KISSsoft Release 03/2015 F

KISSsoft evaluation

File

Name : PlanetarySet 1 (ISO6336)
Description: KISSsoft example
Changed by: kspl on: 07.03.2016 at: 10:51:33

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

1-> 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.

CALCULATION OF A SPUR PLANETARY GEAR

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

Calculation method ISO 6336:2006 Method B

		------- Sun	---------- Planets
---------- Internal gear ---			
Number of planets (1)	[p]	(1)	3
Power (W) .000	[P]		700
Speed (1/min) 0.0	[n]	1200.0	
Speed difference for planet bearing calculation (1/min)	[n2]		760.5
Speed planet carrier (1/min)	[nSteg]		266.7
Torque (Nm) .000	[T]	5.570 19.496	0
Torque Pl.-Carrier (Nm) .067	[TSteg]		25

Application factor	[KA]			1.25
Power distribution factor	[Kgam]			1.00
Required service life (h)	[H]		20000.00	
Gear driving (+) / driven (-)		+	-/+	-

Working flank gear 1: Right flank

1. TOOTH GEOMETRY AND MATERIAL

(geometry calculation according to DIN 3960:1987)

		------- Gear 1	---------- Gear 2	---------- Gear 3 ---
Center distance (mm)	[a]			25.300
Centre distance tolerance	ISO 286:2010 Measure js7			
Normal module (mm)	[mn]			1.0000
Pressure angle at normal section (°)	[alfn]			20.0000
Helix angle at reference circle (°)	[beta]			0.0000
Number of teeth	[z]	22		27 -77
Facewidth (mm)	[b]	5.00		5.00 5.00
Hand of gear	Spur gear			
Planetary axles can be placed in regular pitch.:		120°		
Accuracy grade	[Q-ISO1328:1995]	6		6 6
Inner diameter (mm)	[di]	13.18		18.13
External diameter (mm)	[di]			88.04
Inner diameter of gear rim (mm)	[dbi]	0.00		0.00
Outer diameter of gear rim (mm)	[dbi]			0.00

Material

Gear 1:	18CrNiMo7-6, Case-carburized steel, case-hardened ISO 6336-5 Figure 9/10 (MQ), core strength >=25HRC Jominy J=12mm<HRC28
Gear 2:	18CrNiMo7-6, Case-carburized steel, case-hardened ISO 6336-5 Figure 9/10 (MQ), core strength >=25HRC Jominy J=12mm<HRC28
Gear 3:	34 CrNiMo 6 (1), Through hardened steel, alloyed, through hardened ISO 6336-5 Figure 5/6 (MQ)

	------- Gear 1	---------- Gear 2	---------- Gear 3 ---
Surface hardness	HRC 61	HRC 61	HBW 240

Material quality according to ISO 6336:2006 Normal (Life factors ZNT and YNT >=0.85)

Fatigue strength. tooth root stress (N/mm²)	[sigFlim]	430.00	430.00
290.00			
Fatigue strength for Hertzian pressure (N/mm²)	[sigHlim]	1500.00	1500.00
700.00			
Tensile strength (N/mm²)	[Rm]	1200.00	1200.00
1200.00			
Yield point (N/mm²)	[sigs]	850.00	850.00
1000.00			
Young's modulus (N/mm²)	[E]	206000	206000
206000			
Poisson's ratio	[ny]	0.300	0.300
0.300			
Roughness average value DS, flank (µm)	[RAH]	0.60	0.60
1.05			
Roughness average value DS, root (µm)	[RAF]	3.00	3.00
3.00			
Mean roughness height, Rz, flank (µm)	[RZH]	4.80	4.80
8.00			
Mean roughness height, Rz, root (µm)	[RZF]	20.00	20.00
20.00			

Gear reference profile	1 :		
Reference profile	1.25 / 0.38 / 1.0 ISO 53.2:1997 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 factor		[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 53.2:1997 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 factor		[hprP*]	0.000
Protuberance angle		[alfprP]	0.000
Tip form height coefficient		[hFaP*]	0.000
Ramp angle		[alfKP]	0.000
		not topping	

Reference profile of tool from gear	3 :		
Pinion type cutter (Own input)	Eigene Eingabe		
Number of teeth	[z]		30
Profile shift coefficient	[x*]		0.100
Base diameter (mm)	[db0]		28.191
Addendum coefficient	[haP0*]		1.200
Tip diameter (mm)	[da0]		32.600
Tip form: Radius	[rhoaP0*]		0.200
Dedendum coefficient	[hfP0*]		1.250
Root diameter (mm)	[df0]		27.700
Root radius factor	[rhofP0*]		0.000
Tip form diameter (mm)	[dFa0]		32.395
Root form diameter (mm)	[dFf0]		28.412
		not topping	
Addendum coefficient Reference profile Gear	[haP*]		1.000

Summary of reference profile gears:

Dedendum reference profile	[hfP*]	1.250	1.250
1.148			
Tooth root radius Refer. profile	[rofP*]	0.380	0.380
0.200			
Addendum Reference profile	[haP*]	1.000	1.000
1.000			
Protuberance height factor	[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]	2.00	2.00
8.50			

Lubrication type			oil bath lubrication	
Type of oil			Oil: Klüberoil GEM 1-220 N with details about	
wear coefficient kw				
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
FZG test A/8.3/90 (	ISO 14635-1:2006)	[FZGtestA]	14	
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]		4.500	
Gear ratio	[u]		1.227	
-2.852				
Transverse module (mm)	[mt]		1.000	
Pressure angle at pitch circle (°)	[alft]		20.000	
Working transverse pressure angle (°)	[alfwt]		24.498	
21.790				
	[alfwt.e/i]		24.550 / 24.445	21
.731 /	21.849			
Working pressure angle at normal section (°)	[alfwn]		24.498	
21.790				
Helix angle at operating pitch circle (°)	[betaw]		0.000	
0.000				
Base helix angle (°)	[betab]		0.000	
Reference centre distance (mm)	[ad]		24.500	
-25.000				
Sum of profile shift coefficients	[Summexi]		0.8890	
-0.3131				
Profile shift coefficient	[x]	0.4575	0.4315	
-0.7446				
Tooth thickness (Arc) (module) (module)	[sn*]	1.9038	1.8849	
1.0288				
Tip alteration (mm)	[k*mn]	-0.089	-0.089	
0.000				
Reference diameter (mm)	[d]	22.000	27.000	
-77.000				
Base diameter (mm)	[db]	20.673	25.372	
-72.356				
Tip diameter (mm)	[da]	24.737	29.685	
-76.489				
(mm)	[da.e/i]	24.737 / 24.727	29.685 /	29
.675 -76.489 /	-76.499			
Tip diameter allowances (mm)	[Ada.e/i]	0.000 / -0.010	0.000 /	-0
.010	0.000 / -0.010			
Tip form diameter (mm)	[dFa]	24.737	29.685	
-76.489				
(mm)	[dFa.e/i]	24.737 / 24.727	29.685 /	29
.675 -76.489 /	-76.499			
Active tip diameter (mm)	[dNa.e/i]	24.737 / 24.727	29.685 /	29
.675	-76.489 / -76.499			
Operating pitch diameter (mm)	[dw]	22.718	27.882 /	27
.324	-77.924			
(mm)	[dw.e]	22.728	27.893 /	27
.313 -77.892				

(mm)	[dw.i]	22.709	27.870 / 27.335 / -77.956
Root diameter (mm)	[df]	20.415	25.363 / -80.785
Generating Profile shift coefficient	[xE.e/i]	0.3833 / 0.3421	0.3573 / 0.3161 / -0.8407 / -0.8957
Manufactured root diameter with xE (mm)	[df.e]	20.267	25.215 / -80.948
(mm)	[df.i]	20.184	25.132 / -81.040
Theoretical tip clearance (mm)	[c]	0.250	0.250/ 0.250 / 0.263
Tip clearance upper allowance (mm)	[c.e]	0.381	0.381/ 0.393 / 0.394
Tip clearance lower allowance (mm)	[c.i]	0.314	0.314/ 0.321 / 0.327
Active root diameter (mm)	[dNf]	21.411	26.428/ 26.076 / -80.029
(mm)	[dNf.e]	21.429	26.447/ 26.096 / -79.997
(mm)	[dNf.i]	21.398	26.414/ 26.063 / -80.053
Root form diameter (mm)	[dFf]	21.126	26.051 / -80.476
(mm)	[dFf.e/i]	21.041 / 20.998	25.956 / 25.906 / -80.654 / -80.753
Reserve (dNf-dFf)/2 (mm)	[cF.e/i]	0.216 / 0.178	0.095 / 0.053 / 0.378 / 0.300
Addendum (mm)	[ha = mn * (haP*+x)]	1.369	1.343 / 0.255
(mm)	[ha.e/i]	1.369 / 1.364	1.343 / 1.338 / 0.255 / 0.250
Dedendum (mm)	[hf = mn * (hfP*-x)]	0.793	0.818 / 1.893
(mm)	[hf.e/i]	0.867 / 0.908	0.893 / 0.934 / 1.974 / 2.020
Roll angle at dFa (°)	[xsi_dFa.e/i]	37.649 / 37.599	34.801 / 34.757 / 19.640 / 19.664
Roll angle to dNf (°)	[xsi_dNf.e/i]	15.634 / 15.300	16.860 / 16.590 /
	[xsi_dNf.e/i]	13.790 / 13.465	27.016 / 27.121
Roll angle at dFf (°)	[xsi_dFf.e/i]	10.860 / 10.192	12.368 / 11.824 / 28.215 / 28.393
Tooth height (mm)	[H]	2.161	2.161 / 2.148
Virtual gear no. of teeth	[zn]	22.000	27.000

-77.000				
Normal-tooth thickness at tip circle (mm)	[san]	0.636	0.688	0.842
(mm)	[san.e/i]	0.581 / 0.541	0.634 / 0.595	0.776 / 0.733
Normal space width at root circle (mm)	[efn]	0.000	0.000	0.540
(mm)	[efn.e/i]	0.000 / 0.000	0.000 / 0.000	0.533 / 0.529
Max. sliding velocity at tip (m/s)	[vga]	0.369	0.341/ 0.136	0.107
Specific sliding at the tip	[zetaa]	0.556	0.556/ 0.222	0.308
Specific sliding at the root	[zetaf]	-1.254	-1.254/ -0.445	-0.285
Sliding factor on tip	[Kga]	0.333	0.307/ 0.125	0.098
Sliding factor on root	[Kgf]	-0.307	-0.333/ -0.098	-0.125
Pitch on reference circle (mm)	[pt]	3.142		
Base pitch (mm)	[pbt]	2.952		
Transverse pitch on contact-path (mm)	[pet]	2.952		
Length of path of contact (mm)	[ga]	4.007		4.696
(mm)	[ga.e/i]	3.963	4.724 /	4.032 / 4.642
Length T1-A (mm)	[T1A]	2.786	7.705/ 3.010	-12.401
Length T1-B (mm)	[T1B]	3.840	6.651/ 4.753	-14.145
Length T1-C (mm)	[T1C]	4.710	5.781/ 5.071	-14.463
Length T1-D (mm)	[T1D]	5.738	4.753/ 5.962	-15.353
Length T1-E (mm)	[T1E]	6.792	3.699/ 7.705	-17.097
Diameter of single contact point B (mm)	[d-B]	22.054	28.647/ 27.094	-77.690
(mm)	[d-B.e]	22.054	28.623/ 27.094	-77.710
(mm)	[d-B.i]	22.047	28.679/ 27.087	-77.662
Diameter of single contact point D (mm)	[d-D]	23.645	27.094/ 28.034	-78.602
(mm)	[d-D.e]	23.620	27.094/ 28.010	-78.602

(mm)	[d-D.i]	23.679	27.087/	28.071 -78.614
Transverse contact ratio	[eps_a]	1.357		1 .591
Transverse contact ratio with allowances	[eps_a.e/i]	1.366 / 1.342	1.600 /	1 .572
Overlap ratio	[eps_b]	0.000		0 .000
Total contact ratio	[eps_g]	1.357		1 .591
Total contact ratio with allowances	[eps_g.e/i]	1.366 / 1.342	1.600 /	1 .572

2. FACTORS OF GENERAL INFLUENCE

		------- Gear 1	---------- Gear 2	---------- Gear 3 ---
Nominal circum. force at pitch circle (N)	[Ft]		168.801	168.801
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]		61.438	61.438
Normal force (N)	[Fnorm]	179.6		179.6 179.6
Nominal circumferential force per mm (N/mm)	[w]		33.76	33.76
Only as information: Forces at operating pitch circle:				
Nominal circumferential force (N)	[Ftw]		163.463	166.799
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]		74.486	66.681
Circumferential speed reference circle (m/s) (Planet)	[v]		1.08	
Running-in value (µm)	[yp]		0.495	1.063
Running-in value (µm)	[yf]		0.412	0.987
Gear body coefficient	[CR, bs/b]		0.865 (0.250)	

0.865 (		0.250)	
Correction coefficient	[CM]	0.800	
0.800			
Reference profile coefficient	[CBS]	0.975	
1.001			
Material coefficient	[E/Est]	1.000	
1.000			
Singular tooth stiffness (N/mm/µm)	[c']	9.844	
10.775			
Meshing stiffness (N/mm/µm)	[cgalf]	12.482	
15.547			
Meshing stiffness (N/mm/µm)	[cgbet]	10.609	
13.215			
Reduced mass (kg/mm)	[mRed]	0.0004	0
.0022			
Resonance speed (min-1)	[nE1]	72996	
29564			
Resonance ratio (-)	[N]	0.013	
0.026			
Running-in value (µm)	[ya]	0.495	
1.063			

Planet on rolling bearings. Planet pin fixed on both sides in carrier.

lpa (mm) = 6.50 b (mm) = 5.00 dsh (mm) = 13.50

Tooth trace deviation (active) (µm)	[Fby]	3.66	
3.34			
from deformation of shaft (µm)	[fsh*B1]	0.14	
0.00			

(fsh (µm) = 0.14/ 0.00, B1= 1.00/ 1.00, fHb5 (µm) = 4.50/ 4.80)

Tooth trace		0	
0			

(0:without, 1:crowned, 2:Tip relief, 3:full modification)

(4:Slightly crowned, 5:Helix angle modification, 6:Helix angle modification with crowning)

from production tolerances (µm)	[fma*B2]	9.19	
9.19			
(B2=			
1.00/ 1.00)			
Tooth trace deviation, theoretical (µm)	[Fbx]	4.31	
4.80			
Running-in value y.b (µm)	[yb]	0.65	
1.46			
Dynamic factor	[KV=max(KV12,KV23)]		1.03
	[KV12,KV23]	1.01	
1.03			
Face load factor - flank	[KHb]	1.45	

1.51

- Tooth root	[KFb]		1.29	
1.33				
- Scuffing	[KBb]		1.45	
1.51				
Transverse load factor - flank	[KHa]		1.00	
1.16				
- Tooth root	[KFa]		1.00	
1.16				
- Scuffing	[KBa]		1.00	
1.16				
Helical load factor scuffing	[Kbg]		1.00	
1.00				
Number of load cycles (in mio.)	[NL]	3360.0	912.6	
960.0				

3. TOOTH ROOT STRENGTH

Calculation of Tooth form coefficients according method: B
Internal toothing: Calculation of roF and sFn according to ISO 6336-3:2007-04-01
Internal toothing: Calculation of YF, YS with pinion type cutter (z0= 30, x0= 0.100, rofP*= 0.200)

		------- Gear 1	---------- Gear 2	---------- Gear 3 ---
Calculated with manufacturing profile shift	[xE.e]	0.38	0.36	
-0.84				
Tooth form factor	[YF]	1.55	1.56/ 1.19	
1.04				
Stress correction factor	[YS]	2.01	2.00/ 2.23	
2.41				
Bending lever arm (mm)	[hF]	1.27	1.30/ 0.97	
1.33				
Working angle (°)	[alfFen]	26.13	25.30/ 22.19	
22.26				
Tooth thickness at root (mm)	[sFn]	2.17	2.19/ 2.19	
2.74				
Tooth root radius (mm)	[roF]	0.45	0.45/ 0.45	
0.43				

(hF* = 1.270/ 1.297/ 0.966/ 1.326 sFn* = 2.168/ 2.191/ 2.191/ 2.741)
(roF* = 0.450/ 0.451/ 0.451/ 0.434 dsFn = 20.601/ 25.563/ 25.563/ -80.882 alfsFn = 30.0/ 30.0/ 30.0/ 60.0)

Helix angle factor	[Ybet]	1.00	1.00
Deep tooth factor	[YDT]	1.00	1.00

Gear rim factor	[YB]	1.00	1.00 1.00
Effective facewidth (mm)	[beff]	5.00	5.00/ 5.00 5.00
Nominal stress at tooth root (N/mm²)	[sigF0]	104.87	105.57/ 89.48 84.86
Tooth root stress (N/mm²)	[sigF]	174.48	175.64/ 178.24 169.03
Permissible bending stress at root of Test-gear			
Notch sensitivity factor	[YdrelT]	0.999	0.999/ 0.999 1.004
Surface factor	[YRrelT]	0.957	0.957 0.957
size factor (Tooth root)	[YX]	1.000	1.000 1.000
Finite life factor	[YNT]	0.869	0.892 0.891
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]	860.00	860.00 580.00
Permissible tooth root stress (N/mm²)	[sigFP=sigFG/SFmin]	595.17	427.73/ 427.73 413.65
Limit strength tooth root (N/mm²)	[sigFG]	714.21	513.27/ 513.27 496.38
Required safety	[SFmin]	1.20	1.20 1.20
Safety for Tooth root stress	[SF=sigFG/sigF]	4.09	2.92/ 2.88 2.94
Transmittable power (kW)	[kWRating]	2.39	1.70/ 1.68 1.71

4. SAFETY AGAINST PITTING (TOOTH FLANK)

		------- Gear 1 ----------	Gear 2 ----------	Gear 3 ---
Zone factor	[ZH]	2.23	2.38	
Elasticity coefficient (√N/mm)	[ZE]	189.81	189.81	
Contact ratio factor	[Zeps]	0.939	0.896	
Helix angle factor	[Zbet]	1.000	1.000	
Effective facewidth (mm)	[beff]	5.00	5.00	
Nominal flank pressure (N/mm²)	[sigH0]	662.83	364.84	
Surface pressure at operating pitch circle (N/mm²)	[sigHw]	904.93	548.49	

Single tooth contact factor	[ZB,ZD]	1.03	1.00/ 1.04
1.00			
Flank pressure (N/mm²)	[sigHB, sigHD]	934.36	904.93/ 572.91
548.49			
Lubrication coefficient at NL	[ZL]	1.020	1.020/ 1.038
1.038			
Speed coefficient at NL	[ZV]	0.955	0.955/ 0.904
0.904			
Roughness coefficient at NL	[ZR]	0.929	0.929/ 0.882
0.882			
Work hardening factor at NL	[ZW]	1.000	1.000/ 1.000
1.003			
Finite life factor	[ZNT]	0.879	0.915
0.913			
Small no. of pittings permissible:		no	
Size factor (flank)	[ZX]	1.000	1.000
1.000			
Permissible surface pressure (N/mm²)	[sigHP=sigHG/SHmin]	1326.15	1380.25/ 1261.33
589.65			
Limit strength pitting (N/mm²)	[sigHG]	1193.54	1242.22/ 1135.20
530.68			
Required safety	[SHmin]	0.90	0.90
0.90			
Safety for surface pressure at operating pitch circle	[SHw]	1.32	1.37/ 2.07
0.97			
Safety for stress at single tooth contact	[SHBD=sigHG/sigHBD]	1.28	1.37/ 1.98
0.97			
(Safety regarding transmittable torque)	[(SHBD)^2]	1.63	1.88/ 3.93
0.94			
Transmittable power (kW)	[kWRating]	1.41	1.63/ 3.39
0.81			

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: Klüberoil GEM 1-220 N with details about wear coefficient kw)
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]	0.111	
Lubricant factor	[XL]	1.000	
Roughness factor	[XR]	1.525	
Tooth mass temperature (°C)	[theM]	72.7	
Tip relief factor	[XCa (A)]	1.272	
Loss factor	[HV]	0.146	
Equivalent Young's modulus (N/mm²)	[Er]	226374	
Compressed viscosity index (m2/N)	[alf38]	0.02162	
Dynamic viscosity (Ns/m2)	[etatM]	39.6	
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)		2	
Diameter (mm)	[dy]	22.054	28.647
Relative radius of curvature (mm)	[ρred]	2.434	
Flank pressure (N/mm²)	[pH]	729.176	
Flank pressure (N/mm²)	[pdyn]	995.502	
Minimal specific film thickness (µm)	[lamGFY]	0.130	(hY=0.078 µm)
Safety against micropitting	[Slam(B)]	0.912	

(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]	0.078	
Lubricant factor	[XL]	1.000	
Roughness factor	[XR]	1.254	
Tooth mass temperature (°C)	[theM]	70.7	
Tip relief factor	[XCa (A)]	1.779	
Loss factor	[HV]	0.052	
Equivalent Young's modulus (N/mm²)	[Er]	226374	
Compressed viscosity index (m2/N)	[alf38]	0.02162	
Dynamic viscosity (Ns/m2)	[etatM]	42.8	
Roughness average value (µm)	[Ra]	0.8	

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]	26.076	-76.489
Relative radius of curvature (mm)	[pred]	2.422	
Flank pressure (N/mm²)	[pH]	422.084	
Flank pressure (N/mm²)	[pdyn]	634.551	
Minimal specific film thickness (µm)	[lamGFY]	0.088	(hY=0.072 µm)
Safety against micropitting	[Slam(B)]	0.816	

(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.

4c. Safety of the hardened layer (EHT) according to DNV41.2:2012

Required hardening depth EHT (mm)	[t550]	0.10/ 0.11	0.10/ 0.11 0.00/ 0.00
Required hardness at t550 (HV)	[HV.t]	550	550 550
Condition for hardness on the surface (HV)	[HV.0]	> 463 (HRC46)	> 294 (HRC29) > 0 (HRC 0)
HV.0 calculated with SH = min(1.2, SEHT), tz/aH = 0.5			
Safety of the hardened layer	[SEHT]	1.71	1.71/ 2.00 0.00
Required safety	[SHssmin]	0.90	0.90 0.90
Result		3	3 -1

(-1:Not checked 0:EHT too small 1:EHT too large or HV.0 too low 2:EHT too large (> 0.25*mn) 3:Proof performed and fulfilled, 4:Proof performed but not fulfilled)

4d. Tooth flank fracture according to ISO DTR 19042-1

Calculation according to Method B

Calculation at point (0:A, 1:AB, 2:B, 3:C, 4:D, 5:DE, 6:E, -1:No Point)		4	4/ 4 -1
Diameter (mm)	[dy]	23.64	27.09/ 28.03 0.00
Relative radius of curvature (mm)	[pred]	2.60	2.60/ 4.29 0.00
Flank pressure (N/mm²)	[pH]	705.64	705.64/ 549.02 0.00
Flank pressure (N/mm²)	[pdyn]	963.36	963.36/ 825.39

0.00			
Required hardening depth EHT (mm)	[t550]	0.10/ 0.11	0.10/ 0.11
0.00/	0.00		
The calculation is performed with the minimum hardening depth			
Core hardness (HV)	[HV_{core}]	342	342
252			
Hardness curve from: ISO/DTR 19042, chapter 7.3.2			
Maximum utilization	[AFFmax]	0.40	0.40/ 0.49
0.00			
Depth of maximum load (mm)	[y]	-0.23	-0.23/ -0.21
0.00			
Material shear strength (N/mm²)	[τper]	160.04	160.04/ 164.10
0.00			
Equivalent shear stress (N/mm²)	[τeff]	58.33	58.33/ 74.12
0.00			
Safety	[SFF]	1.85	1.85/ 1.65
0.00			
1 = thresholds for applying the method exceeded		1	1
0			
(500 <= pH <= 3000 N/mm²; 5 <= ρred <= 150 mm; 0.3 <= t550 <= 4.5 mm)			

6. MEASUREMENTS FOR TOOTH THICKNESS

		------- Gear 1	---------- Gear 2	---------- Gear
3 ---				
Tooth thickness deviation	DIN 3967 cd25	DIN 3967 cd25	DIN 3967 cd25	
Tooth thickness allowance (normal section) (mm)	[As.e/i]	-0.054/ -0.084	-0.054/ -0.084	
-0.070/	-0.110			
Number of teeth spanned	[k]	4.000	4.000	
-10.000				
(Internal toothing: k = (Measurement gap number)				
Base tangent length (no backlash) (mm)	[Wk]	10.954	11.006	
-29.633				
Actual base tangent length ('span') (mm)	[Wk.e/i]	10.903/ 10.875	10.955/ 10.927	
-29.699/	-29.736			
Diameter of contact point (mm)	[dMWk.m]	23.365	27.630	
-78.221				
Theoretical diameter of ball/pin (mm)	[DM]	1.938	1.872	
1.682				
Eff. Diameter of ball/pin (mm)	[DMeff]	2.000	2.000	
1.750				
Theor. dim. centre to ball (mm)	[MrK]	12.969	15.479	
-37.959				
Actual dimension centre to ball (mm)	[MrK.e/i]	12.919/ 12.890	15.426/ 15.396	

-38.048/		-38.099		
Diameter of contact point (mm)		[dMMr.m]	22.883	27.929
-78.562				
Diametral measurement over two balls without clearance (mm)				
		[MdK]	25.939	30.909
-75.901				
Actual dimension over balls (mm)		[MdK.e/i]	25.837/ 25.781	30.803/ 30.744
-76.080/		-76.182		
Actual dimension over rolls (mm)		[MdR.e/i]	25.837/ 25.781	30.803/ 30.744
-76.080/		-76.182		
Actual dimensions over 3 rolls (mm)		[Md3R.e/i]	0.000/ 0.000	30.754/ 30.695
-76.064/		-76.166		
Tooth thickness (chordal) in pitch diameter (mm)		['sn]	1.901	1.883
1.029				
	(mm)	['sn.e/i]	1.847/ 1.817	1.829/ 1.799
0.959/	0.919			
Reference chordal height from da.m (mm)		[ha]	1.407	1.373
0.249				
Tooth thickness (Arc) (mm)		[sn]	1.904	1.885
1.029				
	(mm)	[sn.e/i]	1.850/ 1.820	1.831/ 1.801
0.959/	0.919			
Backlash free center distance (mm)		[aControl.e/i]	25.176/ 25.106	-25.454/
-25.539				
Backlash free center distance, allowances (mm)		[jta]	-0.124/ -0.194	-0.154/
-0.239				
dNf.i with aControl (mm)		[dNf0.i]	21.183	25.816
-80.571				
Reserve (dNf0.i-dFf.e)/2 (mm)		[cF0.i]	0.071	-0.070
0.041				
Tip clearance		[c0.i(aControl)]	0.130	0.130
0.099				
Centre distance allowances (mm)		[Aa.e/i]	0.011/ -0.011	0.011/ -0
.011				
Circumferential backlash from Aa (mm)		[jtw_Aa.e/i]	0.010/ -0.010	0.008/ -0
.008				
Radial clearance (mm)		[jrw]	0.205/ 0.113	0.249/ 0
.144				
Circumferential backlash (transverse section) (mm)				
		[jtw]	0.183/ 0.102	0.205/ 0
.117				
Normal backlash (mm)		[jnw]	0.172/ 0.096	0.192/ 0
.110				

Total rotation angle (°)	[j.tSys]	0.4190/ 0.2685

(j.tSys: Rotation angle of planet carrier when driving shaft is fixed)

7. GEAR ACCURACY

		------- Gear 1	---------- Gear 2	---------- Gear 3 ---
According to ISO 1328:1995				
Accuracy grade	[Q-ISO1328]	6		6
6				
Single pitch deviation (µm)	[fptT]	7.00		7.00
7.50				
Base circle pitch deviation (µm)	[fpbT]	6.60		6.60
7.00				
Sector pitch deviation over k/8 pitches (µm)	[Fpk/8T]	9.50		10.00
14.00				
Profile form deviation (µm)	[ffaT]	5.50		5.50
6.50				
Profile slope deviation (µm)	[fHaT]	4.60		4.60
5.50				
Total profile deviation (µm)	[FaT]	7.50		7.50
8.50				
Helix form deviation (µm)	[ffbT]	6.50		6.50
6.50				
Helix slope deviation (µm)	[fHbT]	6.50		6.50
6.50				
Total helix deviation (µm)	[FbT]	9.00		9.00
9.50				
Total cumulative pitch deviation (µm)	[FpT]	20.00		20.00
26.00				
Runout (µm)	[FrT]	16.00		16.00
21.00				
Single flank composite, total (µm)	[FisT]	36.00		35.00
43.00				
Single flank composite, tooth-to-tooth (µm)	[fisT]	16.00		14.00
17.00				
Radial composite, total (µm)	[FidT]	21.00		21.00
26.00				
Radial composite, tooth-to-tooth (µm)	[fidT]	5.00		5.00
5.00				

Axis alignment tolerances (recommendation acc. ISO TR 10064:1992, Quality 6)		
Maximum value for deviation error of axis (µm)	[fSigbet]	5.85
5.85		
Maximum value for inclination error of axes (µm)	[fSigdel]	11.70
11.70		

8. ADDITIONAL DATA

Weight - calculated with da (g)	[Mass]	13.47	16.99	58.44
Total weight (g)	[Mass]	122.87		

Moment of inertia (System referenced to wheel 1):
calculation without consideration of the exact tooth shape

single gears	((da+df)/2...di) (kg*m²)	[TraeghMom]	8.652e-007	1.759e-006	8.314e-005
System	((da+df)/2...di) (kg*m²)	[TraeghMom]	4.857e-006		
Mean coeff. of friction (acc. Niemann)		[mum]	0.139	0.117	
Wear sliding coef. by Niemann		[zetw]	0.755	0.413	

Meshpower (W)	544.444	544.444	
Gear power loss (W)	3.682	1.111	
Total power loss (W)	14.378		
Total efficiency	0.979		

9. DETERMINATION OF TOOTH FORM

Data for the tooth form calculation :
Data not available.

10. SERVICE LIFE, DAMAGE

Required safety for tooth root	[SFmin]	1.20		
Required safety for tooth flank	[SHmin]	0.90		

Service life (calculated with required safeties):

System service life (h)	[Hatt]	> 1000000		
Tooth root service life (h)	[HFatt]	1e+006	1e+006	1e+006
Tooth flank service life (h)	[HHatt]	1e+006	1e+006	1e+006

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

Damage calculated on basis of required service life (20000.0 h)

F1%	F2%	F3%	H1%	H2%	H3%
0.00	0.00	0.00	0.00	0.00	0.00

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
  KHb, KFb according method C
  fma following equation (64), Fbx following (52/53/56)
  fsh calculated by exactly following the method in Annex D, ISO 6336-1:2006
  Literature: Journal "Antriebstechnik", 6/2007, p.64.
  KHa, KFa according to method B
- For the coefficients ZL, ZV, ZR, ZW, ZX, YdrelT, YRrelT and YX, the logarithmically interpolated value taken from the values for the fatigue strength and the static strength based on the number of load cycles is used..

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