KISSsoft

Planetary gear set, spur

01 Spur Planetary (ISO 6336)

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Changed by	Kadkraft-Simufact
Description	KISSsoft example
	Non commercial version for demo and support purposes only ! (914)
	KISSsoft Release 2024

Contents

1 Messages

ⓘ Calculation is consistent.

ⓘ The calculation of the micropitting specified in ISO/TS 6336-22 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.

2 Overview

Calculation method		ISO 6336:2019			
Drawing or article number:					
Gear 1:		0.000.0			
Gear 2:		0.000.0			
Gear 3:		0.000.0			
			--- Sun -------	Planets ------	Internal gear ---
Number of gears	[p]		1	3	1
Power (kW)	[P]		2.000		
Speed (1/min)	[n]	1200.0			0.0
Speed difference for planet bearing calculation (1/min)			[n2]	760.5	
Speed planet carrier (1/min)	[nSteg]		266.7		
Number of load cycles (in mio.)	[NL]	3360.0		912.6	960.0
Torque (Nm)	[T]	15.9		0.0	55.7
Torque Pl.-Carrier (Nm)	[TSteg]		71.620		
Application factor	[KA]		1.25		
Mesh load factor	[Kγ]		1.00		
Required service life (h)	[H]		20000.00		
Gear driving (+) / driven (-)			+	-/+	-
Working flank Gear 1:		Right flank			
Gear 1 direction of rotation:		Clockwise			
Planet carrier direction of rotation:			clockwise		

3 Tooth geometry

Geometry calculation according to		ISO 21771:2007			
			--- Sun -------	Planets ------	Internal gear ---
Center distance (mm)	[a]		32.890		
Center distance tolerance		ISO 286:2010 Measure js7			
Normal module (mm)	[mn]		1.3000		
Transverse module (mm)	[mt]		1.3000		
Normal Diametral Pitch (1/in)	[Pnd]		19.53846		
Transverse Diametral Pitch (1/in)	[Ptd]		19.53846		
Normal pressure angle (°)	[αn]		20.0000		
Helix angle at reference circle (°)	[β]		0.0000		
Number of teeth	[z]	22		27	-77
Facewidth (mm)	[b]	10.00		10.00	10.00
Hand of gear			Spur gear		

Planet gear shafts can be arranged in a regular pitch. Pitch = 120°

Accuracy grade	[Q-ISO 1328:2013]	A6		A6	A6
Inner diameter (mm)	[di]	16.80		24.05	
External diameter (mm)	[di]				114.71
Inner diameter of gear rim (mm)	[dbi]	0.00		0.00	
Outer diameter of gear rim (mm)	[dbi]				0.00

4 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 3
34 CrNiMo 6 (1), Through hardened steel, alloyed, through hardened, ISO 6336-5 Figure 5/6 (MQ)

		--- Sun -------	Planets ------	Internal gear ---
Surface hardness		HRC 61	HRC 61	HBW 240
Material treatment according to ISO 6336:2006 Normal, Life factors Z_{NT} and Y_{NT} ≥ 0.85				
Infinite life strength for tooth root stress (N/mm²)	[σFlim]	430.00	430.00	290.00
Fatigue strength for Hertzian pressure (N/mm²)	[σHlim]	1500.00	1500.00	700.00
Young's modulus (N/mm²)	[E]	206000	206000	206000
Poisson's ratio	[v]	0.300	0.300	0.300
Tensile strength (N/mm²)	[σB]	1200.00	1200.00	1200.00
Yield point (N/mm²)	[σS]	850.00	850.00	1000.00

4.1 Gear roughness

		--- Sun -------	Planets ------	Internal gear ---
Arithmetic mean roughness value R_a, flank (µm)	[RAH]	0.60	0.60	1.05
Arithmetic mean roughness value R_a, root (µm)	[RAF]	3.00	3.00	3.00
Mean peak-to-valley roughness R_z, flank (µm)	[RZH]	4.80	4.80	8.00
Mean peak-to-valley roughness R_z, root (µm)	[RZF]	20.00	20.00	20.00

4.2 Lubrication

Lubrication type	Oil bath lubrication	
Type of oil	Klüberoil GEM 1-220 N with details about wear coefficient kw	
Lubricant base	Mineral-oil base	
Oil nominal kinematic viscosity at 40°C (mm²/s)	[v40]	220.00
Oil nominal kinematic viscosity at 100°C (mm²/s)	[v100]	19.00
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]	0.538 /0.542

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]	0.505 /0.507

Tool reference profile 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]	36.648
Addendum coefficient	[haP0*]	1.200
Tip diameter (mm)	[da0]	42.380
Tip form: Radius	[ρaP0*]	0.200
Dedendum coefficient	[hfP0*]	1.250
Root diameter (mm)	[df0]	36.010
Root radius factor	[ρfP0*]	0.000
Tooth thickness on reference circle, arc (mm)	[sn]	2.137
Tip form diameter (mm)	[dFa0]	42.114
Root form diameter (mm)	[dFf0]	36.935
	not topping	
Addendum coefficient reference profile Gear	[haP*]	1.000
Manufacturing center distance (mm)	[a0]	31.493

5.1.1 Information on final machining

		--- Sun -------	Planets ------	Internal gear ---
Dedendum reference profile	[hfP*]	1.250	1.250	1.123
Tooth root radius reference profile	[ρfP*]	0.380	0.380	0.200
Addendum reference profile	[haP*]	1.000	1.000	1.000
Protuberance height coefficient	[hprP*]	0.000	0.000	0.000
Protuberance angle (°)	[αprP]	0.000	0.000	0.000
Tip form height coefficient	[hFaP*]	0.000	0.000	0.000
Ramp angle (°)	[αKP]	0.000	0.000	0.000
Type of profile modification:	none (only running-in)			
Tip relief, left flank (µm)	[Ca L]	2.000	2.000	8.500
Tip relief, right flank (µm)	[Ca R]	2.000	2.000	8.500

5.2 Basic data

Overall transmission ratio	[itot]	4.500
Transverse module (mm)	[mt]	1.300
Transverse pressure angle (°)	[αt]	20.000
Base helix angle (°)	[βb]	0.000

		-- Pair 1 ----------	Pair 2 --
Gear ratio	[u]	1.227	-2.852
Working pressure angle (°)	[αwt]	24.498	21.790
(°)	[αwt.e/i]	24.545 /24.450	21.736 /21.844
Working pressure angle at normal section (°)	[αwn]	24.498	21.790
Helix angle at operating pitch circle (°)	[βw]	0.000	0.000
Reference center distance (mm)	[ad]	31.850	32.500
Sum of profile shift coefficients	[Σxi]	0.8890	-0.3131

		--- Sun -------	Planets ------	Internal gear ---
Profile shift coefficient	[x]	0.3000	0.5890	-0.9021
Generating profile shift coefficient	[xE.e/i]	0.2429/0.2112		
	[xE.e/i]		0.5320/0.5003	
	[xE.e/i]			-0.9760/-1.0183
Virtual gear no. of teeth	[zn]	22.000	27.000	77.000
Involute length (mm)	[l_dFa-l_dFf]	2.270	2.485	2.561

5.2.1 Tip chamfer or tip rounding

		--- Sun -------	Planets ------	Internal gear ---
Tip rounding (mm)	[rK]	0.350	0.350	0.350
Section	[/]	2	2	2

2-in transverse section, 3-in axial section, 4-In normal section

5.3 Diameters and their allowances

		--- Sun -------	Planets ------	Internal gear ---
Reference diameter (mm)	[d]	28.600	35.100	100.100
Base diameter (mm)	[db]	26.875	32.983	94.063
Tip alteration (mm)	[k*mn]	-0.116	-0.116	0.000
Tip diameter (mm)	[da]	31.748	38.999	99.845

(mm)	[da.e/i]	31.748 /31.738		
(mm)	[da.e/i]		38.999 /38.989	
(mm)	[da.e/i]			99.855 /99.845
Tip diameter allowances (mm)	[Ada.e/i]	0.000 /-0.010		
(mm)	[Ada.e/i]		0.000 /-0.010	
(mm)	[Ada.e/i]			0.010 /-0.000
Tip form diameter (mm)	[dFa]	31.404	38.660	100.300
(mm)	[dFa.e/i]	31.404 /31.394		
(mm)	[dFa.e/i]		38.660 /38.650	
(mm)	[dFa.e/i]			100.310 /100.300
Active tip diameter (mm)	[dNa]	31.404	38.660	
(mm)	[dNa]		38.660	100.300
(mm)	[dNa.e/i]	31.404 /31.394		
(mm)	[dNa.e/i]		38.660 /38.650	
(mm)	[dNa.e/i]		38.660 /38.650	
(mm)	[dNa.e/i]			100.310 /100.300
V-Circle diameter (mm)	[dv]	29.380	36.631	102.445
(mm)	[dv.e/i]	29.232 /29.149		
(mm)	[dv.e/i]		36.483 /36.401	
(mm)	[dv.e/i]			102.748 /102.638
Operating pitch diameter (mm)	[dw]	29.534	36.246	
(mm)	[dw]		35.521	101.301
(mm)	[dw.e/i]	29.545 /29.523		
(mm)	[dw.e/i]		36.260 /36.232	
(mm)	[dw.e/i]		35.508 /35.535	
(mm)	[dw.e/i]			101.340 /101.263
Root diameter (mm)	[df]	26.130	33.381	105.366
(mm)	[df.e/i]	25.982 /25.899		
(mm)	[df.e/i]		33.233 /33.151	
(mm)	[df.e/i]			105.615 /105.525
Active root diameter (mm)	[dNf]	27.800		
(mm)	[dNf]		34.778 /34.584	
(mm)	[dNf]			104.095
(mm)	[dNf.e/i]	27.820 /27.784		
(mm)	[dNf.e/i]		34.804 /34.759	
(mm)	[dNf.e/i]		34.613 /34.564	
(mm)	[dNf.e/i]			104.123 /104.057
Root form diameter (mm)	[dFf]	27.243	34.158	104.994
Root form diameter (mm)	[dFf.e/i]	27.175 /27.141		
(mm)	[dFf.e/i]		34.048 /33.989	
(mm)	[dFf.e/i]			105.262 /105.166

5.4 Tip clearances and tooth heights

		--- Sun -------	Planets ------	Internal gear ---
Theoretical tip clearance (mm)	[c]	0.325		
(mm)	[c]		0.325 /0.293	
(mm)	[c]			0.342
Effective tip clearance (mm)	[c.e/i]	0.458 /0.387		
(mm)	[c.e/i]		0.458 /0.387	
(mm)	[c.e/i]		0.435 /0.360	
(mm)	[c.e/i]			0.475 /0.404
Reserve (dNf-dFf)/2 (mm)	[cF.e/i]	0.340 /0.304		
(mm)	[cF.e/i]		0.408 /0.356	
(mm)	[cF.e/i]		0.312 /0.258	
(mm)	[cF.e/i]			0.602 /0.521
Addendum, $m_n(h_{aP}^*+x+k)$ (mm)	[ha]	1.574	1.950	0.127
(mm)	[ha.e/i]	1.574 /1.569		
(mm)	[ha.e/i]		1.950 /1.945	
(mm)	[ha.e/i]			0.127 /0.122
Dedendum, $m_n(h_{fP}^*-x)$ (mm)	[hf]	1.235	0.859	2.633

(mm)	[hf.e/i]	1.309 /1.350			
(mm)	[hf.e/i]		0.933 /0.975		
(mm)	[hf.e/i]			2.712 /2.757	
Tooth height (mm)	[h]	2.809	2.809	2.760	

5.5 Roll angle

		--- Sun -------	Planets ------	Internal gear ---	
Roll angle at dFa (°)	[ξFa.e/i]	34.637 /34.594			
(°)	[ξFa.e/i]		35.032 /34.998		
(°)	[ξFa.e/i]			21.208 /21.225	
Roll angle to dNf (°)	[ξNf.e/i]	15.327 /15.028			
(°)	[ξNf.e/i]		19.298 /19.054		
(°)	[ξNf.e/i]		18.231 /17.948		
(°)	[ξNf.e/i]			27.104 /27.198	
Roll angle at dFf (°)	[ξFf.e/i]	8.585 /8.071			
(°)	[ξFf.e/i]		14.674 /14.255		
(°)	[ξFf.e/i]			28.648 /28.779	

5.6 Tooth thickness and pitch

		--- Sun -------	Planets ------	Internal gear ---	
Tooth thickness on reference circle, arc, in module	[sn*]	1.7892	1.9996	0.9141	
Normal tooth thickness at tip circle (mm)	[san]	0.912	0.814	1.094	
(mm)	[san.e/i]	0.858 /0.819			
(mm)	[san.e/i]		0.761 /0.721		
(mm)	[san.e/i]			1.028 /0.984	
Without consideration of tip chamfer/ tip rounding					
Normal tooth thickness at tip form circle (mm)	[sFan]	1.113	1.017	1.264	
(mm)	[sFan.e/i]	1.060 /1.021			
(mm)	[sFan.e/i]		0.964 /0.925		
(mm)	[sFan.e/i]			1.198 /1.154	
Normal space width at root circle (mm)	[efn]	0.000	0.956	0.688	
(mm)	[efn.e/i]	0.000 /0.000			
(mm)	[efn.e/i]		0.982 /0.999		
(mm)	[efn.e/i]			0.682 /0.679	
Pitch on reference circle (mm)	[pt]	4.084	4.084	4.084	
Base pitch (mm)	[pbt]	3.838	3.838	3.838	
Transverse pitch on contact-path (mm)	[pet]	3.838	3.838	3.838	

5.7 Sliding

		--- Sun -------	Planets ------	Internal gear ---	
Max. sliding velocity at tip (m/s)	[vga]	0.355	0.456		
(m/s)	[vga]		0.181	0.072	
Specific sliding at the tip	[ζa]	0.447	0.567		
	[ζa]		0.225	0.148	
Specific sliding at the root	[ζf]	-1.311	-0.808		
	[ζf]		-0.174	-0.290	
Mean specific sliding	[ζm]	0.515	0.203		
Sliding factor on tip	[Kga]	0.246	0.316		
	[Kga]		0.128	0.051	
Sliding factor on root	[Kgf]	-0.316	-0.246		
	[Kgf]		-0.051	-0.128	

5.8 Contact ratios

		-- Pair 1 ----------	Pair 2 --		
Minimal length of contact line (mm)	[Lmin]	10.000	10.000		
Transverse contact ratio	[εα]	1.190	1.273		
	[εα.e/m/i]	1.198 /1.188/	1.177 1.281 /	1.269/	1.258
Overlap ratio	[εβ]	0.000	0.000		
Total contact ratio	[εγ]	1.190	1.273		
	[εγ.e/m/i]	1.198 /1.188/	1.177 1.281 /	1.269/	1.258
Length of path of contact (mm)	[ga]	4.569	4.884		
(mm)	[ga.e/i]	4.599 /4.519	4.917 /4.826		

5.8.1 Pair 1

		-- Gear 1	Gear 2 --
Addendum contact ratio	[ε]	0.521	0.669
	[ε.e/i]	0.525 / 0.515	0.674 / 0.662
Length T1-A and T2-A (mm)	[T1A,T2A]	3.555	10.083
(mm)	[.e/i]	3.524 / 3.595	10.083 /10.074
Length T1-B and T2-B (mm)	[T1B,T2B]	4.286	9.352
(mm)	[.e/i]	4.286 / 4.276	9.322 / 9.392
Length T1-C and T2-C (mm)	[T1C,T2C]	6.123	7.515
(mm)	[.e/i]	6.110 / 6.137	7.498 / 7.531
Length T1-D and T2-D (mm)	[T1D,T2D]	7.392	6.246
(mm)	[.e/i]	7.362 / 7.432	6.246 / 6.236
Length T1-E and T2-E (mm)	[T1E,T2E]	8.123	5.515
(mm)	[.e/i]	8.123 / 8.113	5.484 / 5.555
Length T1-T2 (mm)	[T1T2]	13.638	
(mm)	[.e/i]	13.608 /13.668	
Diameter of single contact point B (mm)	[d-B]	28.209	37.918
(mm)	[d-B.e/i]	28.209 /28.203	37.888 /37.957
Diameter of single contact point D (mm)	[d-D]	30.673	35.269
(mm)	[d-D.e/i]	30.644 /30.712	35.269 /35.262

5.8.2 Pair 2

		-- Gear 2	Gear 3 --
Addendum contact ratio	[ε]	0.910	0.363
	[ε.e/i]	0.905 / 0.912	0.377 / 0.346
Length T1-A and T2-A (mm)	[T1A,T2A]	5.200	17.409
(mm)	[.e/i]	5.166 / 5.248	17.409 /17.423
Length T1-B and T2-B (mm)	[T1B,T2B]	6.246	18.455
(mm)	[.e/i]	6.246 / 6.236	18.488 /18.411
Length T1-C and T2-C (mm)	[T1C,T2C]	6.593	18.802
(mm)	[.e/i]	6.611 / 6.575	18.854 /18.750
Length T1-D and T2-D (mm)	[T1D,T2D]	9.037	21.246
(mm)	[.e/i]	9.004 / 9.085	21.246 /21.261
Length T1-E and T2-E (mm)	[T1E,T2E]	10.083	22.292
(mm)	[.e/i]	10.083 /10.074	22.326 /22.249
Length T1-T2 (mm)	[T1T2]	12.209	
(mm)	[.e/i]	12.243 /12.175	
Diameter of single contact point B (mm)	[d-B]	35.269	101.045
(mm)	[d-B.e/i]	35.269 /35.262	101.070 /101.014
Diameter of single contact point D (mm)	[d-D]	37.611	103.216
(mm)	[d-D.e/i]	37.579 /37.657	103.216 /103.228

6 General influence factors

6.1 Forces and circumferential speed

		--- Sun	------- Planets	------ Internal gear ---
Nominal circum. force at pitch circle (N)	[Ft]	370.991	370.991	
Axial force (N)	[Fa]	0.00	0.00	0.00
Total axial force (N)	[F_{atot}]	0.00		0.00
$F_{atot} = F_a*3$				
Radial force (N)	[Fr]	135.030		135.030
Normal force (N)	[Fnorm]	394.80	394.80	394.80
Nominal circumferential force per mm (N/mm)	[w]	37.10	37.10	
Only as information: Forces at operating pitch circle:				
Nominal circumferential force (N)	[Ftw]	359.260	366.591	
Axial force (N)	[Faw]	0.00	0.0 /0.0	0.00
Total axial force (N)	[F_{awtot}]	0.00		0.00
$F_{awtot}=F_a*3$				
Radial force (N)	[Frw]	163.705	146.553	
Circumferential speed reference circle (m/s)	[v]	1.40	(Planet)	

6.2 Contact stiffness

		-- Pair 1	Pair 2 --	
Running-in value (µm)	[yp]	0.564	1.141	
Running-in value (µm)	[yf]	0.600	1.214	
Gear blank factor	[CR, bs/b]	0.862 ,0.250	0.862 ,	0.250
Correction factor	[CM]	0.800	0.800	
Basic rack factor	[CB]	0.975	1.007	
Material coefficient	[E/Est]	1.000	1.000	
Single stiffness (N/mm/µm)	[c']	10.082	11.071	
Theoretical single stiffness (N/mm/µm)	[c'th]	18.165	19.318	
Meshing stiffness (N/mm/µm)	[cγα]	11.523	13.334	
Meshing stiffness (N/mm/µm)	[cγβ]	9.794	11.334	
Reduced mass (kg/mm)	[mRed]	0.0007	0.0039	
Resonance speed (min-1)	[nE1]	54928	20673	
Resonance ratio (-)	[N]	0.017	0.037	

6.3 Calculation of K factors

		-- Pair 1	Pair 2 --
Running-in value (µm)	[yα]	0.600	1.214
Planet runs on rolling bearings. Planet pin fixed on both sides in the carrier.			
lpa (mm)	[lpa]	13.00	
b (mm)	[b]	10.00	
dsh (mm)	[dsh]	17.55	
Effective flank line deviation (µm)	[Fβy]	4.24	3.82
from deformation of shaft (µm)	[fsh*B1]	0.38	0.01
fsh (µm)	[fsh]	0.38	0.01
B1	[B1]	1.00	1.00
fHβ5 (µm)	[fHβ5]	5.50	5.50
Tooth trace		0	0
(0:Without, 1:Crowned, 2:End relief, 3:Full modification, 4:Slightly crowned, 5:Helix angle modification, 6:Helix angle modification with crowning)			
from production tolerances (µm)	[fmα*B2]	10.61	10.97
	[B2]	1.00	1.00
Tooth trace deviation, theoretical (µm)	[Fβx]	4.99	5.49
Running-in value y_β (µm)	[yβ]	0.75	1.67

6.4 K factors

		-- Pair 1	Pair 2 --
Maximum dynamic factor	[max(K_{v12},K_{v23})]		1.05
Dynamic factor	[Kv12,Kv23]	1.02	1.05
Face load factors			
- Flank	[KHβ]	1.43	1.45
- Tooth root	[KFβ]	1.30	1.31
- Scuffing	[KBβ]	1.43	1.45
Transverse load factors			
- Flank	[KHα]	1.00	1.00
- Tooth root	[KFα]	1.00	1.00
- Scuffing	[KBα]	1.00	1.00
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
Internal toothing: calculation of Y_F and Y_S with pinion type cutter, z_0=30, x_0=0.100, ρ_{aP0}^*=0.200

		--- Sun	------- Planets	------ Internal gear ---
Calculated with generating profile shift coefficient	[xE.i]	0.2112	0.5003	-1.0183
Tooth form factor	[YF]	1.88	1.62 /1.48	1.09
Stress correction factor	[YS]	1.81	2.02 /2.10	3.14
Load application angle (°)	[αFen]	26.17	27.53 /26.44	22.25
Load distribution influence factor	[fε]	1.000	1.000	
Bending moment arm (mm)	[hFe]	1.86	1.87 /1.69	1.92

(-)	[hFe*]	1.43	1.44	/1.30	1.48
Tooth root thickness at critical cross section (mm)	[sFn]	2.71	2.92	/2.92	3.68
(-)	[sFn*]	2.09	2.24	/2.24	2.83
Root fillet radius at critical cross section (mm)	[ρF]	0.65	0.55	/0.55	0.29
(-)	[ρF*]	0.50	0.42	/0.42	0.22
Diameter at critical cross section (mm)	[dsFn]	26.36	33.58	/33.58	-105.53
Tangent at critical cross section (°)	[αsFn]	30.00	30.00	/30.00	60.00
Tangent contact point (mm)	[x,y]	1.357 /13.112			
Tangent contact point (mm)	[x,y]		1.458 /16.729		
Tangent contact point (mm)	[x,y]				1.785 /52.740
Helix angle factor	[Yβ]		1.00	1.00	
Deep tooth factor	[YDT]		1.00	1.00	
Gear rim thickness (mm)	[sr]	4.55	4.55		4.55
Gear rim factor	[YB]	1.00	1.00		1.00
Effective facewidth (mm)	[beff]	10.00	10.00	/10.00	10.00
Nominal stress at tooth root (N/mm²)	[σF0]	97.36	93.44	/88.37	96.90
Tooth root stress (N/mm²)	[σF]	165.06	158.42	/151.23	165.83
Permissible bending stress at root of Test-gear					
Notch sensitivity factor	[YδrelT]	0.996	1.002	/1.002	1.020
Surface factor	[YRrelT]	0.957	0.957		0.957
Size factor, tooth root	[YX]	1.000	1.000		1.000
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		
$Y_{ST} \cdot \sigma_{Flim}$ (N/mm²)	[σFE]	860.00	860.00		580.00
Permissible tooth root stress (N/mm²)	[σFP=σFG/SFmin]	565.08	408.29	/408.29	400.34
Limit strength tooth root (N/mm²)	[σFG]	712.00	514.44	/514.44	504.43

7.1 Safety factors

		--- Sun -------	Planets ------	Internal gear ---
Required safety	[SFmin]	1.26	1.26	1.26
Safety for tooth root stress	[SF=σFG/σF]	4.31	3.25 /3.40	3.04
Transmittable power (kW)	[kWRating]	6.85	5.15 /5.40	4.83

8 Calculation of flank strength (pitting)

		--- Sun -------	Planets ------	Internal gear ---
Zone factor	[ZH]	2.23	2.38	
Elasticity coefficient (√N/mm)	[ZE]	189.81	189.81	
Contact ratio factor	[Zε]	0.968	0.953	
Helix angle factor	[Zβ]	1.000	1.000	
Effective facewidth (mm)	[beff]	10.00	10.00	
Nominal contact stress (N/mm²)	[σH0]	628.34	356.89	
Contact stress at operating pitch circle (N/mm²)	[σHw]	858.82	490.94	
Single tooth contact factor	[ZB,ZD]	1.07	1.00 /1.04	1.00
Contact stress (N/mm²)	[σHB, σHD]	920.20	858.82 /509.13	490.94
Lubricant coefficient for N_L	[ZL]	1.020	1.020 /1.038	1.038
Speed factor at N_L	[ZV]	0.959	0.959 /0.912	0.912
Roughness factor for N_L	[ZR]	0.936	0.936 /0.893	0.893
Material hardening factor for N_L	[ZW]	1.000	1.000 /1.000	1.030
Size factor (flank)	[ZX]	1.000	1.000	1.000
Life factor	[ZNT]	0.879	0.915	0.913
Limited pitting is permissible: No				
Permissible contact stress, σHG/SHmin (N/mm²)	[σHP]	1297.03	1349.94 /1246.83	598.21
Pitting stress limit (N/mm²)	[σHG]	1206.24	1255.45 /1159.55	556.33

8.1 Safety factors

		--- Sun -------	Planets ------	Internal gear ---
Required safety	[SHmin]	0.93	0.93	0.93
Safety factor for contact stress on operating pitch circle	[SHw]	1.40	1.46 /2.36	1.13
Safety against pressure at single tooth contact	[SHBD=σHG/σHBD]	1.31	1.46 /2.28	1.13
Safety regarding transmittable torque	[(SHBD)²]	1.72	2.14 /5.19	1.28
Transmittable power (kW)	[kWRating]	3.97	4.94 /11.99	2.97

9 Micropitting

Calculation method according to	ISO/TS 6336-22:2018	
Lubricant load according to FVA Info sheet 54/7 10, Klüberoil GEM 1-220 N with details about wear coefficient kw		
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]	127.666
Contact temperature (°C)	[θBRef,A]	251.735
Lubrication gap thickness (µm)	[hRef,A]	0.051
Specific film thickness in test	[λGFT]	0.102

9.1 Gear pairing 1-2

		------- Gear 1	---------- Gear 2 -------
Calculation of permissible specific film thickness			
Material coefficient	[WW]	1.000	
Permissible specific film thickness	[λGFP]	0.143	
Interim results in accordance with ISO/TS 6336-22:2018			
Coefficient of friction	[μ_m]	0.096	
Lubricant factor	[XL]	1.000	
Roughness factor	[XR]	1.429	
Lubrication coefficient for lubrication type	[XS]	1.000	
Tooth mass temperature (°C)	[θM]	77.124	
Tip relief factor	[XCa(A)]	1.479	
Loss factor	[HV]	0.137	
Equivalent Young's modulus (N/mm²)	[Er]	226373.626	
Pressure-viscosity coefficient (m²/N)	[α38]	0.02162	
Dynamic viscosity (Ns/m²)	[ηtM]	33.400	
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		1	1	
Calculation at point (0:A, 1:AB, 2:B, 3:C, 4:D, 5:DE, 6:E, -1:No Point)		2		
Diameter (mm)	[dy]	28.209	37.918	
Relative radius of curvature (mm)	[ρred]	2.939		
Load sharing factor	[XY]	1.000		
Contact stress (N/mm²)	[pH]	695.696		
Contact stress (N/mm²)	[pdyn]	950.883		
Minimal specific film thickness	[λGFY]	0.140	(h_Y=0.084 µm)	
Safety against micropitting	[Sλ(B)]	0.980		
For interim results, refer to file:	Micropitting_12.tmp			

9.2 Gear pairing 2-3

		------- Gear 2	---------- Gear 3 -------
Calculation of permissible specific film thickness			
Material coefficient	[WW]	0.750	
Permissible specific film thickness	[λGFP]	0.107	
Interim results in accordance with ISO/TS 6336-22:2018			
Coefficient of friction	[μ_m]	0.065	
Lubricant factor	[XL]	1.000	
Roughness factor	[XR]	1.175	
Lubrication coefficient for lubrication type	[XS]	1.000	
Tooth mass temperature (°C)	[θM]	75.654	
Tip relief factor	[XCa(A)]	1.806	
Loss factor	[HV]	0.052	
Equivalent Young's modulus (N/mm²)	[Er]	226373.626	
Pressure-viscosity coefficient (m²/N)	[α38]	0.02162	
Dynamic viscosity (Ns/m²)	[ηtM]	35.293	
Roughness average value (µm)	[Ra]	0.825	

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	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]	34.584	100.300
Relative radius of curvature (mm)	[ρred]	7.414	
Load sharing factor	[XY]	0.333	
Contact stress (N/mm²)	[pH]	252.883	
Contact stress (N/mm²)	[pdyn]	347.870	
Minimal specific film thickness	[λGFY]	0.169	(h_Y=0.139 µm)
Safety against micropitting	[Sλ(B)]	1.577	
For interim results, refer to file:	Micropitting_23.tmp		

The calculation of the micropitting specified in ISO/TS 6336-22 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.

10 Safety of hardened layer (subsurface fatigue)

CHD according to	DNV-CG-0036:2021			
		--- Sun -------	Planets ------	Internal gear ---
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]	330	192	0
	[> HRC.0]	33	0	0
HV.0 is calculated with t_z/a_H = 0.5, S_H = min(S_{EHT}, S_{Hssmin})				
Safety of the hardened layer	[SEHT]	1.72	1.72 /2.66	0.00
Required safety	[SHssmin]	0.93	0.93	0.93
Result		2	2	-1

-1:Not checked, 0:CHD too small, 1:CHD too large or HV.0 too deep, 2:Check performed,
3:Check performed with insufficient hardening depths (t_z/a_H<0.5, t_z/a_{Hst}<0.6)

11 Measurements for tooth thickness

11.1 Tooth thickness tolerances

		--- Sun -------	Planets ------	Internal gear ---
Tooth thickness tolerance		DIN 3967 cd25	DIN 3967 cd25	DIN 3967 cd25
Tooth thickness allowance (normal section) (mm)	[Asn.e/i]	-0.054 /-0.084		
(mm)	[Asn.e/i]		-0.054 /-0.084	
(mm)	[Asn.e/i]			-0.070 /-0.110

11.2 Base tangent lengths

		--- Sun -------	Planets ------	Internal gear ---
Number of teeth spanned	[k]	3.000	4.000	11.000
(Internal toothing: k = (measured number of tooth spaces)				
Base tangent length (no backlash) (mm)	[Wk]	10.262	14.448	42.501
Base tangent length with allowance (mm)	[Wk.e/i]	10.211 /10.183		
(mm)	[Wk.e/i]		14.397 /14.369	
(mm)	[Wk.e/i]			42.567 /42.604
Diameter of measuring circle (mm)	[dMWk.m]	28.745	35.983	103.254

11.3 Measurement over balls and pins

		--- Sun -------	Planets ------	Internal gear ---
Theoretical diameter of ball/pin (mm)	[DM]	2.404	2.537	2.180
Effective diameter of ball/pin (mm)	[DMeff]	2.500	2.750	2.500
Radial single-ball measurement, no backlash (mm)	[MrK]	16.566	20.491	49.116
Radial single-ball measurement (mm)	[MrK.e/i]	16.513 /16.483		
(mm)	[MrK.e/i]		20.441 /20.413	
(mm)	[MrK.e/i]			49.259 /49.207
Diameter of measuring circle (mm)	[dMMr.m]	29.398	36.803	101.901
Diametral measurement over two balls, no backlash (mm)	[MdK]	33.133	40.917	98.211
Diametral measurement over two balls (mm)	[MdK.e/i]	33.026 /32.967		
(mm)	[MdK.e/i]		40.817 /40.761	
(mm)	[MdK.e/i]			98.497 /98.393
Measurement over pins according to DIN 3960 (mm)	[MdR.e/i]	33.026 /32.967		
(mm)	[MdR.e/i]		40.817 /40.761	

(mm)	[MdR.e/i]			98.497 /98.393
Measurement over 3 pins with allowance (mm)	[Md3R.e/i]	0.000 /0.000		
(mm)	[Md3R.e/i]		40.752 /40.696	
(mm)	[Md3R.e/i]			98.476 /98.372

11.4 Tooth thickness

		--- Sun -------	Planets ------	Internal gear ---
Medium tip diameter (mm)	[da.m]	31.743	38.994	99.850
Reference chordal height from da.m (mm)	[hac]	1.619	1.995	0.121
Tooth thickness at height hac, chord (mm)	[sc]	2.323	2.597	1.188
(mm)	[sc.e/i]	2.271 /2.241		
(mm)	[sc.e/i]		2.544 /2.515	
(mm)	[sc.e/i]			1.118 /1.078
Tooth thickness on reference circle, arc (mm)	[sn]	2.326	2.599	1.188
(mm)	[sn.e/i]	2.272 /2.242		
(mm)	[sn.e/i]		2.545 /2.515	
(mm)	[sn.e/i]			1.118 /1.078

11.5 Backlash

		-- Pair 1 ----------	Pair 2 --
Circumferential backlash from Aa (mm)	[jtw_Aa.e/i]	0.011 /-0.011	0.010 /-0.010
Radial backlash (mm)	[jrw]	0.206 /0.111	0.253 /0.142
Circumferential backlash, transverse section (mm)	[jtw]	0.185 /0.100	0.206 /0.115
Normal backlash (mm)	[jnw]	0.166 /0.093	0.191 /0.108
Center distance allowances (mm)	[Aa.e/i]	0.013 /-0.013	-0.013 /0.013
Backlash free center distance (mm)	[aControl.e/i]	32.766 /32.697	33.045 /33.130
Backlash free center distance, allowances (mm)	[jta]	-0.124 /-0.193	0.155 /0.240

		--- Sun -------	Planets ------	Internal gear ---
dNf.i with aControl (mm)	[dNf0.i]	27.573	34.490 /34.224	104.643
Reserve (dNf0.i-dFf.e)/2 (mm)	[cF0.i]	0.199	0.221 /0.088	0.261
Tip clearance (mm)	[c0.i(aControl)]	0.206	0.206 /0.218	0.176

Torsional angle of planet carrier with input fixed:
Total torsional angle (°) [j.tSys] 0.3223/0.2066 (0°19'20"/ 0°12'24")
Torsional angle on input with output fixed:
Total torsional angle (°) [j.tSys] 1.4504/0.9296 (1°27'2"/ 0°55'46")

12 Toothing tolerances

		--- Sun -------	Planets ------	Internal gear ---
According to ISO 1328-1:2013, ISO 1328-2:1997				
Accuracy grade	[Q]	A6	A6	A6
Single pitch tolerance (µm)	[fpT]	8.00	8.00	8.00
Base pitch tolerance (µm)	[fpbT]	7.52	7.52	7.52
Sector pitch tolerance (µm)	[Fpz/8T]	16.00	15.00	17.00
Profile form tolerance (µm)	[ffαT]	8.00	8.00	8.00
Profile slope tolerance (µm)	[fHαT]	6.50	6.50	6.50
Profile tolerance, total (µm)	[FαT]	10.00	10.00	10.00
Helix form tolerance (µm)	[ffβT]	8.00	8.50	8.50
Helix slope tolerance (µm)	[fHβT]	7.50	7.50	8.00
Helix tolerance, total (µm)	[FβT]	11.00	11.00	12.00
Cumulative pitch tolerance, total (µm)	[FpT]	22.00	23.00	26.00
Adjacent pitch difference tolerance (µm)	[fuT]	11.00	11.00	11.00
Runout tolerance (µm)	[FrT]	20.00	21.00	24.00
Single flank composite tolerance, total (µm)	[FisT]	30.00	31.00	34.00
Single flank composite tolerance, tooth-to-tooth (µm)	[fisT]	8.00	8.00	8.00
Radial composite tolerance, total (µm)	[FidT]	23.00	23.00	27.00
Radial composite tolerance, tooth-to-tooth (µm)	[fidT]	6.50	6.50	6.50

FidT (Fi") and fidT (fi") according to ISO 1328:1997 calculated with the geometric mean values for m_n and d.

According to ISO 1328-2:2020				
Accuracy grade	[Q]	R37	R37	R38
Radial composite tolerance, total (µm)	[FidT]	20.00	20.00	25.00
Radial composite tolerance, tooth-to-tooth (µm)	[fidT]	9.00	9.00	11.00

		-- Pair 1 ----------	Pair 2 --

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

Maximum value for deviation error of axis (µm)	[fΣβ]	7.150	7.150
Maximum value for inclination error of axes (µm)	[fΣδ]	14.300	14.300

13 Modifications and determination of the tooth form

13.1 Data for the tooth form calculation

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

14 Supplementary data

14.1 Masses, stiffnesses and moments of inertia

		--- Sun -------	Planets ------	Internal gear ---
Mass (g)	[m]	34.147	44.972	161.835
Total mass (g)	[Σm]	330.90		
Moment of inertia for system, relative to the input:				
calculation without consideration of the exact tooth shape				
Single gears (da+df)/2...di (kg*m²)	[J]	4.779e-06	1.061e-05	0.0004792
System (da+df)/2...di (kg*m²)	[J]	2.635e-05		
Torsional stiffness at driving gear with fixed driven gear:				
Torsional stiffness (MNm/rad)	[cr]	0.029		
Torsion when subjected to nominal torque (°)	[δcr]	0.032		

14.2 Wear, power loss, sound pressure level

		-- Pair 1 ----------	Pair 2 --
Average coefficient of friction according to Niemann	[μ_m]	0.117	0.079
Wear sliding coefficient by Niemann	[ζw]	0.613	0.258
Loss factor	[HV]	0.137	0.052
Meshing power (kW)		1.556	1.556
Gear power loss (kW)	[PVZ]	0.008	0.002
Total power loss (kW)		0.031	
Total efficiency		0.984	
Sound pressure level based on Masuda, without PPTE/δs	[dB(A)]	46.085	48.488

14.3 Planet phase parameters

Distance between planets: Equal
Phase type: Sequential phase

Planet No.	Planet angle (°)	Phase angles sun - planet (°)	Phase angles planet - inner gear (°)
1	0.00	0.00	0.00
2	120.00	240.00	120.00
3	240.00	120.00	240.00

15 Service life, damage

Required safety for tooth root	[S_{Fmin}]	1.2600
Required safety for tooth flank	[S_{Hmin}]	0.9300
Required service life	[H]	20000.0000

Service life (calculated with required safeties):

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

		--- Sun -------	Planets ------	Internal gear ---
Tooth root service life (h)	[HFatt]	1e+06	1e+06	1e+06
Tooth flank service life (h)	[HHatt]	1e+06	1e+06	1e+06

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 (%)	F_3 (%)	H_1 (%)	H_2 (%)	H_3 (%)
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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	168000	1.700e+00	9.654e+29	1.484e+30	100.0000
1	Tooth flank	168000	1.300e+00	9.014e+29	4.295e+30	100.0000
2	Tooth root	45630	1.700e+00	9.654e+29	1.484e+30	100.0000
2	Tooth flank	45630	1.300e+00	9.014e+29	4.295e+30	100.0000
3	Tooth root	48000	1.700e+00	9.654e+29	1.484e+30	100.0000
3	Tooth flank	48000	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

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}]	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

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
  $f_{m\alpha}$ according to equation 64, $F_{\beta x}$ according to 52/53/56
  f_{sh} calculated accurately according to the method in Annex D,
  ISO 6336-1:2006
  Literature: Journal "Antriebstechnik", 6/2007, p.64.
  $K_{H\alpha}$, $K_{F\alpha}$ according to Method B
- The logarithmically interpolated value must be entered for factors Z_L, Z_V, Z_R, Z_W, Z_X, $Y_{\delta relT}$, Y_{RrelT} and Y_X. This value is calculated from the infinite life strength and static strength values, based on the number of load cycles.

End of report (lines: 863)