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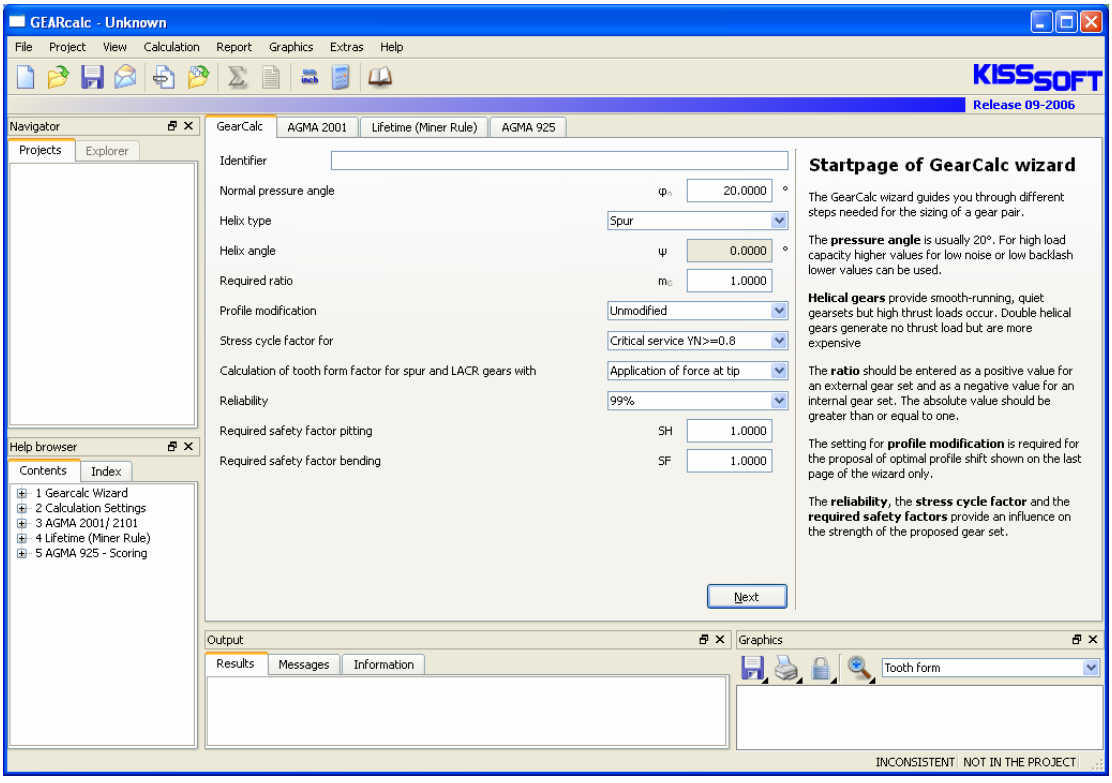
GEARCALC Tutorial 001: AGMA 2001

Keywords: AGMA 2001, GEARCALC
For release:
File: Dokument1
Created / modified: 06.10.2006, M.Fish / 18.01.2007 A. Halter
Download:

Starting GEARCALC

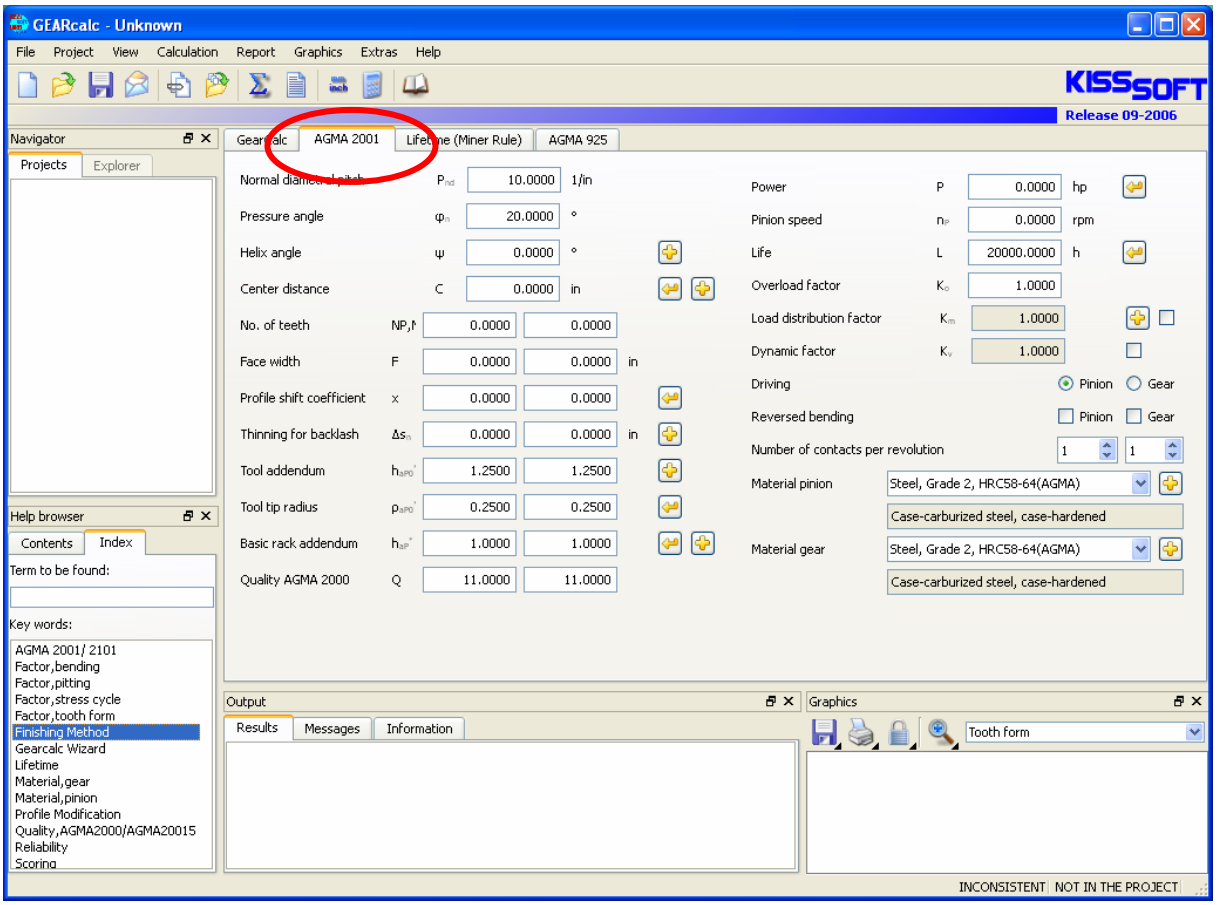
Starting GEARCALC

After installation, an icon can be found in the program list accessed using 'Start' in the bottom left hand corner of the screen. Alternatively click on the GEARCALC icon in the Windows Browser under "C:\Programs\GEARCALC\Bin\gearcalc.exe". The following window will appear:



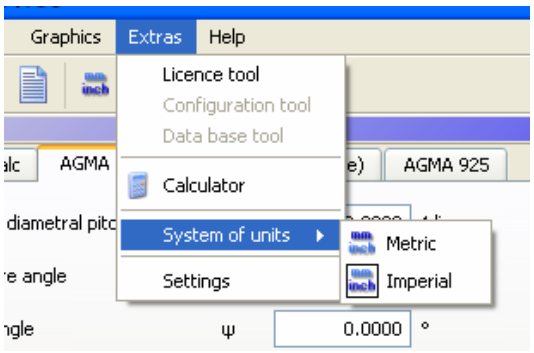
Select Calculation according to AGMA 2001

Click the tab AGMA 2001:



Selecting AGMA 2001 or AGMA 2101

If the program is set to use imperial units then the calculation will automatically be AGMA 2001. If this is changed to Newton units then the calculation method is AGMA 2101. To change the unit system select Extras->System of Units in the main menu.



Enter Data

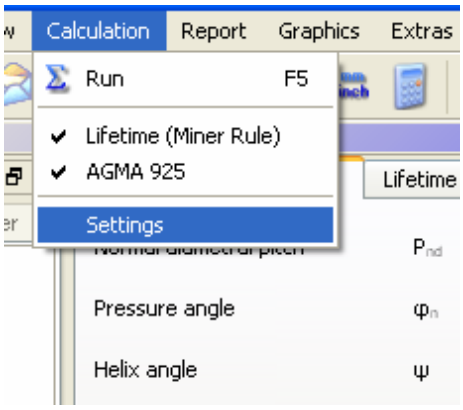
Task description – Motor 2:1 reduction set

A 60hp 1750rpm electric motor drives a belt conveyor through 2:1 reduction spur. This is a general industrial application and not critical in performance.

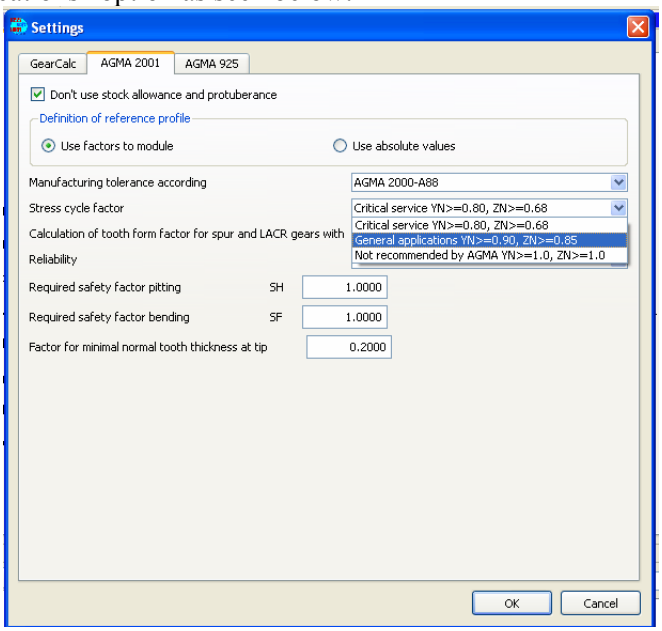
Enter Data For AGMA 2001

Define Operating Settings

Choose Calculation->Settings from the menu system:



A dialog containing the settings for the various settings will appear, and the AGMA 2001 tab will already be selected. The definition of the task calls for a calculation based on a general application. Set the "Stress cycle factor" to the "General applications" option as seen below:



Press OK to save the new settings and return to the main dialog.

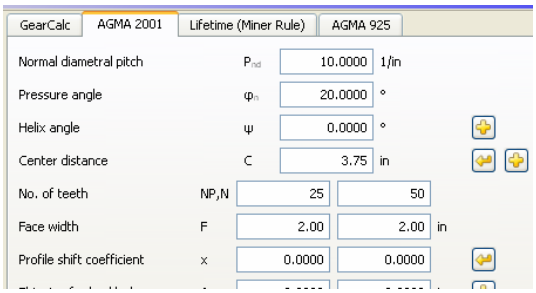
Macro Geometry

The following geometry is defined for the example:

P_{nd} = 10.0
ϕ_C = 20°
ψ_S = 0°
C = 3.75 in
N_S = 25
N_S = 50
F_1 = 2 in
F_2 = 2 in

$x_1 = x_2 = 0.0$

These values are entered directly in the cells provided:

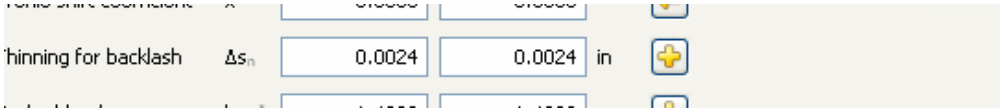


Tooth Thinning For Backlash

Both pinion and gear teeth are thinned 0.0024 in to obtain 0.0048 in backlash:

$\Delta s_{n1} = \Delta s_{n2} = 0.0024$ in

Enter these values in both cells provided:



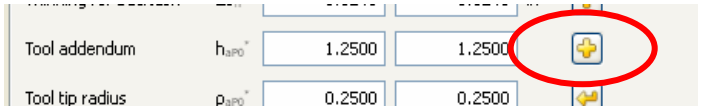
Tool Geometry

Tool Addendum

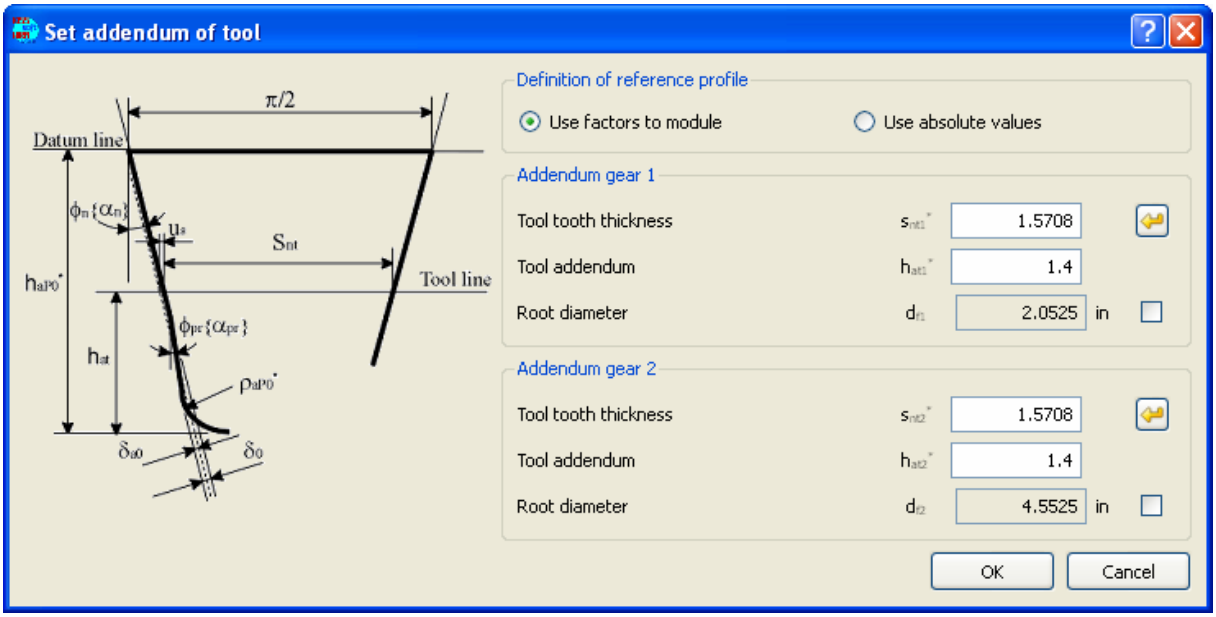
The gears are precision hobbed using the same hob. The definition of profile when set to 'Use factors to module' (in terms of $P_{nd} = 1.0$) is:

s_{nt}^* = $\pi/2$ = 1.5708
h_{at}^* = 1.4

The plus button beside the 'Tool Addendum' field can be used to define the addendum form.



A window will open illustrating the profile definitions. Enter the values for s_{nt}^* and h_{at}^* in the cells for both gears. Click on the 'Root Diameter' cell after each value entry to ensure the correct value is recalculated.



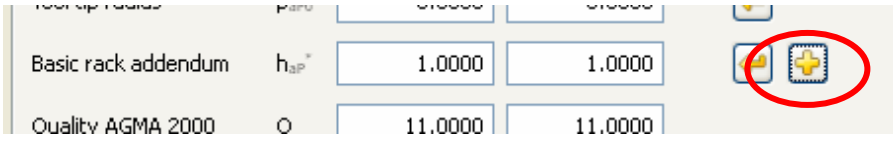
Press OK to confirm the input and return to the main interface. The value of $h_{aP0}^* = 1.4$ is determined for both gears.

Tip Radius

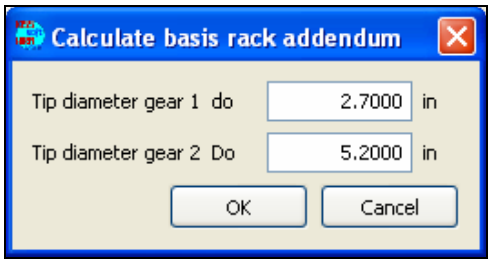
Enter the tip radius $\rho_{aP0}^* = 0.35$ for both gears in the cells provided.

Basic Rack Addendum

The tip diameter values d_0 and D_0 can be entered pressing the plus button beside the 'Basic Rack Addendum' field.

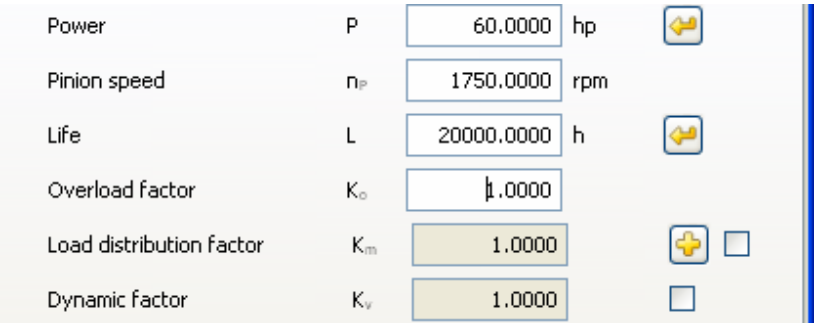


The following window will appear. In this case no adjustment will be needed, so simply confirm the existing values d_0 = 2.7in and D_0 = 5.2in by pressing OK.



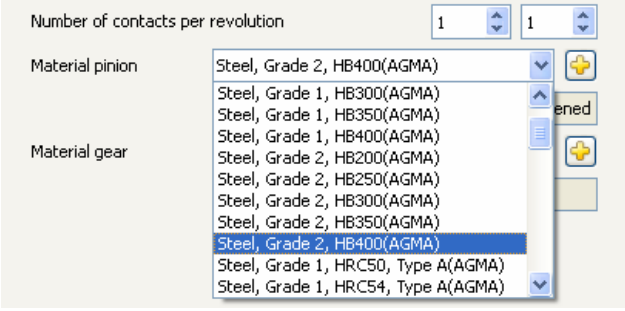
De-Rating Factors

Assume the transmitted power has been determined from field experience to be 60 hp. The pinion speed is 1750 rpm. Also assume the gear set is smooth running, evenly loaded and infrequently started/stopped. The overload factor is therefore set to unity. The load distribution factor, K_m, and dynamic factor, K_v, are left as unity and will be determined later by the calculation procedure for the given settings.



Materials

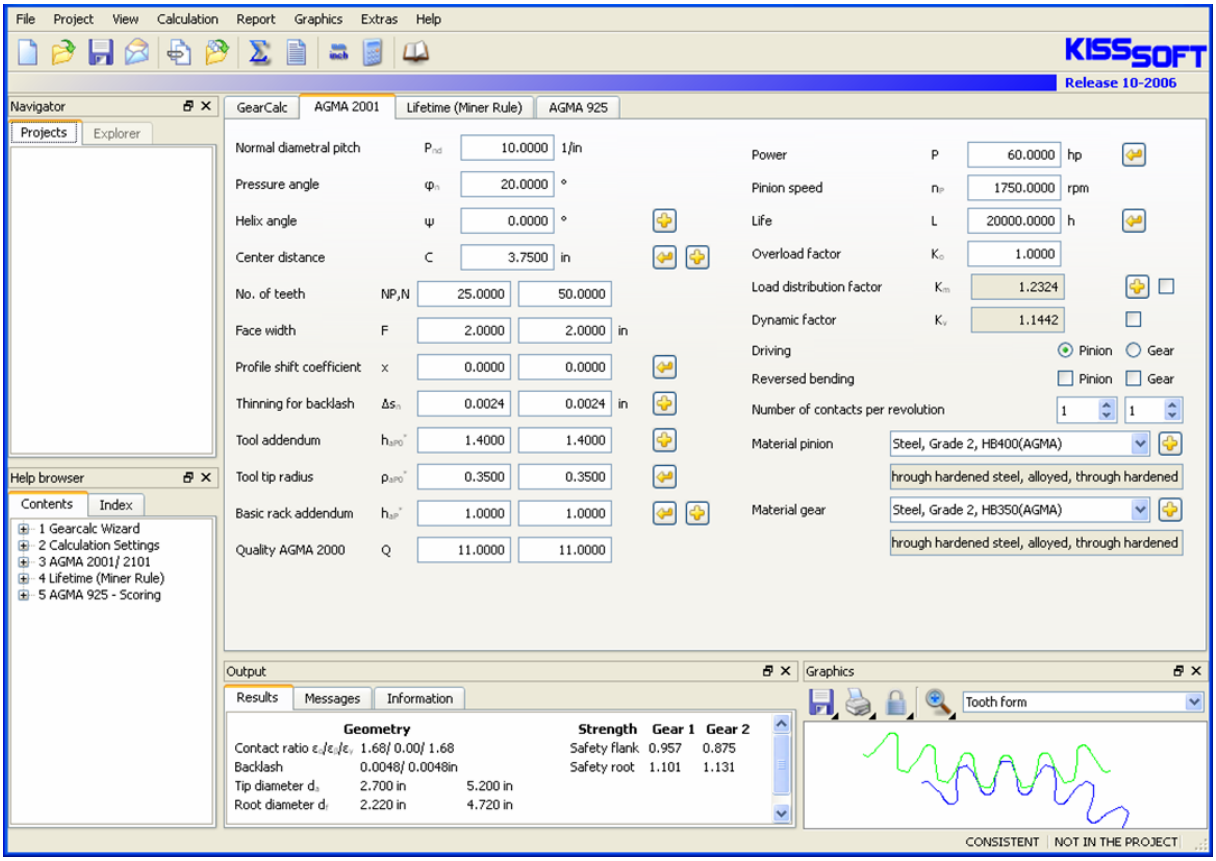
Choose the gear material ‘Steel, Grade 2, HB400(AGMA) from the drop down menu provided.



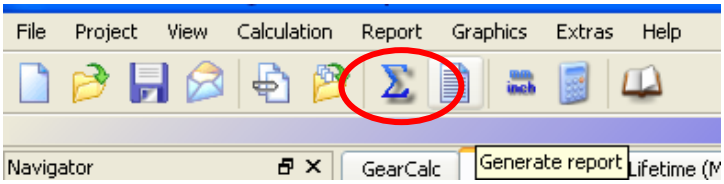
Repeat for the gear material but now select the ‘Steel, Grade 2, HB350(AGMA) entry.

Run Calculation after AGMA 2001 Data Entry

Run the AGMA 2001 calculation to check the data entry by clicking the calculate button:  . On doing this, the tooth mesh and safety factors based on the input will be shown in the 'Graphics' and 'Output' windows respectively.



A text report is generated by pressing the 'Report' button in the toolbar above the interface:



A text report document for this analysis can be found in Annex I.

ANNEX I

KISSSOFT
Berechnungsprogramme für den Maschinenbau

GEARCALC - Release 10-2006
GEARCALC beta version

File
Name : Tutorial No 1 AGMA 2001
Changed by : MF on: 20.10.2006 at: 15:43:48

RESULTS FOR RESISTANCE CALCULATION FOLLOWING AGMA2001-D04 STANDARD

INPUT DATA SUMMARY

GEAR GEOMETRY DATA			Pinion	Gear
Tooth number	NP,NG	=	25	50
Net face width	F1,F2	=	2.0000	2.0000
Outside diameter	do,Do	=	2.7000	5.2000
Normal diametral pitch (1/in)	Pnd	=	10.0000	
Normal pressure angle	PHI(n)	=	20.0000	
Standard helix angle	PSI(s)	=	0.0000	
Operating center distance	C	=	3.7500	
Centre distance tolerance	C.e/i	=	0.0000 / 0.0000	
Gear geometry data for Pnd = 1.0				
Profile shift coefficient	X1,X2	=	0.00000	0.00000
Thinning for backlash del.sn1,	del.sn2	=	0.02400	0.02400
Stock allow. per side for finishing	Us1,Us2	=	0.00000	0.00000
Tool geometry data for Pnd = 1.0				
Tool normal tooth thickness	tce1,tce2	=	1.5708	1.5708
Tool addendum	hao1,hao2	=	1.4000	1.4000
Tool tip radius	rTe1,rTe2	=	0.3500	0.3500
Tool protuberance DELTA(o1),DELTA(o2)		=	0.0000	0.0000

MATERIALS/HEAT-TREATMENT DATA

Material (Pinion) = Steel, Grade 2, HB400(AGMA)
AGMA 2001-C95; AGMA 2101-C95
Material (Gear) = Steel, Grade 2, HB350(AGMA)
AGMA 2001-C95; AGMA 2101-C95
Material type = Through hardened ste Through hardened ste
Heat-treatment = alloyed, through har alloyed, through har

LOAD DATA			Pinion	Gear
Transmitted power (HP)	P	=	60.0000	
Pinion speed (rpm)	n(P)	=	1750.0000	
Required life (HRS)	L	=	20000	
Reliability	R	=	99 %	
Driving:		=	PINION	
Number of contacts per revolution		=	1	1
Reversed bending (0=No; 1=Yes)		=	0	0
Spur gear loading type		=	TIP	
Stress cycle factors, Curve chosen, Figs. 17 & 18		=	Upper (for general applications)	

DERATING FACTORS

Overload (or application) factor	Ko	=	1.0000	
Size factor	Ks	=	1.0000	
Surface condition factor	Cf	=	1.0000	
Rim thickness factor	KB	=	1.0000	1.0000

Load distribution factor	Km =	1.2324
Dynamic factor	Kv =	1.1442

GEOMETRY SUMMARY-1

		Pinion	Gear
Generating pitch dia	ds,Ds =	2.5000	5.0000
Operating pitch dia	d,D =	2.5000	5.0000
Base dia	db,Db =	2.3492	4.6985
Mean dia of pinion	dm =	2.5000	
Root diameter (manufactured)	dR,DR =	2.2134/2.2134	4.7134/4.7134
Limit (SAP) (manufactured)	dc,Dc =	2.3733	4.8579
Top of fillet (manufactured)	de,De =	2.3541/2.3541	4.8051/4.8051

PRESSURE ANGLES

Standard transverse	PHI(s) =	20.0000
Operating transverse	PHI(t) =	20.0000
Standard normal	PHI(c) =	20.0000
Operating normal	PHI(n) =	20.0000

HELIX ANGLES

Standard	PSI(s) =	0.0000
Operating	PSI =	0.0000
Base	PSI(b) =	0.0000

PITCHES

Transverse diametral	Pd =	10.0000
Transverse circular	p =	0.3142
Normal circular	pn =	0.3142
Transverse base	pb =	0.2952
Normal base	pN =	0.2952
Axial	px =	------

DISTANCES ALONG LINE OF ACTION

Start of active profile (SAP)	C1 =	0.1685
Low single tooth contact (LPSTC)	C2 =	0.3702
Pitch point	C3 =	0.4275
High single tooth contact (HPSTC)	C4 =	0.4637
End of active profile (EAP)	C5 =	0.6654
Distance between interference points	C6 =	1.2826
Active length of line of action	Z =	0.4969
Pinion addendum portion of Z	Za =	0.2379
Pinion dedendum portion of Z	Zb =	0.2590
Dist. from pitch point to stress calc	Zc =	0.0573

LENGTH OF CONTACT LINE

Minimum	Lmin =	2.0000
Maximum	Lmax =	4.0000
Average	Lavg =	3.0000

RATIOS

Contact length	mL =	2.0000
Transverse (profile) contact	mp =	1.6832
Axial (face) contact	mF =	0.0000
Total contact	mt =	1.6832
Gear ratio	mG =	2.0000
Load sharing (mN = F/Lmin)	mN =	1.0000

TRANSVERSE RADII OF CURVATURE

At operating pitch point of pinion	RP =	0.4275
At operating pitch point of gear	RG =	0.8551
At point of stress calc of pinion	R1 =	0.3702
At point of stress calc of gear	R2 =	0.9124

TOOTH DEPTHS

Operating addendum	a1,a2 =	0.1000	0.1000
Operating dedendum	b1,b2 =	0.1433	0.1433
Operating clearance	c1,c2 =	0.0433	0.0433
Whole depth	ht1,ht2 =	0.2433	0.2433
Working depth	hK =	0.2000	

TRANSVERSE CIRCULAR TOOTH THICKNESSES (manufactured)

Topland	to1,to2 =	0.0694/0.0694	0.0750/0.0750
Operating	tr1,tr2 =	0.1547/0.1547	0.1547/0.1547
Generating	tg1,tg2 =	0.1547/0.1547	0.1547/0.1547
Base	tb1,tb2 =	0.1804/0.1804	0.2154/0.2154

NORMAL CIRCULAR TOOTH THICKNESSES (manufactured)

Topland	tno1,tno2 =	0.0694/0.0694	0.0750/0.0750
Operating	tnr1,tnr2 =	0.1547/0.1547	0.1547/0.1547
Generating	tng1,tng2 =	0.1547/0.1547	0.1547/0.1547
Base	tnb1,tnb2 =	0.1804/0.1804	0.2154/0.2154

LEAD	L1,L2 =	0.0000	0.0000

OPERATING CIRCULAR BACKLASH (manufactured)

Transverse (only through Center dist. tol.)	=	0.0000/ 0.0000
Transverse (total)	B =	0.0048/ 0.0048
Normal (total)	Bn =	0.0045/ 0.0045

PROFILE SHIFT COEFFICIENTS FOR MANUFACTURING

Theoretical, no backlash	X1,X2 =	0.0000	0.0000
Manufacturing	Xe1,Xe2 =	-0.0330/ -0.0330	-0.0330/ -0.0330

NOTE: All dims in inches, all angles in degrees.
All geometry data, which are not declared as 'manufacturing',
are for the theoretical (no backlash) tooth meshing situation.

GEOMETRY SUMMARY-2

PITTING RESISTANCE GEOMETRY FACTOR DATA

Helical overlap factor	C(PSI) =	1.0000
Minimum length of contact	Lmin =	2.0000
Pitting resistance geometry factor	I =	0.0990

BENDING STRENGTH GEOMETRY FACTOR DATA

		Pinion	**Gear**
Load angle	PHI(L) =	28.059	24.544
Height of Lewis parabola	h =	1.8902	1.9199
Tooth thickness at critical section	t =	1.8683	2.0914
Radius at curvature of fillet curve	ro =	0.4365	0.3952
Loaded at tip (No load sharing)			
(h, t, ro for Pnd = 1.0)			
Diameter of the critical point F	DFpoint =	2.2958	4.7866
Helical factor	Ch =	1.0000	
Helix angle factor	K(PSI) =	1.0000	
Stress correction factor	Kf =	1.4172	1.5143
Tooth form factor	Y =	0.3593	0.4277
Bending strength geometry factor	J =	0.2535	0.2824

LOAD / MATERIAL SUMMARY

Pitch line velocity	(FPM)	vt =	1145.4
Transmitted tangential load	(LB.)	Wt =	1728.7
Torque transmitted by pinion	(LB.IN.)	T(1) =	2160.9
Torque transmitted by gear	(LB.IN.)	T(2) =	4321.7
Contact load factor for pitting resist.		K =	518.4
Unit load factor for bending strength		U(L) =	8640.5

MATERIALS/HEAT TREATMENT DATA

Modulus of elasticity (lb/in²)	EP,EG =	30000000	30000000
Poisson's ratio	MU(P),MU(G) =	0.3000	0.3000
Surface hardness		HB 400	HB 350
Allowable contact stress	SAC(P), SAC(G) =	173900	156450
Allowable bending stress	SAT(P), SAT(G) =	57200	52100

DERATING FACTOR SUMMARY

Overload (or application) factor	Ko =	1.0000	
Size factor	Ks =	1.0000	
Surface condition factor	Cf =	1.0000	
Rim thickness factor	KB =	1.0000	1.0000
Load distribution factor	Km =	1.2324	
Transmission accuracy grade number	Qnu =	10	
Dynamic factor	Kv =	1.1442	
Combined derating factor pitting	Ko*Kv*Km*Ks*Cf =	1.4101	
Combined derating factor bending	Ko*Kv*Km*Ks*KB =	1.4101	

Km CALCULATED USING AGMA2001/2101 METHOD (CHAPTER 15)

Gear unit type: Commercial enclosed gear unit		
Mesh alignment factor	Cma =	0.1582
Mounting procedure: Without contact improvement at assembly		
Mesh alignment correction factor	Ce =	1.0000
Gearing: Without longitudinale flanc correction		
Lead correction factor	Cmc =	1.0000
Pinion proportion factor	Cpf =	0.0675
Pinion proportion modifier	Cpm =	1.1000
Large offset pinion (s1/s >= 0.175)		
Face load distribution factor	Cmf =	1.2324

NOTE: Transverse load distribution factor Cmt = 1.0

STRENGTH SUMMARY

		Pinion	**Gear**
Stress cycle factor (Contact)	Z(N) =	0.8843*a*	0.8985*a*
Surface condition factor	C(f) =	1.0000	1.0000
Hardness ratio factor	C(H) =	1.0000	1.0000
Temperature factor	K(T) =	1.0000	1.0000
Reliability factor	K(R) =	1.0000	
Allow. contact stress No. (lb/in²)	Sac =	153779	140571
Stress cycle factor (Root)	Y(N) =	0.9253*a*	0.9367*a*
Reverse loading factor	=	1.0000	1.0000
Allow. bending stress No. (lb/in²)	Sat =	52924	48804

a NOTE: Based on life (HRS) L = 20000
Curve chosen, Figs. 17 & 18 = Upper (for general applications)

STRESS SUMMARY

Elastic coefficient	(lb^.5/in)	Cp =	2290.0
Contact stress No.	(lb/in²)	Sc =	160726.5
Pinion bending stress No.	(lb/in²)	St1 =	48058.8
Gear bending stress No.	(lb/in²)	St2 =	43139.0

RESULTING SAFETY FACTORS

Safety factor (Bending)	Sat/st =	1.10	1.13
Safety factor (Contact)	Sac/sc =	0.96	0.87

SERVICE FACTORS

Service factor for bending	KSF =	1.10	1.13
Service factor for contact	CSF =	0.92	0.76
Service factor for gear set	SF =	0.76	

POWER RATING CALCULATION

(Calculation of the transmittable power)

			Pinion	**Gear** *a*
Allow. transmitted power for pitting (HP)	Pac =	54.92		45.90
Allow. transmitted power for bending (HP)	Pat =	66.07		67.88
Allowable transmitted power (HP)	P =		45.90	
Life factor for pitting resistance	Z(N) =	0.884 *b*		0.899 *b*
Life factor for bending resistance	Y(N) =	0.925 *b*		0.937 *b*
Durability (Pitting) life (HRS)	L(C) =	20000.0		20000.0
Durability (Pitting) life (CYCS/10^6)	N(C) =	2100.0		1050.0
Bending fatigue life (HRS)	L(T) =	20000.0		20000.0
Bending fatigue life (CYCS/10^6)	N(T) =	2100.0		1050.0

a NOTE: Based on allowable stresses at life (HRS) L = 20000
b NOTE: Pitting and Bending Life calculated for general applications
(Upper portion in fig. 17 and 18)

MANUFACTURING DATA

Tooth thickness dimensions

		Pinion	**Gear**
Thinning for backlash	As =	0.0024/ 0.0024	0.0024/ 0.0024
Normal circular tooth thickness	sn =	0.1547/ 0.1547	0.1547/ 0.1547
Span measurement	Wk =	0.7708/ 0.7708	1.6914/ 1.6914
Number of teeth spanned	k =	3.0000	6.0000
Diameter of span contact point	dWk =	2.4724	4.9936
Measurement over 1 ball	MrK =	1.3673/ 1.3673	2.6184/ 2.6184
Measurement over 2 balls	MdK =	2.7295/ 2.7295	5.2369/ 5.2369 *c*
Ball or roll diameter	DM =	0.1728	0.1728
Diameter of ball/roll contact point	dMM =	2.4979	5.0022
Normal chordal thickness	'sn =	0.1546/ 0.1546	0.1547/ 0.1547 *a*
Normal chordal height	ha =	0.1025	0.1012

a NOTE: Tooth thickness measured at generating pitch diameter
c NOTE: When measuring over 2 balls, the two balls must be in the same transverse plane.
NOTE: All dims in inches.

Tolerances

Following AGMA 2000-A88:

Accuracy grade	Q-AGMA2000 =	11	11
Pitch Variation Allowable (mil)	VpA =	2.6	2.9
Runout Radial Tolerance (mil)	VrT =	8.7	10.2
Profile Tolerance (mil)	VphiT =	3.3	3.7
Tooth Alignment Tolerance (mil)	VpsiT =	4.3	4.3
Composite Tolerance, Tooth-to-Tooth (mil)	VqT =	5.5	5.5
Composite Tolerance, Total (mil)	VcqT =	14.2	15.7

NOTE: All dims in 1/10000 in.

End report lines: 330