GEAR 2	GEAR 3
According to DIN 3961:1978				
One or several gear data (mn, b or d) lay beyond the limits covered by the standard.				
The tolerances are calculated on the basis of the formulae in the standard.				
However, their values are outside the official range of validity!				
Accuracy grade	[Q-DIN3961]	6	6	6
Profile form deviation (µm)	[ff]	5.00	5.00	5.00
Profile slope deviation (µm)	[fHa]	4.50	4.50	4.50
Total profile deviation (µm)	[Ff]	7.00	7.00	7.00
Helix form deviation (µm)	[fbf]	4.00	4.00	4.00
Helix slope deviation (µm)	[fHb]	8.00	8.00	8.00
Total helix deviation (µm)	[Fb]	9.00	9.00	9.00
Normal base pitch deviation (µm)	[fpe]	6.00	6.00	7.00
Single pitch deviation (µm)	[fp]	6.00	6.00	7.00
Adjacent pitch difference (µm)	[fu]	8.00	8.00	9.00
Total cumulative pitch deviation (µm)	[Fp]	17.00	17.00	22.00
Sector pitch deviation over z/8 pitches (µm)	[Fpz/8]	11.00	11.00	14.00
Runout (µm)	[Fr]	11.00	11.00	14.00
Tooth Thickness Variation (µm)	[Rs]	7.00	7.00	8.00
Single flank composite, total (µm)	[Fi']	19.00	19.00	23.00
Single flank composite, tooth-to-tooth (µm)	[fi']	9.00	9.00	10.00
Radial composite, total (µm)	[Fi"]	15.00	15.00	19.00
Radial composite, tooth-to-tooth (µm)	[fi"]	5.50	5.50	7.00
According DIN 58405:1972 (Precision Mechanics):				
Tooth-to-tooth composite error (µm)	[fi"]	5.50	7.00	8.00
Composite error (µm)	[Fi"]	16.00	20.00	22.00
Axis alignment error (µm)	[fp]	3.45	3.45	3.45
Flank direction error (µm)	[fbeta]	5.00	5.00	5.00
Runout (µm)	[Trk, Fr]	18.00	21.00	24.00

8. ADDITIONAL DATA

Mass (g)	[m]	10.96	25.99	82.13
Total mass (g)	[m]	171.04		
Moment of inertia (system with reference to the drive):				
calculation without consideration of the exact tooth shape				
single gears ((da+df)/2...di) (kg*m²)	[TraeghMom]	2.034e-007	3.963e-006	0.0001091
System ((da+df)/2...di) (kg*m²)	[TraeghMom]	3.141e-006		

Torsional stiffness on input for stopped output:			
Torsional stiffness (MNm/rad)	[cr]	0.015	
Torsion when subjected to nominal torque (°)	[delcr]	0.070	
Mean coeff. of friction (acc. Niemann)	[mum]	0.181	0.128
Wear sliding coef. by Niemann	[zetw]	0.964	0.410
Meshpower (W)		349.147	349.147
Gear power loss (W)		3.534	0.615
Total power loss (W)		12.446	
Total efficiency		0.970	
Sound pressure level (according to Masuda, without contact analysis)			
	[dB(A)]	34.9	34.2

9. MODIFICATIONS AND TOOTH FORM DEFINITION

Data for the tooth form calculation :
Data not available.

10. SERVICE LIFE, DAMAGE

Required safety for tooth root	[SFmin]	1.40		
Required safety for tooth flank	[SHmin]	1.00		
Service life (calculated with required safeties):				
System service life (h)	[Hatt]	60.686		
Tooth root service life (h)	[HFatt]	1e+006	60.69	1e+006
Tooth flank service life (h)	[HHatt]	319.1	3870	1e+006

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

Damage calculated on the basis of the required service life (2000.0 h)

F1%	F2%	F3%	H1%	H2%	H3%
0.00	3295.6762	0.0000	626.7319	51.6777	0.0000

Damage calculated on basis of system service life [Hatt] (60.7 h)

F1%	F2%	F3%	H1%	H2%	H3%
0.00	100.0000	0.0000	19.0168	1.5680	0.0000

Calculation of the factors required to define reliability R(t) according to B. Bertsche with Weibull distribution; t in (h):

R(t) = 100 * [Exp(-((t*fac - t0)/(T - t0))^b)]^p %

Gear		p	fac	b	t0	T	R(H)%
1	Tooth root	1	32419	1.7	9.654e+029	1.484e+030	100.00
1	Tooth flank	1	32419	1.3	9.325e+006	4.443e+007	16.29
2	Tooth root	3	4593	1.7	2.691e+005	4.135e+005	0.00
2	Tooth flank	3	4593	1.3	1.602e+007	7.633e+007	100.00
3	Tooth root	1	5682	1.7	9.654e+029	1.484e+030	100.00
3	Tooth flank	1	5682	1.3	9.014e+029	4.295e+030	100.00

Reliability of the configuration for required service life (%) 0.00 (Bertsche)

REMARKS:

- Specifications with [.e/i] imply: Maximum [e] and Minimal value [i] with consideration of all tolerances
  Specifications with [.m] imply: Mean value within tolerance

- For the backlash tolerance, the center distance tolerances and the tooth thickness deviation are taken into account. Shown is the maximal and the minimal backlash corresponding the largest resp. the smallest allowances
  The calculation is done for the operating pitch circle.
- Details of calculation method:
  cg according to method B
  KV according to method B

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