

Appendix – Example 1 runs

ISO 6336 2006 Rating, version 2.0031

FTM Paper Gear Set 1
151-29 5 mn a 20 18 helix
Nitrided

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American Gear Manufacturers Association
Gear Rating Suite - GUI Version 3.0.170

**** Gear Geometry Error Messages ****

42) Note: Zero backlash x factors are not being used for rating. The sum of X1 + X2, -0.1648 does not correspond to the value 0.0000 calculated from the center distance and the pressure angle.

**** Velocity Error Messages ****

4) WARNING: X-Factors are outside limits for mesh stiffness calculation.

**** Load Distribution Error Messages ****

5) Note: Mesh misalignment is approximated from gear quality.

**** Durability Factors Error Messages ****

3) Note: Pinion cycles above 1.E10, graph of flank (pitting) life factor extrapolated to 1.9705E11

4) Note: Gear cycles above 1.E10, graph of flank (pitting) life factor extrapolated to 3.7843E10

**** Strength Factors Error Messages ****

4) Note: Pinion cycles above 1.E10, graph of root (bending) life factor extrapolated to 1.9705E11

13) Note: Gear cycles above 1.E10, graph of root (bending) life factor extrapolated to 3.7843E10

**** Gear Geometry (External Gears) ****

		<u>Pinion</u>	<u>Gear (Wheel)</u>	
	Gear Set Type	Single Helical		
<i>z</i>	Number of Teeth	29	151	
<i>u</i>	Gear Ratio (Hunting Tooth Set)		5.2069	
<i>m_n</i>	Normal Module		5.0000	mm
<i>a</i>	Center Distance		18.6283	inch
<i>a_s</i>	Standard Center Distance		18.6283	inch
<i>b</i>	Face Width	6.2500	6.2500	inch
<i>b_{eff}</i>	Effective Face Width		6.2500	inch
<i>n</i>	Speed	18,744.8	3,600.0	rpm
<i>v_t</i>	Pitch Line Velocity		29,456.3	ft/min
<i>α_n</i>	Normal Reference Pressure Angle		20.0000	degrees
<i>α_{wt}</i>	Transverse Operating Pressure Angle		20.9419	degrees
<i>β</i>	Helix Angle		18.0000	degrees
<i>β_w</i>	Operating Helix Angle		18.0000	degrees
<i>h_t</i>	Whole depth	0.4887	0.4887	inch
<i>c</i>	Tip to Root Clearance	0.0950	0.0950	inch

Pinion Tip to Gear Root / Gear Tip to Pinion Root

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** Diameters **		<u>Pinion</u>	<u>Gear (Wheel)</u>	
d_a	Tip Diameter	6.3961	31.648	inch
h_a	Addendum	1.0000	1.0000	normalized
d	Reference Pitch Diameter	6.0024	31.254	inch
d_w	Operating (working) Pitch Diameter	6.0024	31.254	inch
d_{SAP}	Start of Active Profile (Minimum)	5.7104	30.932	inch
d_{SOI}	Start of Involute Diameter	5.6625	30.798	inch
d_b	Base Diameter	5.6059	29.1896	inch
d_f	Root Diameter	5.4188	30.670	inch

** Ratios **		<u>Pinion</u>	<u>Gear (Wheel)</u>
ϵ_α	Transverse (Profile) Contact Ratio	1.6405	
ϵ_β	Axial (Face) Contact Ratio	3.1230	
ϵ_γ	Total Contact Ratio	4.7635	
b_{eff} / d_w	Facewidth to Operating Pitch Diameter Ratio	1.0412	0.2000
b_{eff} / a	Facewidth to Center Distance Ratio	0.3355	0.3355

**** Line of Action Data ****

Gear Driving, First Contact Near Gear Root Sliding velocity is for pinion, change sign for gear sliding velocity
 Point C1 determined by gear tip diameter

<u>Points on line of action</u>	Distance on line of action	Pinion Roll Angle	Pinion Diameter inch	Gear Roll Angle	Gear Diameter inch	Sliding Velocity in/sec	Specific Sliding Pinion	Specific Sliding Gear
C1 Gear End of Active Profile	0.5435	11.1106	5.7104	24.0045	31.648	-1,238.19	-1.1605	0.5371
C2 Gear Highest Point STC	0.9325	19.0616	5.9080	22.4775	31.355	-328.02	-0.1792	0.1520
C3 Working Pitch Point	1.0727	21.9271	6.0024	21.9271	31.254	0.0000	0.0000	0.0000
C4 Gear Lowest Point STC	1.1508	23.5244	6.0601	21.6204	31.199	182.845	0.0809	-0.0881
C5 Gear Start of Active Profile	1.5398	31.4754	6.3961	20.0934	30.932	1,093.01	0.3616	-0.5665
C6 Total Line of Action Length	6.6581 inch							
Point C5 determined by Pinion Tip diameter								
Percent Approach Action: 46.89%								
Percent Recess Action: 53.11%								

**** Tool Data - Same for Pinion & Gear ****

** Tool Data - Same for Pinion & Gear **		<u>Hob or Rack Type Cutter</u>	
h_{aP}	ISO (1/2 pitch) Tool Addendum (from ref. line)	1.4000	normalized
s_0	Measured Tool Tooth Thickness	1.5708	normalized
pr	Protuberance of Tool	0.0000	inch
q	Finishing Stock Allowance - Normal	0.0000	inch
r_T	Tool Tip Radius	0.3936	normalized
h_{a0}	Hypothetical Tool Addendum	1.4000	normalized

**** Surface Finish ****

** Surface Finish **		<u>Pinion</u>	<u>Gear (Wheel)</u>	
R_a	Flank Roughness, Arithmetic Average	32.000	32.000	micro-inch
R_a	Root Roughness, Arithmetic Average	64.000	64.000	micro-inch

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 Gear Rating Suite - GUI Version 3.0.170

** Tooth Thickness **		<u>Pinion</u>	<u>Gear (Wheel)</u>	
s_{an}	Normal Tip Tooth Thickness	0.1347	0.1499	inch
	Normal Tip Tooth Thickness	0.6843	0.7613	normalized
a	Center Distance for Calculation of Zero Backlash (Mean)	18.6283		inch
$\Delta x/2$	Thinning for Backlash (on ref. diameter)	0.0600	0.0600	normalized
x	Profile Shift Coefficient (Zero Backlash x Factor)	0.0000	0.0000	normalized
Rating Based on Nominal (with thinning) Thickness				
j_t	Transverse Circular Backlash	0.0248		inch

** Configuration Data **		<u>Pinion</u>	<u>Gear (Wheel)</u>	
	Gear Blank Construction	Solid	Solid	
l	Pinion Shaft Bearing Span	8.0000		inch
s	Pinion Offset	0.0000		inch
d_{sh}	Pinion Shaft External Diameter	3.0000		inch
d_{shi}	Pinion Shaft Internal Diameter	0.0000		inch
	Tooth Alignment Correction		None	
ρ_F	Set Arrangement		ISO 6336-1 figure 13 A	
	Contact Pattern		Favorable	
ν_{40}	Kinematic Viscosity of Lubricant at 40 C	32.000		cSt
C_a	Design Tip Modification	0.0000		0.0001 in

** ISO Materials **		<u>Pinion</u>	<u>Gear (Wheel)</u>
	Material	NT: Gas Nitrided Steel	NT: Gas Nitrided Steel
	Material Sub-class		
	Material Quality	MQ	MQ

** Material Hardness **		<u>Pinion</u>	<u>Gear (Wheel)</u>
	Surface Hardness	90 Rockwell 15N	90 Rockwell 15N
	Note: Hardness conversions are approximate		

** Application Data (Wheel Driving) **		<u>Pinion</u>	<u>Gear (Wheel)</u>	
n	Speed	18,744.8	3,600.0	rpm
L	Design Life	20.0000		years
N_L	Design Life	1.9705E11	3.7843E10	cycles
	Contacts per Revolution	1	1	
	Idler?	No	No	

** Life Factor Data **		<u>Pinion</u>	<u>Gear (Wheel)</u>
N_L	Number of Cycles	1.9705E11	3.7843E10
Z_N	Pitting Durability Stress Cycle Factor (input)	0.0000	0.0000
Y_N	Bending Strength Stress Cycle Factor (input)	0.0000	0.0000
Z_{N10}	Pitting Durability Cycle Factor at 10^10	0.8500	0.8500
Y_{N10}	Bending Strength Cycle Factor at 10^10	0.8500	0.8500

** Tolerances **		<u>Pinion</u>	<u>Gear (Wheel)</u>
	ISO 1328-1 Accuracy Grade	6.0000	6.0000

**** ISO 6336 2006 Rating Output ****
Power Rating, Calculate from Safety Factor

**** ISO Factors ****

K_A	Application Factor	1.4000	
S_{Hmin}	Minimum Safety Factor, Durability	1.2000	
S_{Fmin}	Minimum Safety Factor, Strength	1.4000	
	Face Load Factor, Strength	Calculated	

**** Dynamic Factor ****

K_v	Dynamic Factor (Method B)	1.1665	
m_{red}	Reduced Mass of Pair	0.0741	lb/in
c'	Max.Single Pair Stiffness	12.6634	lb/(in μ in)
$c_{\gamma\alpha}$	Mean Value Mesh Stiffness per Unit Face - for K_v	18.7465	lb/(in μ in)
N_S	Resonance Ratio	3.5800	

**** Load Distribution Factor ****

	Tooth Alignment Correction	None	
	Set arrangement	ISO 6336-1 figure 13 A	
	Contact Pattern	Favorable	
$K_{H\beta}$	Face Load Factor, flank (Method B)	1.0962	
$K_{F\beta}$	Face Load Factor, root (Method B)	1.0884	
$K_{H\alpha}$	Trans.Load Factor, flank (Method B)	1.1332	
$K_{F\alpha}$	Trans Load Factor, root (Method B)	1.1332	
f_{sh0}	Unit Load Shaft Deflection	0.0249	0.0001 in
$F_{\beta x}$	Initial Equivalent Misalignment	7.2653	0.0001 in
$F_{\beta y}$	Effective Equiv Misalignment	6.1755	0.0001 in
$c_{\gamma\beta}$	Mesh stiffness per Unit Face - for $K_{H\beta}$	15.9345	lb/(in μ in)

Type of Rating:

Power Rating, Calculate from Safety Factor

** Surface Durability Rating Factors **		<u>Pinion</u>	<u>Gear (Wheel)</u>
Z _H	Zone Factor	2.3944	
Z _E	Elastic Factor	189.812	(lb/in ²) ^{1/2}
Z _ε	Contact Ratio Factor	0.7808	
Z _β	Helix Angle Factor	1.0254	
Z _B , Z _D	Single Pair Tooth Contact Factor	1.0000	1.0000
Z _{NT}	Life Factor, static	1.0000	1.0000
	Life Factor, reference	0.8500	0.8500
Z _L	Lubrication Factor, static	1.0000	
	Lubrication Factor, reference	0.9224	
Z _R	Roughness Factor, static	1.0000	
	Roughness Factor, reference	0.9833	
Z _V	Velocity Factor, static	1.0000	
	Velocity Factor, reference	1.0690	
Z _W	Work Hardening Factor, static	1.0000	1.0000
	Work Hardening Factor, reference	1.0000	1.0000
Z _X	Size Factor	1.0000	
** Bending Strength Rating Factors **		<u>Pinion</u>	<u>Gear (Wheel)</u>
Y _F	Tooth Form Factor	1.5013	1.2643
Y _S	Stress Correction Factor	1.7976	2.1428
	Contact Ratio	0.6686	
Y _{DT}	Deep Tooth Factor	1.0000	
	Rim Thickness Factor	1.0000	1.0000
Y _β	Helix Angle Factor	0.8500	
Y _{NT}	Life Factor, static	1.0000	1.0000
	Life Factor, reference	0.8500	0.8500
Y _{δrelT}	Relative Notch Sensitivity Factor, static	0.9595	1.0286
	Relative Notch Sensitivity Factor, reference	0.9616	0.9989
Y _{RrelT}	Relative Surface Factor, static	1.0000	1.0000
	Relative Surface Factor, reference	0.9948	0.9948
Y _X	Size Factor, static	1.0000	1.0000
	Size Factor, reference	1.0000	1.0000

**** MAIN RATING VALUES ****

** Surface Durability Ratings **		<u>Pinion</u>	<u>Gear (Wheel)</u>
σ_{Hlim}	Allowable Stress Number, contact	1,250.00	1,250.00
σ_{HG}	Pitting Stress Limit, static	1,212.04	1,212.04
	Pitting Stress Limit, reference	1,030.24	1,030.24
σ_{HP}	Permissible Contact Stress, static	1,010.03	1,010.03
	Permissible Contact Stress, reference	858.53	858.53
σ_{HP}	Permissible contact Stress	811.06	837.00
σ_{H0}	Nominal Contact Stress		569.43
σ_H	Contact Stress	811.06	811.06
S_H	Durability Safety Factor	1.2000	1.2384
** Bending Strength Ratings **		<u>Pinion</u>	<u>Gear (Wheel)</u>
σ_{Flim}	Allowable Bending Stress	420.00	420.00
σ_{FG}	Tooth Root Stress Limit, static	803.52	834.73
	Tooth Root Stress Limit, reference	682.99	709.52
σ_{FP}	Permissible Tooth Root Stress, static	573.94	596.23
	Permissible Tooth Root Stress, reference	487.85	506.80
σ_{FP}	Permissible Tooth Root Stress	459.57	493.46
σ_{F0}	Nominal Tooth Root Stress	143.712	144.271
σ_F	Tooth Root Stress	289.480	290.605
S_F	Strength Safety Factor	2.2226	2.3773
** POWER SUMMARY **		<u>Pinion</u>	<u>Gear (Wheel)</u>
F_t	Tangential Force	11,179.1	lbf
	Torque	33,551.	174,697. in-lb
	Power at Specified Safety factor	9,978.7	hp

API 613 5th Edition Rating

FTM Paper Gear Set 1
151-29 5 mn a 20 18 helix
Nitrided

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American Gear Manufacturers Association
Gear Rating Suite - GUI Version 3.0.170

** AGMA 6011 Error Messages **

Note: All 6011 warnings also apply to API 613

7) Note, see AGMA 6011 I03 Table 2 for recommended accuracy grades as a function of pitch line velocity

** API 613 Error Messages **

5) Warning, standard violated: Pinion Tooth accuracy must be ISO 1328-1 grade 4 or better

6) Warning, standard violated: Gear Tooth accuracy must be ISO 1328-1 grade 4 or better

** Gear Geometry (External Gears) **

		<u>Pinion</u>	<u>Gear (Wheel)</u>	
Gear Set Type		Single Helical		
N_P N_G	Number of Teeth	29	151	
m_G	Gear Ratio (Hunting Tooth Set)	5.2069		
m_n	Normal Module	5.0000		mm
C	Center Distance	18.6283		inch
	Standard Center Distance	18.6283		inch
F	Face Width	6.2500	6.2500	inch
F	Effective Face Width	6.2500		inch
n	Speed	18,744.8	3,600.0	rpm
v_t	Pitch Line Velocity	29,456.3		ft/min
ϕ_n	Normal Reference Pressure Angle	20.0000		degrees
ϕ_t	Transverse Operating Pressure Angle	20.9419		degrees
ψ_s	Helix Angle	18.0000		degrees
	Operating Helix Angle	18.0000		degrees
h_t	Whole depth	0.4887	0.4887	inch
c	Tip to Root Clearance	0.0950	0.0950	inch

Pinion Tip to Gear Root / Gear Tip to Pinion Root

** Diameters **

		<u>Pinion</u>	<u>Gear (Wheel)</u>	
d_o D_o	Tip Diameter	6.3961	31.648	inch
a_{oP} a_{oG}	Addendum	1.0000	1.0000	normalized
D	Reference Pitch Diameter	6.0024	31.254	inch
d	Operating (working) Pitch Diameter	6.0024	31.254	inch
d_{SAP}	Start of Active Profile (Minimum)	5.7104	30.932	inch
	Start of Involute Diameter	5.6625	30.798	inch
D_b	Base Diameter	5.6059	29.1896	inch
D_R	Root Diameter	5.4188	30.670	inch

** Ratios **

		<u>Pinion</u>	<u>Gear (Wheel)</u>	
m_P	Transverse (Profile) Contact Ratio	1.6405		
m_F	Axial (Face) Contact Ratio	3.1230		
m_t	Total Contact Ratio	4.7635		
	Facewidth to Operating Pitch Diameter Ratio	1.0412	0.2000	
	Facewidth to Center Distance Ratio	0.3355	0.3355	

API 613 5th Edition Rating

FTM Paper Gear Set 1
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 Nitrided

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** Line of Action Data **

Gear Driving, First Contact Near Gear Root Sliding velocity is for pinion, change sign for gear sliding velocity
 Point C1 determined by gear tip diameter

	Distance on line of action	Pinion Roll Angle	Pinion Diameter inch	Gear Roll Angle	Gear Diameter inch	Sliding Velocity in/sec	Specific Sliding Pinion	Specific Sliding Gear
<u>Points on line of action</u>								
C1 Gear End of Active Profile	0.5435	11.1106	5.7104	24.0045	31.648	-1,238.19	-1.1605	0.5371
C2 Gear Highest Point STC	0.9325	19.0616	5.9080	22.4775	31.355	-328.02	-0.1792	0.1520
C3 Working Pitch Point	1.0727	21.9271	6.0024	21.9271	31.254	0.0000	0.0000	0.0000
C4 Gear Lowest Point STC	1.1508	23.5244	6.0601	21.6204	31.199	182.845	0.0809	-0.0881
C5 Gear Start of Active Profile	1.5398	31.4754	6.3961	20.0934	30.932	1,093.01	0.3616	-0.5665
C6 Total Line of Action Length	6.6581 inch							
Point C5 determined by Pinion Tip diameter								
Percent Approach Action:	46.89%							
Percent Recess Action:	53.11%							

** Tool Data - Same for Pinion & Gear **

		Hob or Rack Type Cutter	
h_a	ISO (1/2 pitch) Tool Addendum (from ref. line)	1.4000	normalized
t_m	Measured Tool Tooth Thickness	1.5708	normalized
δ_{a0}	Protuberance of Tool	0.0000	inch
	Finishing Stock Allowance - Normal	0.0000	inch
r_T	Tool Tip Radius	0.3936	normalized
h_{a0}	Hypothetical Tool Addendum	1.4000	normalized

** Tooth Thickness **

		<u>Pinion</u>	<u>Gear (Wheel)</u>	
t_o	Normal Tip Tooth Thickness	0.1347	0.1499	inch
	Normal Tip Tooth Thickness	0.6843	0.7613	normalized
C	Center Distance for Calculation of Zero Backlash (Mean)	18.6283		inch
Δ_n	Thinning for Backlash (on ref. diameter)	0.0600	0.0600	normalized
x	Profile Shift Coefficient (Zero Backlash x Factor)	0.0000	0.0000	normalized

Rating Based on Nominal (with thinning) Thickness

B_t	Transverse Circular Backlash	0.0248	inch
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** API Materials **

	<u>Pinion</u>	<u>Gear (Wheel)</u>
	Material is Steel	
Heat Treatment	Nitrided	Nitrided
Surface Hardness	90.0 Rockwell 15N	90.0 Rockwell 15N

Note: Hardness conversions are approximate

** Application Data (Wheel Driving) **

	<u>Pinion</u>	<u>Gear (Wheel)</u>	
n_p	Speed	18,744.8	3,600.0 rpm
q	Contacts per Revolution	1	1
	Idler?	No	No

API 613 5th Edition Rating

FTM Paper Gear Set 1
 151-29 5 mn a 20 18 helix
 Nitrided

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 American Gear Manufacturers Association
 Gear Rating Suite - GUI Version 3.0.170

** API 613 Data **

		<u>Pinion</u>	<u>Gear (Wheel)</u>	
I_m	Material Index Number (pitting allowable)	300.23	300.23	psi
S_a	Bending Stress Number (allowable)	27,557.2	27,557.2	psi
	Type of Rating:	Power Rating, Calculate from Service Factor		
SF	API 613 Service Factor (input)	1.4000		

** AGMA 908 DATA (normalized) **

		<u>Pinion</u>	<u>Gear (Wheel)</u>	
K_f	Stress Correction Factor	1.4277	1.5500	
I	I-Factor	0.2363		
J	J-Factor	0.5467	0.6264	

** API 613 RATING OUTPUT **

** PITTING **

K_a	Tooth Pitting Index, allowable	214.449	psi
	Allowable Power at input Service Factor	6,024.2	hp

** BENDING **

		<u>Pinion</u>	<u>Gear (Wheel)</u>	
	Allowable Power at input Service Factor	6,903.3	7,909.8	hp

** POWER SUMMARY **

	Allowable Power at Input Service Factor	6,024.2	hp
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**** Strength and Stress Cycle Factor Error Messages ****

172) WARNING: Number of cycles exceeds the range defined in the standard, stress cycle factors extrapolated beyond 1E10 cycles

**** Effective Case Error Messages ****

213) WARNING: Contact stress is not known, case depth as a function of contact stresses is undefined

214) WARNING: Contact stress is not known, core hardness coefficient is undefined

**** AGMA 6011 Error Messages ****

7) Note, see AGMA 6011 I03 Table 2 for recommended accuracy grades as a function of pitch line velocity

		** Gear Geometry (External Gears) **		
		<u>Pinion</u>	<u>Gear (Wheel)</u>	
Gear Set Type		Single Helical		
N_P	N_G Number of Teeth	29	151	
m_G	Gear Ratio (Hunting Tooth Set)	5.2069		
m_n	Normal Module	5.0000	mm	
C	Center Distance	18.6283	inch	
	Standard Center Distance	18.6283	inch	
F	Face Width	6.2500	6.2500	inch
F	Effective Face Width	6.2500 inch		
n	Speed	18,744.8	3,600.0	rpm
v_t	Pitch Line Velocity	29,456.3 ft/min		
ϕ_n	Normal Reference Pressure Angle	20.0000 degrees		
ϕ_t	Transverse Operating Pressure Angle	20.9419 degrees		
ψ_s	Helix Angle	18.0000 degrees		
	Operating Helix Angle	18.0000 degrees		
h_t	Whole depth	0.4887	0.4887	inch
c	Tip to Root Clearance	0.0950	0.0950	inch
		Pinion Tip to Gear Root / Gear Tip to Pinion Root		
		<u>Pinion</u>	<u>Gear (Wheel)</u>	
d_o	D_o Tip Diameter	6.3961	31.648	inch
a_{oP}	a_{oG} Addendum	1.0000	1.0000	normalized
D	Reference Pitch Diameter	6.0024	31.254	inch
d	Operating (working) Pitch Diameter	6.0024	31.254	inch
d_{SAP}	Start of Active Profile (Minimum)	5.7104	30.932	inch
	Start of Involute Diameter	5.6625	30.798	inch
D_b	Base Diameter	5.6059	29.1896	inch
D_R	Root Diameter	5.4188	30.670	inch

FTM Paper Gear Set 1
151-29 5 mn a 20 18 helix
Nitrided **40,000 Hours**

American Gear Manufacturers Association
Gear Rating Suite - GUI Version 3.0.170

** Ratios **		<u>Pinion</u>	<u>Gear (Wheel)</u>
m_p	Transverse (Profile) Contact Ratio	1.6405	
m_F	Axial (Face) Contact Ratio	3.1230	
m_t	Total Contact Ratio	4.7635	
	Facewidth to Operating Pitch Diameter Ratio	1.0412	0.2000
	Facewidth to Center Distance Ratio	0.3355	0.3355

**** Line of Action Data ****

Gear Driving, First Contact Near Gear Root Sliding velocity is for pinion, change sign for gear sliding velocity
Point C1 determined by gear tip diameter

	Distance on line	Pinion Roll Angle	Pinion Diameter inch	Gear Roll Angle	Gear Diameter inch	Sliding Velocity in/sec	Specific Sliding Pinion	Specific Sliding Gear
<u>Points on line of action</u>	of action							
C1 Gear End of Active Profile	0.5435	11.1106	5.7104	24.0045	31.648	-1,238.19	-1.1605	0.5371
C2 Gear Highest Point STC	0.9325	19.0616	5.9080	22.4775	31.355	-328.02	-0.1792	0.1520
C3 Working Pitch Point	1.0727	21.9271	6.0024	21.9271	31.254	0.0000	0.0000	0.0000
C4 Gear Lowest Point STC	1.1508	23.5244	6.0601	21.6204	31.199	182.845	0.0809	-0.0881
C5 Gear Start of Active Profile	1.5398	31.4754	6.3961	20.0934	30.932	1,093.01	0.3616	-0.5665
C6 Total Line of Action Length	6.6581 inch							
Point C5 determined by Pinion Tip diameter								
Percent Approach Action: 46.89%								
Percent Recess Action: 53.11%								

**** Tool Data - Same for Pinion & Gear ****

		Hob or Rack Type Cutter
h_a	ISO (1/2 pitch) Tool Addendum (from ref. line)	1.4000 normalized
t_m	Measured Tool Tooth Thickness	1.5708 normalized
δ_{a0}	Protuberance of Tool	0.0000 inch
	Finishing Stock Allowance - Normal	0.0000 inch
r_T	Tool Tip Radius	0.3936 normalized
h_{a0}	Hypothetical Tool Addendum	1.4000 normalized

**** Surface Finish ****

	<u>Pinion</u>	<u>Gear (Wheel)</u>
f_p	Flank Roughness, Arithmetic Average	32.000 micro-inch

**** Tooth Thickness ****

	<u>Pinion</u>	<u>Gear (Wheel)</u>
t_o	Normal Tip Tooth Thickness	0.1347 inch
	Normal Tip Tooth Thickness	0.6843 normalized
C	Center Distance for Calculation of Zero Backlash (Mean)	18.6283 inch
Δ_n	Thinning for Backlash (on ref. diameter)	0.0600 normalized
x	Profile Shift Coefficient (Zero Backlash x Factor)	0.0000 normalized

Rating Based on Nominal (with thinning) Thickness

B_t	Transverse Circular Backlash	0.0248 inch
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**** Configuration Data ****

	<u>Pinion</u>	<u>Gear (Wheel)</u>
	Solid	Solid
S	Pinion Shaft Bearing Span	8.0000 inch
S_1	Pinion Offset	Not used for 6011

FTM Paper Gear Set 1
151-29 5 mn a 20 18 helix
Nitrided **40,000 Hours**

American Gear Manufacturers Association
Gear Rating Suite - GUI Version 3.0.170

**** AGMA Materials ****

	<u>Pinion</u>	<u>Gear (Wheel)</u>	
Material	Steel	Steel	
Material Sub Class	Nitralloy 135M	Nitralloy 135M	
Heat Treatment	Nitrided	Nitrided	
Material Grade	2	2	
μ_P μ_G Poisson's Ratio	0.3000	0.3000	
E_P E_G Modulus of Elasticity	29,500,000.	29,500,000.	psi

**** Material Hardness ****

	<u>Pinion</u>	<u>Gear (Wheel)</u>
Surface Hardness	90 Rockwell 15N	90 Rockwell 15N
Core Hardness	321 Brinell	321 Brinell

Note: Hardness conversions are approximate

**** Application Data (Wheel Driving) ****

	<u>Pinion</u>	<u>Gear (Wheel)</u>	
n_p Speed	18,744.8	3,600.0	rpm
L Design Life		40,000.	hours
N Design Life	4.4988E10	8.6400E09	cycles
q Contacts per Revolution	1	1	
Idler?	No	No	

**** Tolerances ****

	<u>Pinion</u>	<u>Gear (Wheel)</u>
AGMA 2000 Quality Number	Q12	Q12

**** AGMA 6011-I03 Rating Output ****

Power Rating, Calculate from Service Factor

**** Effective Case Data ****

	<u>Pinion</u>	<u>Gear (Wheel)</u>	
U_c Core Hardness Coefficient	0.0000	0.0000	
Total Case Depth	0.0000	0.0000	inch
Figure 15 Heavy Minimum Total Case Depth	0.0237	0.0237	inch
Figure 15 Normal Minimum Total Case Depth	0.0171	0.0171	inch

**** Dynamic Factor ****

K_v Dynamic Factor (input)	1.1300
A_v Required Transmission Accuracy	A 4

**** Load Distribution Factor ****

Intended Service (per std)	Precision Enclosed Gearing
Leads Properly Modified? (per std)	Yes
Lapped or Adjusted at Assembly? (per std)	Yes
C_{mc} Lead Correction Factor (per std)	0.8000
C_{pf} Pinion Proportion Factor	0.1447
C_{pm} Pinion Proportion Modifier (per std)	1.0000
C_{ma} Mesh Alignment Factor	0.1439
C_e Mesh Align Correction Factor (per std)	0.8000
K_m Load Distribution Factor	1.2079

AGMA 6011-I03 Rating, rating engine version 1.0031
 FTM Paper Gear Set 1
 151-29 5 mn a 20 18 helix
 Nitrided **40,000 Hours**

Data Set: 1 Page 4
 2017/07/27 16:16:18
 American Gear Manufacturers Association
 Gear Rating Suite - GUI Version 3.0.170

** AGMA 908 DATA (normalized) **		<u>Pinion</u>	<u>Gear (Wheel)</u>	
	Minimum Contact Length		10.5500	inch
K_f	Stress Correction Factor	1.4277	1.5500	
I	I-Factor		0.2363	
J	J-Factor	0.5467	0.6264	
** Yield Strength Factors **		<u>Pinion</u>	<u>Gear (Wheel)</u>	
	Application Requirements (for yield strength factor):		Industrial Practice	
K_y	Yield Strength Factor	0.7500	0.7500	
K_{my}	Load Distribution Factor - Overload		1.1600	
W_{max}	Maximum Tangential Load		11,739.8	lbf
s_{ay}	Allowable Yield Strength	121,922.	121,922.	psi
	Yield Strength Safety Factor	5.0849	6.3252	
** General Factors **				
K_s	Size Factor		1.0000	
K_T	Temperature Factor		1.0000	
W_t	Tangential Load		11,739.8	lbf
** Pitting Durability Stress Factors Summary **		<u>Pinion</u>	<u>Gear (Wheel)</u>	
C_f	Surface Condition Factor		1.0000	
C_G	Gear Ratio Factor		0.8389	
C_H	Hardness Ratio Factor		1.0000	
C_p	Elastic Coefficient		2,271.44	(lb/in ²) ^{.5}
Z_N	Pitting Durability Stress Cycle Factor	0.6243	0.6848	
** Bending Strength Stress Factors Summary **		<u>Pinion</u>	<u>Gear (Wheel)</u>	
C_H	Hardness Ratio Factor		1.0000	
K_B	Rim Thickness Factor	1.0000	1.0000	
Y_N	Bending Strength Stress Cycle Factor	0.7621	0.8038	

**** MAIN RATING VALUES ****

		<u>Pinion</u>	<u>Gear (Wheel)</u>	
** PITTING **				
<i>K</i>	Contact Load Factor		373.03	psi
<i>s_{ac}</i>	Allowable Contact Stress Number	183,000.	183,000.	psi
<i>P_{acu}</i>	Allowable Transmitted Power at Unity Service Factor	14,670.8	17,648.7	hp
<i>C_{SF}</i>	Service Factor (minimum, input)		1.4000	
<i>P_{ac}</i>	Allowable Power at Input Service Factor	10,479.1	12,606.2	hp
** BENDING **				
		<u>Pinion</u>	<u>Gear (Wheel)</u>	
<i>U_L</i>	Unit Load		9,542.1	psi
<i>P_{atu}</i>	Allowable Transmitted Power at Unity Service Factor	18,743.6	22,652.5	hp
<i>s_{at}</i>	Allowable Bending Stress Number	53,180.	53,180.	psi
<i>K_{SF}</i>	Service Factor (minimum, input)		1.4000	
<i>P_{at}</i>	Allowable Power at Input Service Factor	13,388.3	16,180.4	hp
** POWER SUMMARY **				
		<u>Pinion</u>	<u>Gear (Wheel)</u>	
<i>W_t</i>	Tangential Force		11,739.8	lbf
<i>T_P T_G</i>	Member Torque	35,234.	183,459.	in-lb
<i>P_a</i>	Allowable Power at Input Service Factor		10,479.1	hp

**** Strength and Stress Cycle Factor Error Messages ****

172) WARNING: Number of cycles exceeds the range defined in the standard, stress cycle factors extrapolated beyond 1E10 cycles

**** Effective Case Error Messages ****

213) WARNING: Contact stress is not known, case depth as a function of contact stresses is undefined
 214) WARNING: Contact stress is not known, core hardness coefficient is undefined

**** AGMA 6011 Error Messages ****

7) Note, see AGMA 6011 I03 Table 2 for recommended accuracy grades as a function of pitch line velocity
 18) Note: standard recommends rating at 40,000 hours

**** Gear Geometry (External Gears) ****

		<u>Pinion</u>	<u>Gear (Wheel)</u>	
Gear Set Type		Single Helical		
N_P	N_G Number of Teeth	29	151	
m_G	Gear Ratio (Hunting Tooth Set)	5.2069		
m_n	Normal Module	5.0000		mm
C	Center Distance	18.6283		inch
	Standard Center Distance	18.6283		inch
F	Face Width	6.2500	6.2500	inch
F	Effective Face Width	6.2500		inch
n	Speed	18,744.8	3,600.0	rpm
v_t	Pitch Line Velocity	29,456.3		ft/min
ϕ_n	Normal Reference Pressure Angle	20.0000		degrees
ϕ_t	Transverse Operating Pressure Angle	20.9419		degrees
ψ_s	Helix Angle	18.0000		degrees
	Operating Helix Angle	18.0000		degrees
h_t	Whole depth	0.4887	0.4887	inch
c	Tip to Root Clearance	0.0950	0.0950	inch
		Pinion Tip to Gear Root / Gear Tip to Pinion Root		

**** Diameters ****

		<u>Pinion</u>	<u>Gear (Wheel)</u>	
d_o	D_o Tip Diameter	6.3961	31.648	inch
a_{oP}	a_{oG} Addendum	1.0000	1.0000	normalized
D	Reference Pitch Diameter	6.0024	31.254	inch
d	Operating (working) Pitch Diameter	6.0024	31.254	inch
d_{SAP}	Start of Active Profile (Minimum)	5.7104	30.932	inch
	Start of Involute Diameter	5.6625	30.798	inch
D_b	Base Diameter	5.6059	29.1896	inch
D_R	Root Diameter	5.4188	30.670	inch

** Ratios **		<u>Pinion</u>	<u>Gear (Wheel)</u>
m_p	Transverse (Profile) Contact Ratio	1.6405	
m_F	Axial (Face) Contact Ratio	3.1230	
m_t	Total Contact Ratio	4.7635	
	Facewidth to Operating Pitch Diameter Ratio	1.0412	0.2000
	Facewidth to Center Distance Ratio	0.3355	0.3355

**** Line of Action Data ****

Gear Driving, First Contact Near Gear Root Sliding velocity is for pinion, change sign for gear sliding velocity
 Point C1 determined by gear tip diameter

	Distance on line	Pinion Roll Angle	Pinion Diameter inch	Gear Roll Angle	Gear Diameter inch	Sliding Velocity in/sec	Specific Sliding Pinion	Specific Sliding Gear
<u>Points on line of action</u>	of action							
C1 Gear End of Active Profile	0.5435	11.1106	5.7104	24.0045	31.648	-1,238.19	-1.1605	0.5371
C2 Gear Highest Point STC	0.9325	19.0616	5.9080	22.4775	31.355	-328.02	-0.1792	0.1520
C3 Working Pitch Point	1.0727	21.9271	6.0024	21.9271	31.254	0.0000	0.0000	0.0000
C4 Gear Lowest Point STC	1.1508	23.5244	6.0601	21.6204	31.199	182.845	0.0809	-0.0881
C5 Gear Start of Active Profile	1.5398	31.4754	6.3961	20.0934	30.932	1,093.01	0.3616	-0.5665
C6 Total Line of Action Length	6.6581 inch							
	Point C5 determined by Pinion Tip diameter							
	Percent Approach Action:	46.89%						
	Percent Recess Action:	53.11%						

**** Tool Data - Same for Pinion & Gear ****

		Hob or Rack Type Cutter
h_a	ISO (1/2 pitch) Tool Addendum (from ref. line)	1.4000 normalized
t_m	Measured Tool Tooth Thickness	1.5708 normalized
δ_{a0}	Protuberance of Tool	0.0000 inch
	Finishing Stock Allowance - Normal	0.0000 inch
r_T	Tool Tip Radius	0.3936 normalized
h_{a0}	Hypothetical Tool Addendum	1.4000 normalized

**** Surface Finish ****

		<u>Pinion</u>	<u>Gear (Wheel)</u>
f_p	Flank Roughness, Arithmetic Average	32.000	32.000 micro-inch

**** Tooth Thickness ****

		<u>Pinion</u>	<u>Gear (Wheel)</u>
t_o	Normal Tip Tooth Thickness	0.1347	0.1499 inch
	Normal Tip Tooth Thickness	0.6843	0.7613 normalized
C	Center Distance for Calculation of Zero Backlash (Mean)	18.6283	inch
Δ_n	Thinning for Backlash (on ref. diameter)	0.0600	0.0600 normalized
x	Profile Shift Coefficient (Zero Backlash x Factor)	0.0000	0.0000 normalized

Rating Based on Nominal (with thinning) Thickness

B_t	Transverse Circular Backlash	0.0248	inch
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**** Configuration Data ****

		<u>Pinion</u>	<u>Gear (Wheel)</u>
	Gear Blank Construction	Solid	Solid
S	Pinion Shaft Bearing Span	8.0000	inch
S_1	Pinion Offset	Not used for 6011	

** AGMA Materials **			
		<u>Pinion</u>	<u>Gear (Wheel)</u>
Material		Steel	Steel
Material Sub Class		Nitralloy 135M	Nitralloy 135M
Heat Treatment		Nitrided	Nitrided
Material Grade		2	2
μ_P μ_G Poisson's Ratio		0.3000	0.3000
E_P E_G Modulus of Elasticity		29,500,000.	29,500,000. psi

** Material Hardness **		
	<u>Pinion</u>	<u>Gear (Wheel)</u>
Surface Hardness	90 Rockwell 15N	90 Rockwell 15N
Core Hardness	321 Brinell	321 Brinell
Note: Hardness conversions are approximate		

** Application Data (Wheel Driving) **			
		<u>Pinion</u>	<u>Gear (Wheel)</u>
n_p Speed		18,744.8	3,600.0 rpm
L Design Life		175,200.	hours
N Design Life		1.9705E11	3.7843E10 cycles
q Contacts per Revolution		1	1
Idler?		No	No

** Tolerances **		
	<u>Pinion</u>	<u>Gear (Wheel)</u>
AGMA 2000 Quality Number	Q12	Q12

**** AGMA 6011-I03 Rating Output ****
Power Rating, Calculate from Service Factor

** Effective Case Data **			
		<u>Pinion</u>	<u>Gear (Wheel)</u>
U_c Core Hardness Coefficient		0.0000	0.0000
Total Case Depth		0.0000	0.0000 inch
Figure 15 Heavy Minimum Total Case Depth		0.0237	0.0237 inch
Figure 15 Normal Minimum Total Case Depth		0.0171	0.0171 inch

** Dynamic Factor **		
K_v Dynamic Factor (input)		1.1300
A_v Required Transmission Accuracy		A 4

** Load Distribution Factor **		
Intended Service (per std)		Precision Enclosed Gearing
Leads Properly Modified? (per std)		Yes
Lapped or Adjusted at Assembly? (per std)		Yes
C_{mc} Lead Correction Factor (per std)		0.8000
C_{pf} Pinion Proportion Factor		0.1447
C_{pm} Pinion Proportion Modifier (per std)		1.0000
C_{ma} Mesh Alignment Factor		0.1439
C_e Mesh Align Correction Factor (per std)		0.8000
K_m Load Distribution Factor		1.2079

** AGMA 908 DATA (normalized) **		<u>Pinion</u>	<u>Gear (Wheel)</u>	
	Minimum Contact Length		10.5500	inch
K_f	Stress Correction Factor	1.4277	1.5500	
I	I-Factor		0.2363	
J	J-Factor	0.5467	0.6264	
** Yield Strength Factors **		<u>Pinion</u>	<u>Gear (Wheel)</u>	
	Application Requirements (for yield strength factor):		Industrial Practice	
K_y	Yield Strength Factor	0.7500	0.7500	
K_{my}	Load Distribution Factor - Overload		1.1600	
W_{max}	Maximum Tangential Load		9,949.8	lbf
s_{ay}	Allowable Yield Strength	121,922.	121,922.	psi
	Yield Strength Safety Factor	5.9998	7.4632	
** General Factors **				
K_s	Size Factor		1.0000	
K_T	Temperature Factor		1.0000	
W_t	Tangential Load		9,949.8	lbf
** Pitting Durability Stress Factors Summary **		<u>Pinion</u>	<u>Gear (Wheel)</u>	
C_f	Surface Condition Factor		1.0000	
C_G	Gear Ratio Factor		0.8389	
C_H	Hardness Ratio Factor		1.0000	
C_p	Elastic Coefficient		2,271.44	(lb/in ²) ^{.5}
Z_N	Pitting Durability Stress Cycle Factor	0.5748	0.6304	
** Bending Strength Stress Factors Summary **		<u>Pinion</u>	<u>Gear (Wheel)</u>	
C_H	Hardness Ratio Factor		1.0000	
K_B	Rim Thickness Factor	1.0000	1.0000	
Y_N	Bending Strength Stress Cycle Factor	0.7265	0.7663	

**** MAIN RATING VALUES ****

		<u>Pinion</u>	<u>Gear (Wheel)</u>	
** PITTING **				
<i>K</i>	Contact Load Factor		316.16	psi
<i>s_{ac}</i>	Allowable Contact Stress Number	183,000.	183,000.	psi
<i>P_{acu}</i>	Allowable Transmitted Power at Unity Service Factor	12,433.8	14,957.7	hp
<i>C_{SF}</i>	Service Factor (minimum, input)		1.4000	
<i>P_{ac}</i>	Allowable Power at Input Service Factor	8,881.3	10,684.1	hp
** BENDING **				
<i>U_L</i>	Unit Load		8,087.2	psi
<i>P_{atu}</i>	Allowable Transmitted Power at Unity Service Factor	17,870.0	21,596.9	hp
<i>s_{at}</i>	Allowable Bending Stress Number	53,180.	53,180.	psi
<i>K_{SF}</i>	Service Factor (minimum, input)		1.4000	
<i>P_{at}</i>	Allowable Power at Input Service Factor	12,764.3	15,426.3	hp
** POWER SUMMARY **				
<i>W_t</i>	Tangential Force		9,949.8	lbf
<i>T_P T_G</i>	Member Torque	29,861.5	155,486.	in-lb
<i>P_a</i>	Allowable Power at Input Service Factor		8,881.3	hp

**** Dynamic Factor Error Messages ****

58) Note: Dynamic Factor (1.1100) set per maximum (most conservative) value for 'very accurate gearing' in figure 1.

**** Strength and Stress Cycle Factor Error Messages ****

172) WARNING: Number of cycles exceeds the range defined in the standard, stress cycle factors extrapolated beyond 1E10 cycles

**** Effective Case Error Messages ****

213) WARNING: Contact stress is not known, case depth as a function of contact stresses is undefined

214) WARNING: Contact stress is not known, core hardness coefficient is undefined

**** Gear Geometry (External Gears) ****

		<u>Pinion</u>	<u>Gear (Wheel)</u>	
Gear Set Type		Single Helical		
N_P	N_G Number of Teeth	29	151	
m_G	Gear Ratio (Hunting Tooth Set)	5.2069		
m_n	Normal Module	5.0000		mm
C	Center Distance	18.6283		inch
	Standard Center Distance	18.6283		inch
F	Face Width	6.2500	6.2500	inch
F	Effective Face Width	6.2500		inch
n	Speed	18,744.8	3,600.0	rpm
v_t	Pitch Line Velocity	29,456.3		ft/min
ϕ_n	Normal Reference Pressure Angle	20.0000		degrees
ϕ_t	Transverse Operating Pressure Angle	20.9419		degrees
ψ_s	Helix Angle	18.0000		degrees
	Operating Helix Angle	18.0000		degrees
h_t	Whole depth	0.4887	0.4887	inch
c	Tip to Root Clearance	0.0950	0.0950	inch
		Pinion Tip to Gear Root / Gear Tip to Pinion Root		

**** Diameters ****

		<u>Pinion</u>	<u>Gear (Wheel)</u>	
d_o	D_o Tip Diameter	6.3961	31.648	inch
a_{oP}	a_{oG} Addendum	1.0000	1.0000	normalized
D	Reference Pitch Diameter	6.0024	31.254	inch
d	Operating (working) Pitch Diameter	6.0024	31.254	inch
d_{SAP}	Start of Active Profile (Minimum)	5.7104	30.932	inch
	Start of Involute Diameter	5.6625	30.798	inch
D_b	Base Diameter	5.6059	29.1896	inch
D_R	Root Diameter	5.4188	30.670	inch

** Ratios **		<u>Pinion</u>	<u>Gear (Wheel)</u>
m_p	Transverse (Profile) Contact Ratio	1.6405	
m_F	Axial (Face) Contact Ratio	3.1230	
m_t	Total Contact Ratio	4.7635	
	Facewidth to Operating Pitch Diameter Ratio	1.0412	0.2000
	Facewidth to Center Distance Ratio	0.3355	0.3355

**** Line of Action Data ****

Gear Driving, First Contact Near Gear Root Sliding velocity is for pinion, change sign for gear sliding velocity
 Point C1 determined by gear tip diameter

	Distance on line	Pinion Roll Angle	Pinion Diameter inch	Gear Roll Angle	Gear Diameter inch	Sliding Velocity in/sec	Specific Sliding Pinion	Specific Sliding Gear
<u>Points on line of action</u>	of action							
C1 Gear End of Active Profile	0.5435	11.1106	5.7104	24.0045	31.648	-1,238.19	-1.1605	0.5371
C2 Gear Highest Point STC	0.9325	19.0616	5.9080	22.4775	31.355	-328.02	-0.1792	0.1520
C3 Working Pitch Point	1.0727	21.9271	6.0024	21.9271	31.254	0.0000	0.0000	0.0000
C4 Gear Lowest Point STC	1.1508	23.5244	6.0601	21.6204	31.199	182.845	0.0809	-0.0881
C5 Gear Start of Active Profile	1.5398	31.4754	6.3961	20.0934	30.932	1,093.01	0.3616	-0.5665
C6 Total Line of Action Length	6.6581 inch							
Point C5 determined by Pinion Tip diameter								
Percent Approach Action: 46.89%								
Percent Recess Action: 53.11%								

**** Tool Data - Same for Pinion & Gear ****

		Hob or Rack Type Cutter
h_a	ISO (1/2 pitch) Tool Addendum (from ref. line)	1.4000 normalized
t_m	Measured Tool Tooth Thickness	1.5708 normalized
δ_{a0}	Protuberance of Tool	0.0000 inch
	Finishing Stock Allowance - Normal	0.0000 inch
r_T	Tool Tip Radius	0.3936 normalized
h_{a0}	Hypothetical Tool Addendum	1.4000 normalized

**** Surface Finish ****

		<u>Pinion</u>	<u>Gear (Wheel)</u>
f_p	Flank Roughness, Arithmetic Average	32.000	32.000 micro-inch

**** Tooth Thickness ****

		<u>Pinion</u>	<u>Gear (Wheel)</u>
t_o	Normal Tip Tooth Thickness	0.1347	0.1499 inch
	Normal Tip Tooth Thickness	0.6843	0.7613 normalized
C	Center Distance for Calculation of Zero Backlash (Mean)	18.6283	inch
Δ_n	Thinning for Backlash (on ref. diameter)	0.0600	0.0600 normalized
x	Profile Shift Coefficient (Zero Backlash x Factor)	0.0000	0.0000 normalized

Rating Based on Nominal (with thinning) Thickness

B_t	Transverse Circular Backlash	0.0248	inch
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**** Configuration Data ****

		<u>Pinion</u>	<u>Gear (Wheel)</u>
	Gear Blank Construction	Solid	Solid
S	Pinion Shaft Bearing Span	8.0000	inch
S_1	Pinion Offset	0.0000	inch

** AGMA Materials **		<u>Pinion</u>	<u>Gear (Wheel)</u>	
	Material	Steel	Steel	
	Material Sub Class	Nitralloy 135M	Nitralloy 135M	
	Heat Treatment	Nitrided	Nitrided	
	Material Grade	2	2	
μ_P μ_G	Poisson's Ratio	0.3000	0.3000	
E_P E_G	Modulus of Elasticity	29,500,000.	29,500,000.	psi

** Material Hardness **		<u>Pinion</u>	<u>Gear (Wheel)</u>	
	Surface Hardness	90 Rockwell 15N	90 Rockwell 15N	
	Core Hardness	321 Brinell	321 Brinell	
Note: Hardness conversions are approximate				

** Application Data (Wheel Driving) **		<u>Pinion</u>	<u>Gear (Wheel)</u>	
n_p	Speed	18,744.8	3,600.0	rpm
L	Design Life		20.0000	years
N	Design Life	1.9705E11	3.7843E10	cycles
q	Contacts per Revolution	1	1	
	Idler?	No	No	

** Life Factor Data **		<u>Pinion</u>	<u>Gear (Wheel)</u>	
	Number of Cycles	1.9705E11	3.7843E10	
Z_N	Pitting Durability Stress Cycle Factor (input)	0.0000	0.0000	
Y_N	Bending Strength Stress Cycle Factor (input)	0.0000	0.0000	
	Pitting Durability Cycle Factor at 10 ¹⁰	0.6792	0.6792	
	Bending Strength Cycle Factor at 10 ¹⁰	0.8000	0.8000	

** Tolerances **		<u>Pinion</u>	<u>Gear (Wheel)</u>	
	AGMA 2000 Quality Number	Q12	Q12	

**** AGMA 2001-D04 Rating Output ****
Power Rating, Calculate from Service Factor

** Effective Case Data **		<u>Pinion</u>	<u>Gear (Wheel)</u>	
U_c	Core Hardness Coefficient	0.0000	0.0000	
	Total Case Depth	0.0000	0.0000	inch
	Figure 15 Heavy Minimum Total Case Depth	0.0237	0.0237	inch
	Figure 15 Normal Minimum Total Case Depth	0.0171	0.0171	inch

** Dynamic Factor **				
V_p	Pitch Variation (input)	2.0866	2.7559	0.0001 in
A_v	Transmission Accuracy Number		5.0000	
K_v	Dynamic Factor		1.1100	

**** Load Distribution Factor ****

	Intended Service (input)	Precision Enclosed Gearing
	Leads Properly Modified? (input)	No
	Lapped or Adjusted at Assembly? (input)	No
C_{mc}	Lead Correction Factor (input)	1.0000
C_{pf}	Pinion Proportion Factor	0.1447
C_{pm}	Pinion Proportion Modifier (input)	1.0000
C_{ma}	Mesh Alignment Factor	0.1439
C_e	Mesh Align Correction Factor (input)	1.0000
K_m	Load Distribution Factor	1.2886

**** AGMA 908 DATA (normalized) ****

		<u>Pinion</u>	<u>Gear (Wheel)</u>	
	Minimum Contact Length	10.5500		inch
K_f	Stress Correction Factor	1.4277	1.5500	
I	I-Factor		0.2363	
J	J-Factor	0.5467	0.6264	

**** Yield Strength Factors ****

		<u>Pinion</u>	<u>Gear (Wheel)</u>	
	Application Requirements (for yield strength factor):			Industrial Practice
K_y	Yield Strength Factor	0.7500	0.7500	
K_{my}	Load Distribution Factor - Overload		1.1600	
W_{max}	Maximum Tangential Load	9,494.6		lbf
	Stress due to Wmax	14,543.7	11,691.8	psi
s_{ay}	Allowable Yield Strength	121,922.	121,922.	psi
	Yield Strength Safety Factor	6.2874	7.8210	

**** General Factors ****

K_s	Size Factor	1.0000		
K_T	Temperature Factor	1.0000		
W_t	Tangential Load	9,494.6		lbf

**** Pitting Durability Stress Factors Summary ****

		<u>Pinion</u>	<u>Gear (Wheel)</u>	
C_f	Surface Condition Factor	1.0000		
C_G	Gear Ratio Factor	0.8389		
C_H	Hardness Ratio Factor	1.0000		
C_p	Elastic Coefficient	2,271.44		(lb/in ²) ^{.5}
Z_N	Pitting Durability Stress Cycle Factor	0.5748	0.6304	

**** Bending Strength Stress Factors Summary ****

		<u>Pinion</u>	<u>Gear (Wheel)</u>	
C_H	Hardness Ratio Factor	1.0000		
K_B	Rim Thickness Factor	1.0000	1.0000	
Y_N	Bending Strength Stress Cycle Factor	0.7265	0.7663	

**** MAIN RATING VALUES ****

		<u>Pinion</u>	<u>Gear (Wheel)</u>	
** PITTING **				
<i>K</i>	Contact Load Factor		301.69	psi
<i>s_{ac}</i>	Allowable Contact Stress Number	183,000.	183,000.	psi
<i>P_{acu}</i>	Allowable Transmitted Power at Unity Service Factor	11,865.1	14,273.4	hp
<i>C_{SF}</i>	Service Factor (minimum, input)		1.4000	
<i>P_{ac}</i>	Allowable Power at Input Service Factor	8,475.1	10,195.3	hp
** BENDING **				
<i>U_L</i>	Unit Load		7,717.2	psi
<i>P_{atu}</i>	Allowable Transmitted Power at Unity Service Factor	17,052.1	20,608.3	hp
<i>s_{at}</i>	Allowable Bending Stress Number	53,180.	53,180.	psi
<i>K_{SF}</i>	Service Factor (minimum, input)		1.4000	
<i>P_{at}</i>	Allowable Power at Input Service Factor	12,180.1	14,720.2	hp
** POWER SUMMARY **				
<i>W_t</i>	Tangential Force		9,494.6	lbf
<i>T_P T_G</i>	Member Torque	28,495.5	148,373.	in-lb
<i>P_a</i>	Allowable Power at Input Service Factor		8,475.1	hp

**** Effective Case Error Messages ****

213) WARNING: Contact stress is not known, case depth as a function of contact stresses is undefined

214) WARNING: Contact stress is not known, core hardness coefficient is undefined

**** Gear Geometry (External Gears) ****

		<u>Pinion</u>	<u>Gear (Wheel)</u>	
	Gear Set Type	Single Helical		
N_P N_G	Number of Teeth	29	151	
m_G	Gear Ratio (Hunting Tooth Set)	5.2069		
m_n	Normal Module	5.0000		mm
C	Center Distance	18.6283		inch
	Standard Center Distance	18.6283		inch
F	Face Width	6.2500	6.2500	inch
F	Effective Face Width	6.2500		inch
n	Speed	18,744.8	3,600.0	rpm
v_t	Pitch Line Velocity	29,456.3		ft/min
ϕ_n	Normal Reference Pressure Angle	20.0000		degrees
ϕ_t	Transverse Operating Pressure Angle	20.9419		degrees
ψ_s	Helix Angle	18.0000		degrees
	Operating Helix Angle	18.0000		degrees
h_t	Whole depth	0.4887	0.4887	inch
c	Tip to Root Clearance	0.0950	0.0950	inch

Pinion Tip to Gear Root / Gear Tip to Pinion Root

**** Diameters ****

		<u>Pinion</u>	<u>Gear (Wheel)</u>	
d_o D_o	Tip Diameter	6.3961	31.648	inch
a_{oP} a_{oG}	Addendum	1.0000	1.0000	normalized
D	Reference Pitch Diameter	6.0024	31.254	inch
d	Operating (working) Pitch Diameter	6.0024	31.254	inch
d_{SAP}	Start of Active Profile (Minimum)	5.7104	30.932	inch
	Start of Involute Diameter	5.6625	30.798	inch
D_b	Base Diameter	5.6059	29.1896	inch
D_R	Root Diameter	5.4188	30.670	inch

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** Ratios **		<u>Pinion</u>	<u>Gear (Wheel)</u>
m_p	Transverse (Profile) Contact Ratio	1.6405	
m_F	Axial (Face) Contact Ratio	3.1230	
m_t	Total Contact Ratio	4.7635	
	Facewidth to Operating Pitch Diameter Ratio	1.0412	0.2000
	Facewidth to Center Distance Ratio	0.3355	0.3355

**** Line of Action Data ****

Gear Driving, First Contact Near Gear Root Sliding velocity is for pinion, change sign for gear sliding velocity
 Point C1 determined by gear tip diameter

	Distance on line	Pinion Roll Angle	Pinion Diameter inch	Gear Roll Angle	Gear Diameter inch	Sliding Velocity in/sec	Specific Sliding Pinion	Specific Sliding Gear
<u>Points on line of action</u>	of action							
C1 Gear End of Active Profile	0.5435	11.1106	5.7104	24.0045	31.648	-1,238.19	-1.1605	0.5371
C2 Gear Highest Point STC	0.9325	19.0616	5.9080	22.4775	31.355	-328.02	-0.1792	0.1520
C3 Working Pitch Point	1.0727	21.9271	6.0024	21.9271	31.254	0.0000	0.0000	0.0000
C4 Gear Lowest Point STC	1.1508	23.5244	6.0601	21.6204	31.199	182.845	0.0809	-0.0881
C5 Gear Start of Active Profile	1.5398	31.4754	6.3961	20.0934	30.932	1,093.01	0.3616	-0.5665
C6 Total Line of Action Length	6.6581 inch							
Point C5 determined by Pinion Tip diameter								
Percent Approach Action: 46.89%								
Percent Recess Action: 53.11%								

**** Tool Data - Same for Pinion & Gear ****

		Hob or Rack Type Cutter
h_a	ISO (1/2 pitch) Tool Addendum (from ref. line)	1.4000 normalized
t_m	Measured Tool Tooth Thickness	1.5708 normalized
δ_{a0}	Protuberance of Tool	0.0000 inch
	Finishing Stock Allowance - Normal	0.0000 inch
r_T	Tool Tip Radius	0.3936 normalized
h_{a0}	Hypothetical Tool Addendum	1.4000 normalized

**** Surface Finish ****

		<u>Pinion</u>	<u>Gear (Wheel)</u>
f_p	Flank Roughness, Arithmetic Average	32.000	32.000 micro-inch

**** Tooth Thickness ****

		<u>Pinion</u>	<u>Gear (Wheel)</u>
t_o	Normal Tip Tooth Thickness	0.1347	0.1499 inch
	Normal Tip Tooth Thickness	0.6843	0.7613 normalized
C	Center Distance for Calculation of Zero Backlash (Mean)	18.6283	inch
Δ_n	Thinning for Backlash (on ref. diameter)	0.0600	0.0600 normalized
x	Profile Shift Coefficient (Zero Backlash x Factor)	0.0000	0.0000 normalized

Rating Based on Nominal (with thinning) Thickness

B_t	Transverse Circular Backlash	0.0248	inch
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**** Configuration Data ****

		<u>Pinion</u>	<u>Gear (Wheel)</u>
	Gear Blank Construction	Solid	Solid
S	Pinion Shaft Bearing Span	8.0000	inch
S_1	Pinion Offset	0.0000	inch

		<u>Pinion</u>	<u>Gear (Wheel)</u>	
** AGMA Materials **				
	Material	Steel	Steel	
	Material Sub Class	Nitralloy 135M	Nitralloy 135M	
	Heat Treatment	Nitrided	Nitrided	
	Material Grade	2	2	
μ_P μ_G	Poisson's Ratio	0.3000	0.3000	
E_P E_G	Modulus of Elasticity	29,500,000.	29,500,000.	psi
** Material Hardness **				
	Surface Hardness	90 Rockwell 15N	90 Rockwell 15N	
	Core Hardness	321 Brinell	321 Brinell	
Note: Hardness conversions are approximate				
** Application Data (Wheel Driving) **				
n_p	Speed	18,744.8	3,600.0	rpm
L	Design Life	175,200.		hours
N	Design Life	1.9705E11	3.7843E10	cycles
q	Contacts per Revolution	1	1	
	Idler?	No	No	
** Tolerances **				
	AGMA 2000 Quality Number	<u>Q12</u>	<u>Q12</u>	
** API 617 Seventh edit Output **				
Power Rating, Calculate from Service Factor				
** Effective Case Data **				
U_c	Core Hardness Coefficient	0.0000	0.0000	
	Total Case Depth	0.0000	0.0000	inch
	Figure 15 Heavy Minimum Total Case Depth	0.0237	0.0237	inch
	Figure 15 Normal Minimum Total Case Depth	0.0171	0.0171	inch
** Dynamic Factor **				
V_p	Pitch Variation (input)	2.0866	2.7559	0.0001 in
A_v	Transmission Accuracy Number		0.0000	
K_v	Dynamic Factor		1.1200	
** Load Distribution Factor **				
K_m	Load Distribution Factor (input)		1.2162	
** AGMA 908 DATA (normalized) **				
	Minimum Contact Length	<u>10.5500</u>	<u>10.5500</u>	inch
K_f	Stress Correction Factor	1.4277	1.5500	
I	I-Factor		0.2363	
J	J-Factor	0.5467	0.6264	

**** Yield Strength Factors ****

		<u>Pinion</u>	<u>Gear (Wheel)</u>
	Application Requirements (for yield strength factor):	Industrial Practice	
K_y	Yield Strength Factor	0.7500	0.7500
K_{my}	Load Distribution Factor - Overload		1.1600
W_{max}	Maximum Tangential Load		7,975.6 lbf
s_{ay}	Allowable Yield Strength	121,922.	121,922. psi
	Yield Strength Safety Factor	7.4849	9.3105

**** General Factors ****

K_s	Size Factor	1.0000	
K_T	Temperature Factor	1.2500	
W_t	Tangential Load	7,975.6	lbf

**** Pitting Durability Stress Factors Summary ****

		<u>Pinion</u>	<u>Gear (Wheel)</u>
C_f	Surface Condition Factor	1.0000	
C_G	Gear Ratio Factor	0.8389	
C_H	Hardness Ratio Factor	1.0000	
C_p	Elastic Coefficient	2,271.44	(lb/in ²) ^{.5}
Z_N	Pitting Durability Stress Cycle Factor	0.5747	0.6304

**** Bending Strength Stress Factors Summary ****

		<u>Pinion</u>	<u>Gear (Wheel)</u>
C_H	Hardness Ratio Factor	1.0000	
K_B	Rim Thickness Factor	1.0000	1.0000
Y_N	Bending Strength Stress Cycle Factor	0.7266	0.7664

**** MAIN RATING VALUES ****

		<u>Pinion</u>	<u>Gear (Wheel)</u>	
** PITTING **				
<i>K</i>	Contact Load Factor		253.426	psi
<i>s_{ac}</i>	Allowable Contact Stress Number	183,000.	183,000.	psi
<i>P_{acu}</i>	Allowable Transmitted Power at Unity Service Factor	9,966.8	11,989.8	hp
<i>C_{SF}</i>	Service Factor (minimum, input)		1.4000	
<i>P_{ac}</i>	Allowable Power at Input Service Factor	7,119.1	8,564.2	hp
** BENDING **				
		<u>Pinion</u>	<u>Gear (Wheel)</u>	
<i>U_L</i>	Unit Load		6,482.6	psi
<i>P_{atu}</i>	Allowable Transmitted Power at Unity Service Factor	14,326.2	17,313.6	hp
<i>s_{at}</i>	Allowable Bending Stress Number	53,180.	53,180.	psi
<i>K_{SF}</i>	Service Factor (minimum, input)		1.4000	
<i>P_{at}</i>	Allowable Power at Input Service Factor	10,233.0	12,366.8	hp
** POWER SUMMARY **				
		<u>Pinion</u>	<u>Gear (Wheel)</u>	
<i>W_t</i>	Tangential Force		7,975.6	lbf
<i>T_P T_G</i>	Member Torque	23,936.6	124,635.	in-lb
<i>P_a</i>	Allowable Power at Input Service Factor		7,119.1	hp

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** AGMA 6011 Error Messages **

Note: All 6011 warnings also apply to API 613

7) Note, see AGMA 6011 I03 Table 2 for recommended accuracy grades as a function of pitch line velocity

** API 613 Error Messages **

5) Warning, standard violated: Pinion Tooth accuracy must be ISO 1328-1 grade 4 or better

6) Warning, standard violated: Gear Tooth accuracy must be ISO 1328-1 grade 4 or better

** Gear Geometry (External Gears) **

		<u>Pinion</u>	<u>Gear (Wheel)</u>	
Gear Set Type		Single Helical		
N_P N_G	Number of Teeth	29	151	
m_G	Gear Ratio (Hunting Tooth Set)	5.2069		
m_n	Normal Module	5.0000		mm
C	Center Distance	18.6283		inch
	Standard Center Distance	18.6283		inch
F	Face Width	6.2500	6.2500	inch
F	Effective Face Width	6.2500		inch
n	Speed	18,744.8	3,600.0	rpm
v_t	Pitch Line Velocity	29,456.3		ft/min
ϕ_n	Normal Reference Pressure Angle	20.0000		degrees
ϕ_t	Transverse Operating Pressure Angle	20.9419		degrees
ψ_s	Helix Angle	18.0000		degrees
	Operating Helix Angle	18.0000		degrees
h_t	Whole depth	0.4887	0.4887	inch
c	Tip to Root Clearance	0.0950	0.0950	inch

Pinion Tip to Gear Root / Gear Tip to Pinion Root

** Diameters **

		<u>Pinion</u>	<u>Gear (Wheel)</u>	
d_o D_o	Tip Diameter	6.3961	31.648	inch
a_{oP} a_{oG}	Addendum	1.0000	1.0000	normalized
D	Reference Pitch Diameter	6.0024	31.254	inch
d	Operating (working) Pitch Diameter	6.0024	31.254	inch
d_{SAP}	Start of Active Profile (Minimum)	5.7104	30.932	inch
	Start of Involute Diameter	5.6625	30.798	inch
D_b	Base Diameter	5.6059	29.1896	inch
D_R	Root Diameter	5.4188	30.670	inch

** Ratios **

		<u>Pinion</u>	<u>Gear (Wheel)</u>	
m_P	Transverse (Profile) Contact Ratio	1.6405		
m_F	Axial (Face) Contact Ratio	3.1230		
m_t	Total Contact Ratio	4.7635		
	Facewidth to Operating Pitch Diameter Ratio	1.0412	0.2000	
	Facewidth to Center Distance Ratio	0.3355	0.3355	

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** Line of Action Data **

Gear Driving, First Contact Near Gear Root Sliding velocity is for pinion, change sign for gear sliding velocity
 Point C1 determined by gear tip diameter

	Distance on line of action	Pinion Roll Angle	Pinion Diameter inch	Gear Roll Angle	Gear Diameter inch	Sliding Velocity in/sec	Specific Sliding Pinion	Specific Sliding Gear
<u>Points on line of action</u>								
C1 Gear End of Active Profile	0.5435	11.1106	5.7104	24.0045	31.648	-1,238.19	-1.1605	0.5371
C2 Gear Highest Point STC	0.9325	19.0616	5.9080	22.4775	31.355	-328.02	-0.1792	0.1520
C3 Working Pitch Point	1.0727	21.9271	6.0024	21.9271	31.254	0.0000	0.0000	0.0000
C4 Gear Lowest Point STC	1.1508	23.5244	6.0601	21.6204	31.199	182.845	0.0809	-0.0881
C5 Gear Start of Active Profile	1.5398	31.4754	6.3961	20.0934	30.932	1,093.01	0.3616	-0.5665
C6 Total Line of Action Length	6.6581 inch							
Point C5 determined by Pinion Tip diameter								
Percent Approach Action:	46.89%							
Percent Recess Action:	53.11%							

** Tool Data - Same for Pinion & Gear **

		Hob or Rack Type Cutter	
h_a	ISO (1/2 pitch) Tool Addendum (from ref. line)	1.4000	normalized
t_m	Measured Tool Tooth Thickness	1.5708	normalized
δ_{a0}	Protuberance of Tool	0.0000	inch
	Finishing Stock Allowance - Normal	0.0000	inch
r_T	Tool Tip Radius	0.3936	normalized
h_{a0}	Hypothetical Tool Addendum	1.4000	normalized

** Tooth Thickness **

		<u>Pinion</u>	<u>Gear (Wheel)</u>	
t_o	Normal Tip Tooth Thickness	0.1347	0.1499	inch
	Normal Tip Tooth Thickness	0.6843	0.7613	normalized
C	Center Distance for Calculation of Zero Backlash (Mean)	18.6283		inch
Δ_n	Thinning for Backlash (on ref. diameter)	0.0600	0.0600	normalized
x	Profile Shift Coefficient (Zero Backlash x Factor)	0.0000	0.0000	normalized

Rating Based on Nominal (with thinning) Thickness

B_t	Transverse Circular Backlash	0.0248	inch
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** API Materials **

	<u>Pinion</u>	<u>Gear (Wheel)</u>
	Material is Steel	
Heat Treatment	Nitrided	Nitrided
Surface Hardness	90.0 Rockwell 15N	90.0 Rockwell 15N

Note: Hardness conversions are approximate

** Application Data (Wheel Driving) **

	<u>Pinion</u>	<u>Gear (Wheel)</u>	
n_p	Speed	18,744.8	3,600.0 rpm
q	Contacts per Revolution	1	1
	Idler?	No	No

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** API 613 Data **		<u>Pinion</u>	<u>Gear (Wheel)</u>	
I_m	Material Index Number (pitting allowable)	300.23	300.23	psi
S_a	Bending Stress Number (allowable)	27,557.2	27,557.2	psi
	Type of Rating:	Power Rating, Calculate from Service Factor		
SF	API 613 Service Factor (input)	1.4000		

** AGMA 908 DATA (normalized) **		<u>Pinion</u>	<u>Gear (Wheel)</u>	
K_f	Stress Correction Factor	1.4277	1.5500	
I	I-Factor		0.2363	
J	J-Factor	0.5467	0.6264	

**** API 613 RATING OUTPUT ****

** PITTING **				
K_a	Tooth Pitting Index, allowable	214.449		psi
	Allowable Power at input Service Factor	6,024.2		hp

** BENDING **		<u>Pinion</u>	<u>Gear (Wheel)</u>	
	Allowable Power at input Service Factor	6,903.3	7,909.8	hp

** POWER SUMMARY **				
	Allowable Power at Input Service Factor	6,024.2		hp