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Committee D02 on PETROLEUM PRODUCTS AND LUBRICANTS

February 21st, 2014

Reply to:
Chris Prengaman
The Lubrizol Corporation
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Wickliffe, OH 44092
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(440) 347-2377 (FAX)
crpr@lubrizol.com

ASTM D02.B0.03 L-37-1 Next Generation Hardware Task Force
Members and Guests:

Attached for your review and comment are the unconfirmed minutes of the:

- **January 30th , 2013 Next Generation Hardware Task Force Meeting; Detroit, MI.**

Please direct any corrections or comments to my attention.

Sincerely,

Date: 2014.02.21 15:24:23 -05'00'

Chris Prengaman, Chairman
L-37-1 Hardware Taskforce Chairman

Report of Meeting
L-37-1 Next Generation Hardware Task Force Meeting
Courtyard by Marriott, Detroit Airport
January 30th, 2014 Meeting

Attendees:
Voting Members in **BOLD**
Gottwald, Thomas – Afton Chemical
Boschert, Tom – Afton Chemical
Koglin, Cory – Afton Chemical
Hobson, Kevin – Afton Chemical
Schwenk, Daniel – Afton Chemical
Kearney, Bill – Afton Chemical
Dharte, John – American Axle Manufacturing
Marsh, Greg – American Axle Manufacturing
Parke, Scott – ASTM TMC
Guzikowski, Joe – Dana
Mosher, Donna – Eaton (Teleconference)
Dennis, Mike – The Gleason Works (Teleconference)
Reardon, Arthur – The Gleason Works (Teleconference)
Smith, Dale – Intertek Automotive Research
Trader, Angela – Intertek Automotive Research
Prengaman, Chris – Lubrizol
Gropp, Jerry – Lubrizol
Bubonic, Brad – Lubrizol
Umerley, Matt – Lubrizol
Muransky, Troy - Meritor
Koehler, Brian – Southwest Research Institute
Comfort, Allen – US Army RDECOM/TARDEC
Dwornick, Bridget – US Army RDECOM/TARDEC

The meeting was called to order at 815 EST.

1.0 Agenda Review

The agenda was reviewed

2.0 Meeting Minutes Approval

Motion: Motion to approve prior minutes that have been posted for review on the TMC website. 1st B. Koehler, 2nd T. Gottwald.

1. 8/7/2013 – Teleconference
2. 8/14/2013 – Automation Alley
3. 10/30/2013 – Teleconference
4. 11/6/2013 – Automation Alley
5. 11/19/2013 – Teleconference
6. 1/8/2014 – Teleconference
7. 1/15/2014 – Teleconference
8. 1/22/2014 – Teleconference

Approved by voice vote unanimously.

3.0 Background

C. Prengaman & T. Boschert shared a background on the testing progress to date.

4.0 Data Update

C. Prengaman & T. Gottwald shared an update with the test data.

T. Gottwald shared that 8 different chemistries have been evaluated on the Gleason hardware. The Gleason testing to date used all 2 minute ramps.

G. Marsh shared some background on the Zeta gearset and history.

B. Koehler suggested a build workshop to allow the labs to send their builders for the Gleason hardware.

The group shared concerns about re-using the Dana model 60 housings and expressed intrest in identifying a replacement option.

4.0 Gleason Presentation & Discussion

M. Dennis and A. Reardon gave a presentation to the group on behalf of The Gleason Works.

The discussion focused on the manufacturing process for the gears.
The gearsets are machined from billet Timken 8620 steel.
M. Dennis gave approximate pricing of $458-531 per gearset.
The first batch was CMM/roll tested every piece.
The overall process is the steel is sent to an outside vendor to machine the gear blanks. The blanks are ground, heat treated, hard turned and then the final grinding process to finished dimensioned followed by shot peening.

***Motion*:**
"For the L37-1 TF to move forward with test development using hardware supplied by The Gleason Works.

- Place order with Gleason ASAP.
- TF to visit Gleason, lubriting shop, labs.
- TF to schedule build workshops.
- Evaluate lubriting supplier/testing.
- Develop test specific housing/gear box."

T. Gottwald 1st J. Guzikowski 2nd
Approved by hand vote: 9 approve, 0 negative, 0 abstain.

The group discussed if extra steel should be ordered to set aside for a larger batch to maintain the same heat of steel.

The group discussed the Lubriting process. Some axle builders are familiar with the company Custom Coatings, based in Auburn, Indiana. This is the shop that lubrited the last Dana model 60 batch.

The group discussed dunage options – and directed Gleason to come up with a solution to simply shipment of ring and pinions.

The panel will discuss on teleconference with Gleason & Custom Coatings requirements for thel ubrite process.

The group discussed the following visits:

Gleason – During hardware build
Custom Coatings
Lab Visits – Prior to starting final testing.
Build Workshops – Prior to mass building of axles.

The group discussed housing replacements:
It may be possible to purchase new Dana model 60 housings from the aftermarket group at Dana.
Several aftermarket companies manufacture Dana model 60 housings.
A dedicated test box was discussed, however concerns over the interior shape not matching an axle was had by several in the group.

The group discussed the proposed test matrix (see attachment).
The group did not feel the matrix could be determined at this time. This will be discussed as we move forward.

Ratings: The group discussed the wear definition will need revised to accommodate the lack of tooling marks present on the gearsets. Afton will supply their pinions to the labs on tested parts to allow the raters to review. Lubrizol will bring the parts from Detroit back to Ohio and then ship to Texas.

The group agreed to purchase the following amounts of hardware with this first batch:

- Enough hardware to run an expected 20 tests as part of a ~80 test matrix
- Any additional evaluation runs the lab wishes to run
- + 1 years supply of candidate testing

This supply should last till the end of 2015. This timing was based on hardware arriving mid 2014, and a test approved for use at the end of 2014.

Labs are requested to send their numbers back to the chair by February 12th.

Motion:
"Custom Coatings will be used for Lubriting"
T. Gottwald 1st T. Muransky 2nd
Approved unanimously by voice vote.

5.0 Adjournment

Motion to adjourn .

Respectfully Submitted
Chris Prengaman

L-37-1Hardware Taskforce Meeting

January 30th, 2014
8am EST
Meeting, Detroit Courtyard by Marriott Airport Hotel

Agenda

1. Call to order/Agenda review
2. Meeting Minute Approval
    a. 8/7/2013
    b. 8/14/2013
    c. 10/30/2013
    d. 11/6/2013
    e. 11/19/2013
    f. 1/8/2014
    g. 1/15/2014
    h. 1/22/2014
3. Background
4. Data Update
5. Test Matrix & Reference Oil Discussion
6. Gleason Presentation – 9:30 AM
7. Order Quantities
8. Test Procedure
9. Rating Aids
10. New business
11. Adjournment

Call in number → **216-706-7052 code 324160**

Join online meeting
https://meet.lubrizol.com/crpr/DD6H0VWN

First online meeting?

Lunch will be provided – Please RSVP to meeting notice
Directions to Hotel:
Courtyard Detroit Metro Airport Romulus
30653 Flynn Drive
Romulus, MI 48174
(800) 321-2211

L-37-1 History

L-37-1 History

- Nov 2010
  - Began Discussions to begin development of next generation test
- Zeta & Gleason hardware types proposed
- Zeta Hardware was selected to develop further
  - Test conditions mimicked L-37 surface interface

AAM Zeta 218 mm History

- Initial Test conditions demonstrated separation with reference fluids
- Pilot Batch & Initial hardware order acquired
- Some existing commercial formulations demonstrated difficulties passing test
- Multiple variations of test conditions evaluated
- 180+ tests

Gleason History

- Reversed Engineered Dana Model 60 Gearset
- Modified Geometry to increase bending strength
- 2 Pilot batches acquired

Goal of replacement test

- Replacement test should discriminate existing reference fluids & maintain historical severity levels for existing commercial formulations.

L-37-1
Next Generation Test

Test Data

1/30/14

Zeta	Gleason
• 218 mm	• 248 mm
• Lapped Gears	• Ground Gears
• Aluminum Independent Rear Housing	• Steel Dana Model 60 Housing
• 1.2 L Fill	• 2.8 L Fill
• 3.45:1 Ratio	• 5.86:1 Ratio
• 11.4 % offset	• 11.5 % offset
• Assembled by AAM	• Lab Built

Zeta

- Test Conditions
  - 16.5 hours
  - 1650 ft-lbs (wheel)
  - 124 rpm (wheel)
- Simulated to L-37 interface conditions

Gleason

- Test Conditions
  - 24 hours
  - 1740 ft-lbs (wheel)
  - 80 rpm (wheel)
- SAME AS L-37!

	ZETA								GLEASON								
Free-form Comment	**Pinion Rating**				**Ring Rating**				**Pinion Rating**				**Ring Rating**				**Free-form Comment**
COMMENT	WEAR	RIDG	RIPP	SPIT	WEAR	RIDG	RIPP	SPIT	WEAR	RIDG	RIPP	SPIT	WEAR	RIDG	RIPP	SPIT	**COMMENT**
	TMC 134 (Fail Oil)								**TMC 134 (Fail Oil)**								
	6	5	10	9.9	7	8	10	10	6	7	9	9.9	7	7	10	9.9	Chipping on pinion.
	6	4	9	9.4	7	4	10	9.9	7	6	9	9.9	7	6	9	2	2 broken teeth on ring.
	6	4	10	9.9	7	5	10	9.9	7	6	10	9.9	7	7	10	9.9	Chipping on pinion.
	7	**9**	8	9.9	7	**9**	10	9.9	7	7	10	3	7	7	10	3	Tooth breakage- test terminated at 7hrs 15 min. Chipping
	8	**9**	8	9.9	9	**9**	10	9.9	6	5	6	9.8	7	5	7	9.9	
	7	**9**	9	9.9	7	**10**	10	9.9									
	6	8	5	9.9	7	9	10	9.9									
	TMC 117 (Afton - Pass Oil)								**TMC 117 (Afton - Pass Oil)**								
	7	8	8	9.9	8	10	10	10	7	8	8	9.9	7	10	10	10	
	6	9	6	9.9	7	10	8	10	7	8	9	9.9	7	8	9	9.9	
	7	9	9	9.9	7	9	10	9.9	7	8	8	9.9	7	8	10	9.9	
	7	10	10	9.9	7	10	10	9.9	7	8	9	9.9	7	8	10	9.9	
	7	9	8	9.9	8	10	9	9.9									
	7	9	7	9.9	7	9	9	9.9									
	TMC 152 (Pass Oil)								**TMC 152 (Pass Oil)**								
	7	9	10	9.9	8	10	10	10	7	9	9	9.9	7	10	10	9.9	
	7	10	10	9.9	8	10	10	10	7	10	10	9.9	7	10	10	10	
	TMC 155 (Pass Oil)								**TMC 155 (Pass Oil)**								
	7	10	10	9.9	9	10	10	10	7	9	10	9.9	7	10	10	10	155-1
	7	10	10	9.9	7	10	10	9.9	7	9	9	9.9	7	10	10	10	155-1
									7	9	9	9.9	7	10	10	9.9	155-1
									7	10	10.0	9.9	7	10	10	10	155
	TMC 134 - Canadian								**TMC 134 - Canadian**								
									6	6	7	9	6	6	7	9.9	
	TMC 117 (Afton - Pass Oil)								**TMC 117 (Afton - Pass Oil)**								
									7	10	10.0	10	7	10	10	10	
									7	9	10.0	9.9	7	9	10	9.9	
	TMC 152 - Canadian								**TMC 152 - Canadian**								
	7	10	10	9.9	8	10	10	9.9	7	9	10	9.9	7	10	10	10	
	8	10	10	9.9	8	10	10	9.9	7	9	10	9.9	7	10	10	9.9	
	TMC 134 (Fail Oil) - Lubrited																
	7	9	9	9.9	7	9	9	9.9									
	TMC 117 (Afton - Pass Oil)																
	7	9	9	9.9	9	10	10	9.9									
	Commercial Formulations								**Commercial Formulations**								
A - GL-5	7	9	8	9.9	8	10	10	10	7	10	10	9.9	7	10	10	9.9	E - GL-5 with QPL #
B - J2360 with QPL #	7	9	8	9.9	7	9	10	9.9									
C - J2360 with QPL #	7	9	9	9.5	8	10	10	9.9									
D - J2360 with QPL #	8	10	10	9.6	8	10	10	9.9									
									High Temperature (Stressed)								
									5	5	6	7	5	5	6	9.8	F - expected to fail
									7	9	10	9.9	7	9	10	9.9	G - 75W-140
									7	9	10	9.9	7	10	10	10	H

What does this all mean?

- Zeta hardware
  - Test conditions have shifted mild to allow TMC 117 to pass.
  - Mild conditions have allowed **TMC 134 (fail oil) to pass!**
- Gleason hardware is reversed engineered L-37
  - NEED MORE DATA!

Next Steps

- Place pilot order of hardware
- Redesign/evaluate fluids
- Full Batch Order
- Finalize Test Procedure & Publish ASTM document – Official SP Group formed
- Final Lab Audits (TMC & SP Group)
- First Hardware Batch Test Matrix
- Inclusion into SAE J2360 & API GL-5 specifications

Hardware Test Matrix

Hardware Order

Gleason Results, 2013 Batch

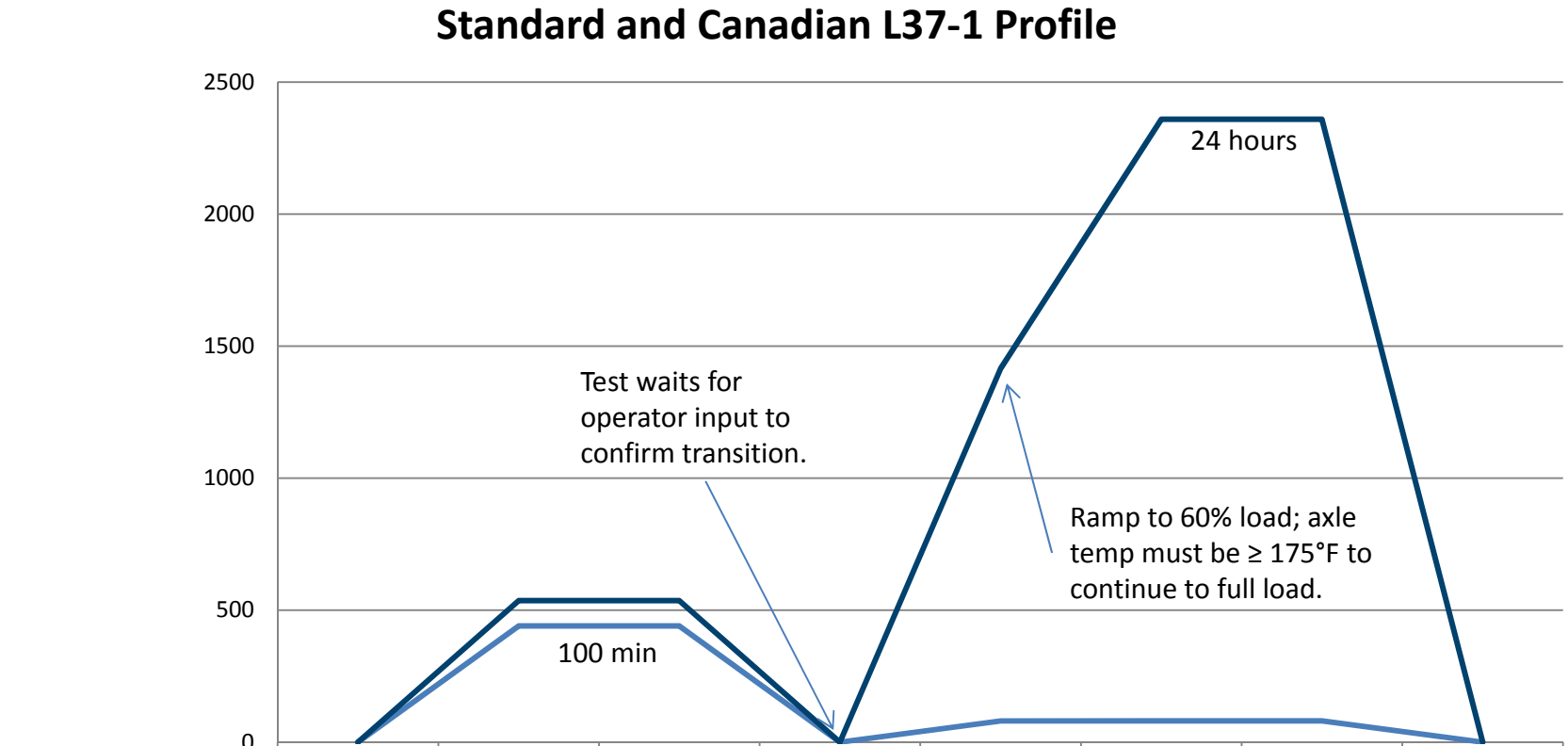
Prepared for ASTM L-37-1 TF
Courtyard Detroit Metro Airport
Romulus
Jan. 30, 2014

Passion for Solutions™

Background and Method

- **Same ratio as current axle: 5.86**
- **Ground gears**
  - Consistency part-to-part
- **Currently run installed in Dana Model 60 housings**
- **Run under the current specification**
  - Modified only to run on an electric stand without transmission shifting
  - Full load
  - 24 hours
  - No changes to break-in
  - Standard & Canadian temps
  - High Temp test also runs as expected (16hr, 325°F)

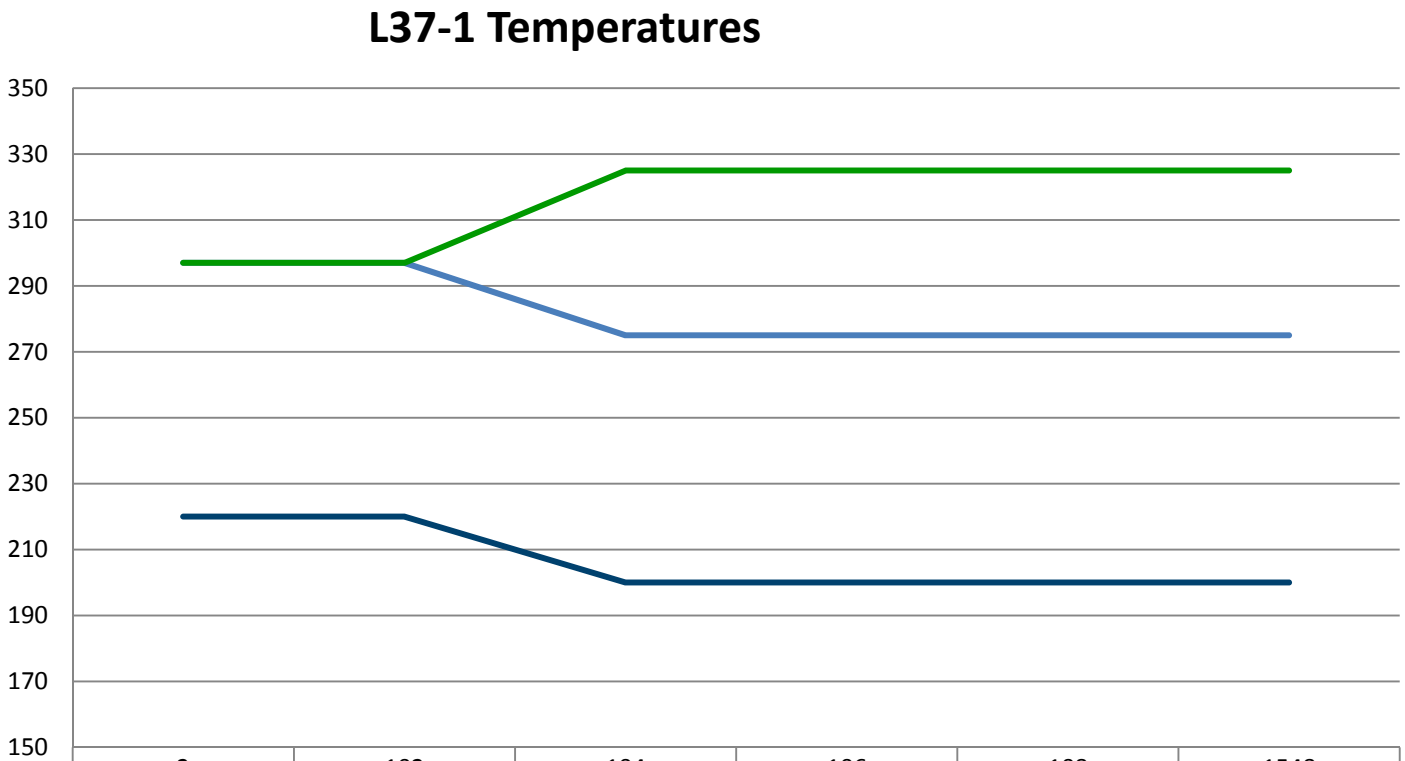
Graphical representation of ramps



	0	2	102	104	106	108	1548	1550
Wheel Speed (RPM)	0	440	440	0	80	80	80	0
Wheel Torque (Nm)	0	536	535.6	0	1415.4	2359	2359	0

*BI & Test times start when wheel speed, wheel torque, and fluid temp are in spec.

Confirmation of BI & Test Temperatures



	2	102	104	106	108	1548
Standard Test Temp (F)	297	297	275	275	275	275
Canadian Test Temp (F)	220	220	200	200	200	200
HT Test Temp (F)	297	297	325	325	325	325

*Not representative of actual temperature ramps.

Data

Favorable Results

- Reference oils performed as expected
  - TMC Oil 134
    - All runs failed as desired (due to ripple or ridge on ring and pinion)
    - Standard and Canadian
  - TMC Oils 155, 155-1, 152-1, 152-2
    - All passing fluids passed
    - Standard and Canadian
  - TMC Oil 117
    - Passed, but discriminated against more robust TMC oils
    - Standard and Canadian
- Store bought fluids
  - Passed standard test (GL-5 fluid with QPL#)
  - Passed HT test (75W-140)
- Any gear failures (tooth cracks/breakage) occurred on Oil 134
  - 2 runs of 27 gears run

Reported Failure/Faulty Run Result Causes

- Unconfirmed oils run
- Building systems caused multiple shutdowns (process water & electrical supply failures)
- 1 Gear not shot-peened (was not run)

Benefits

Benefits

- Runs exact same speeds, temps, loads and duration as the current L-37 test
- Endless supply of test specific hardware vs. finite lifespan production hardware
- Continuity of L37 requirements & link to historic data
  - Reference oils, J2360, and GL-5 approved fluids are showing equivalent results between Gleason and Dana
- Eventual cost reductions

Example of 152-1/152-2 on V1L500 & Gleason

TEST METHOD D6121
L-37
Form 1
Test Result Summary Sheet

Oil Test					
Lab:	EV	Stand:	2A	Stand Run :	1150
Start Date:	20131212	Date Completed: 20131213	EOT Time: 07:39	Test Length:	23:59
TMC Oil Code:	152-1	Laboratory Oil Code:	EV 341	Viscosity Grade:	90
Oil Code:	90506				
Formulation Stand Code:					
Latest Information Letter Test Was Run Under:	13-4				
Test Hardware:	NONLUBRITED	Test Version:	STANDARD		
Pinion Batch:	V1L500	Ring Batch:	P4T813		

Last Reference Oil Calibrating Stand Information - Fill Out For Non-reference Oil Tests Only					
Stand:	2A	Stand Run:	TMC Oil Code:	Date Completed:	
Pinion Batch:		Ring Batch:			
Test Hardware:	NONLUBRITED	Test Version:	STANDARD		

	Ring Gear Results				
	Wear	Rippling	Ridging	Pitting/Spalling	Scoring
Original Merit Results C	8	10	10	9.9	10
Transformed Results	8.0000	0.6931	0.6931	0.5108	10.0000
Correction Factor	0.0000	0.0000	0.0000	0.0000	0.0000
Corrected Transformed Results	8.0000	0.6931	0.6931	0.5108	10.0000
Severity Adjustment A	0.0000	0.0000	0.0000	0.0000	0.0000
Final Transformed Results	8.0000	0.6931	0.6931	0.5108	10.0000
Final Merit Results	8.0	10.0	10.0	9.9	10.0

	Pinion Gear Results				
	Wear	Rippling	Ridging	Pitting/Spalling	Scoring
Original Merit Results B,C	8	9	9	9.9	10
Transformed Results	8.0000	*-0.4055*	*-0.4055*	0.5108	10.0000
Correction Factor	0.0000	0.0000	0.0000	0.0000	0.0000
Corrected Transformed Results	8.0000	*-0.4055*	*-0.4055*	0.5108	10.0000
Severity Adjustment A	0.0000	0.0000	0.0000	0.0000	0.0000
Final Transformed Results	8.0000	*-0.4055*	*-0.4055*	0.5108	10.0000
Final Merit Results	8.0	9.0	9.0	9.9	10.0

A AT THE PRESENT TIME THERE ARE NO SEVERITY ADJUSTMENTS
B WITH ANY APPLICABLE EXCLUSIONS APPLIED
C IF TOOTH BREAKAGE OCCURS, LEAVE RESULTS BLANK AND REPORT IN COMMENT SECTION

133518 Report created 27-Jan-2014 10:33:06

TEST METHOD D6121
L-37
Form 1
Test Result Summary Sheet

Oil Test					
Lab:	EV	Stand:	3	Stand Run :	150
Start Date:	20140123	Date Completed: 20140124	EOT Time: 10:55	Test Length:	24:00
TMC Oil Code:	152-2	Laboratory Oil Code:		Viscosity Grade:	
Oil Code:	98621				
Formulation Stand Code:					
Latest Information Letter Test Was Run Under:	13-4				
Test Hardware:	NONLUBRITED	Test Version:	STANDARD		
Pinion Batch:		Ring Batch:			

Last Reference Oil Calibrating Stand Information - Fill Out For Non-reference Oil Tests Only					
Stand:	3	Stand Run:	TMC Oil Code:	Date Completed:	
Pinion Batch:		Ring Batch:			
Test Hardware:		Test Version:			

	Ring Gear Results				
	Wear	Rippling	Ridging	Pitting/Spalling	Scoring
Original Merit Results C	7	10	10	9.9	10
Transformed Results	7.0000	0.6931	0.6931	0.5108	10.0000
Correction Factor	0.0000	0.0000	0.0000	0.0000	0.0000
Corrected Transformed Results	7.0000	0.6931	0.6931	0.5108	10.0000
Severity Adjustment A	0.0000	0.0000	0.0000	0.0000	0.0000
Final Transformed Results	7.0000	0.6931	0.6931	0.5108	10.0000
Final Merit Results	7.0	10.0	10.0	9.9	10.0

	Pinion Gear Results				
	Wear	Rippling	Ridging	Pitting/Spalling	Scoring
Original Merit Results B,C	7	9	9	9.9	10
Transformed Results	7.0000	*-0.4055*	*-0.4055*	0.5108	10.0000
Correction Factor	0.0000	0.0000	0.0000	0.0000	0.0000
Corrected Transformed Results	7.0000	*-0.4055*	*-0.4055*	0.5108	10.0000
Severity Adjustment A	0.0000	0.0000	0.0000	0.0000	0.0000
Final Transformed Results	7.0000	*-0.4055*	*-0.4055*	0.5108	10.0000
Final Merit Results	7.0	9.0	9.0	9.9	10.0

A AT THE PRESENT TIME THERE ARE NO SEVERITY ADJUSTMENTS
B WITH ANY APPLICABLE EXCLUSIONS APPLIED
C IF TOOTH BREAKAGE OCCURS, LEAVE RESULTS BLANK AND REPORT IN COMMENT SECTION

135367 Report created 27-Jan-2014 11:25:16

Cost Benefits – Comparable Now, Cheaper Tomorrow

Afton/Gleason L37 axle cost 2013-2014				
Item #	Part description	Cost	Comments	Notes
1	Gleason Pinion/Ring	$ 784.00	based on order qty of 40pcs in 2013	
2	Rear gasket	$ 6.00	Local distributor	
3	Pinion seal	$ 10.00	Local autozone	
4	Pinion head bearing	$ 42.08	Local autozone	cone part # HM803146; cup part # HM803110
5	Pinion tail bearing	$ 25.00	Local autozone	cone part # HM88542; cup part # HM88510
6	Differential bearing RS	$ 30.58	Local autozone	cone part# 387A; cup part# 382S
7	Differential bearing Non-RS	$ 30.58	Local autozone	cone part# 387A; cup part# 382S
8	Differential carrier	$ -	Labs to use current stock	
9	Axle housing	$ -	Labs to use current stock	
10	rear cover	$ -	Labs to use current stock	
11	Assembly-5 hours	$ 375.00	Assume's $75/hr	
	Total	$ 1,303.24		

Afton/Gleason L37 axle cost future				
Item #	Part description	Cost	Comments	Notes
1	Gleason Pinion/Ring	$400 to $500	based on talks of 1000+ units	
2	Rear gasket	$ 6.00	Local distributor	
3	Pinion seal	$ 10.00	Local autozone	
4	Pinion head bearing	$ 42.08	Local autozone	cone part # HM803146; cup part # HM803110
5	Pinion tail bearing	$ 25.00	Local autozone	cone part # HM88542; cup part # HM88510
6	Differential bearing RS	$ 30.58	Local autozone	cone part# 387A; cup part# 382S
7	Differential bearing Non-RS	$ 30.58	Local autozone	cone part# 387A; cup part# 382S
8	Differential carrier	$ -	Labs to use current stock	
9	Axle housing	$ -	Labs to use current stock	
10	rear cover	$ -	Labs to use current stock	
11	Assembly-5 hours	$ 375.00	Assume's $75/hr	
	Total	$920 to $1020		

*Further reduced with test specific housing (assembly time)

Next Steps

- **Order Parts**
  - Reduction in gear costs (development is paid for)
- **Axle Build Workshops/Lab Visits**
- **Lubrited Hardware Evaluation**
  - Custom Coating, Inc.
- **Test Housing Development**
  - 3rd Party to develop robust housing/test box
  - Ease of build → Faster test turn around
  - Labs will only need as many test housings as they want (i.e. won't need to store full sized housings any longer)
  - Cost reduction benefits

ASTM Grinding-Lapping Basics

Mike Dennis – Race Guy Engineer

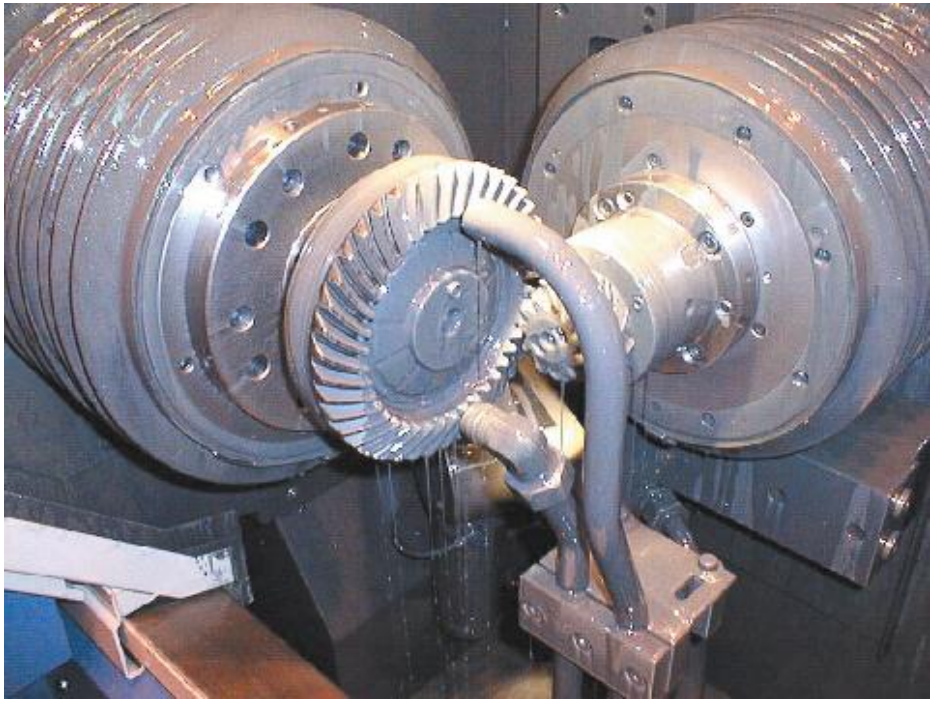
Dr. Art Reardon – Metals Guy Professor

The Gleason Works

Video: CorporateVideo

- ✓ Lapping
  - Surface refinement process
- ✓ Grinding
  - Corrective machining process
- ✓ Carbide Hard Finishing - Skiving
  - Corrective machining process

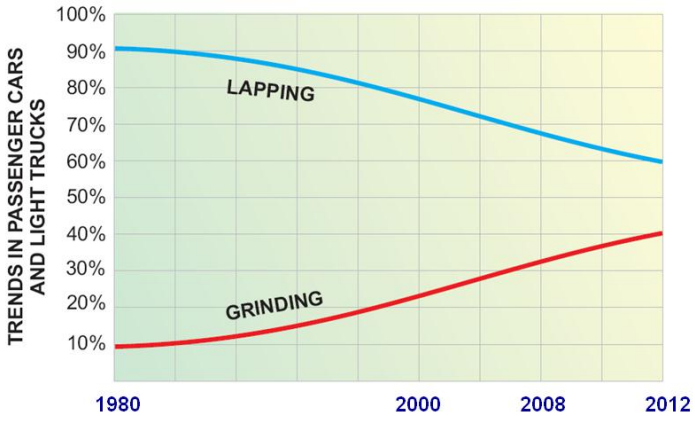
- ✓ Machine with 4 Crucial Elements
  - Two precision spindles
  - Three linear axes (X, Y, & Z) or (V,H,G)
  - Torque system
  - Compound supply



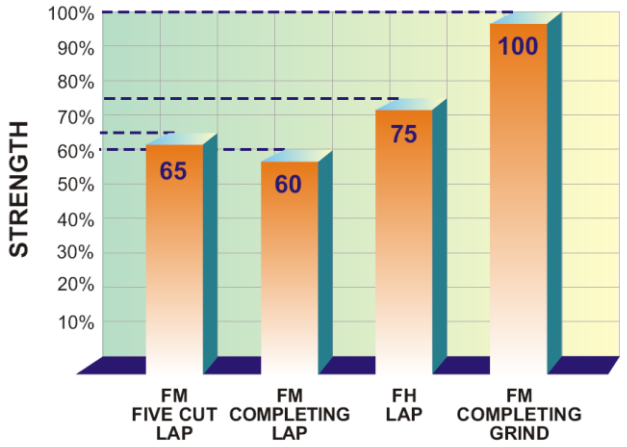
Video: Lapping.wmv

- ✓ One economical machine completes gear and pinion simultaneously
- ✓ Stable and forgiving process – lower “tech”
- ✓ Fast cycle times
  - 2-3 min for typical for automotive
  - 4-5 min typical truck
- ✓ Excellent noise behavior

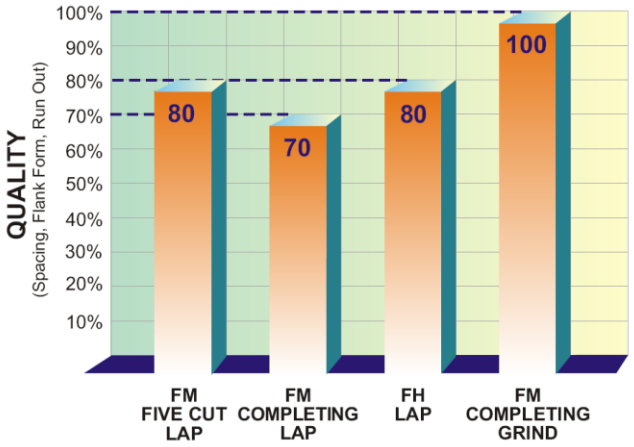
Trend Lapping vs. Grinding



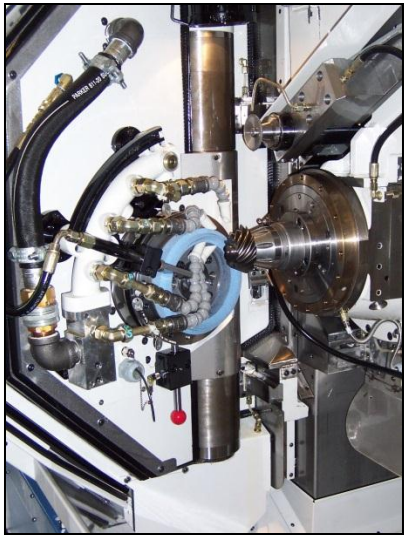
Strength Lapped vs. Ground

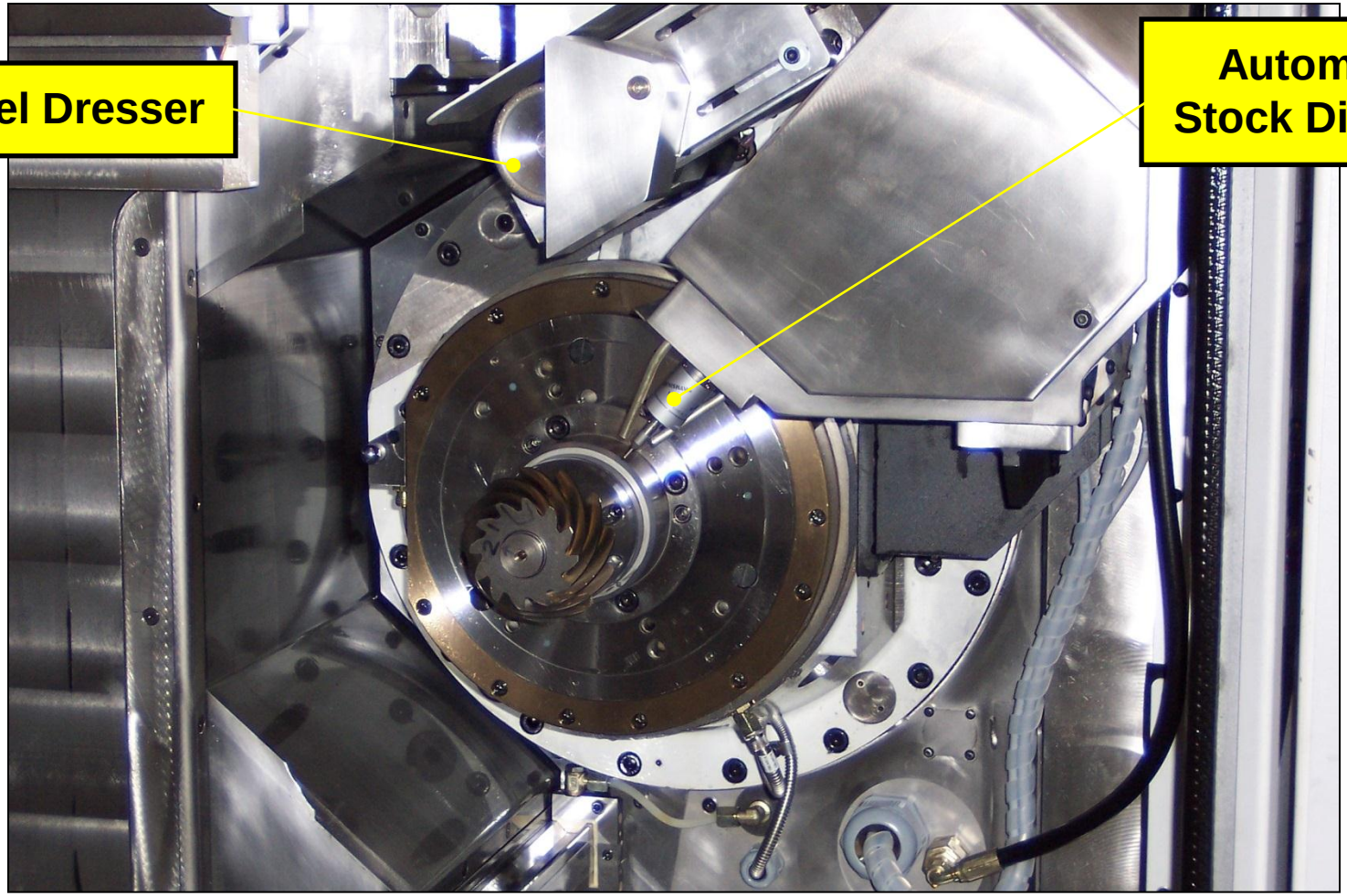


AGMA Quality Lapped vs. Ground



- ✓ Higher strength
  - Smooth root blend
  - Uniform tooth spacing
- ✓ Longevity
  - No imbedded lapping compound
- ✓ Economically competitive
  - Some analysis show gap is small when all effects are considered
- ✓ Interchangeable pinions and gears
- ✓ Easier part cleaning
- ✓ No lapping compound
- ✓ Less concern with heat treat distortion





Video: Grinding.wmv

Video: EndRem.wmv

Gleason

THE TOTALGEAR SOLUTIONS™ PROVIDER

GleasonCorpVideo.wmv

Gear Technology for Nearly 150 Years…

- Founded in 1865
- Private company since 2000
- Headquarters in Rochester, New York, USA

…Today, the world leader in gear technology

OVERVIEW

Our mission is to be:

- Largest global supplier of bevel and cylindrical gear production machines and related tools and services
- Entire product offering is focused on gear technology
- Broadest range of products in the industry, covering all major gear processes across all size ranges and applications

OVERVIEW

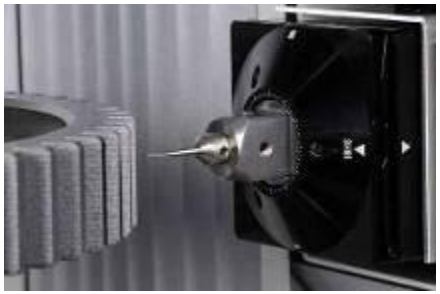
Gleason

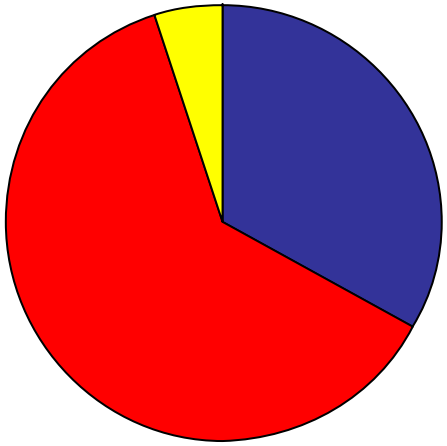
THE TOTALGEAR SOLUTIONS™ PROVIDER

- Industry leader in product and process technology with approximately 300 patents issued and pending
- Significant global infrastructure and customer support network
- Serving a diverse set of end-markets

THE TOTALGEAR SOLUTIONS™ PROVIDER

Sales by Product

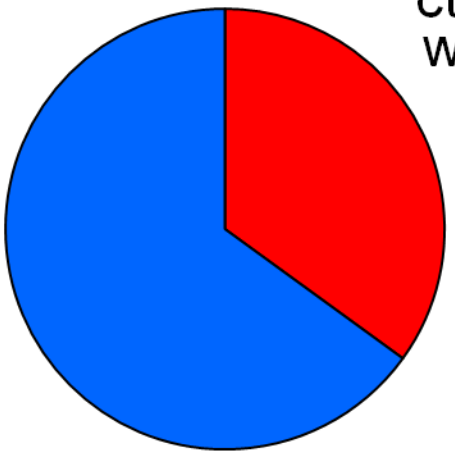




Gleason

Sales by Product

Machines
65%



Cutting Tools
Workholding
Services
35%

Gear Solutions…

- From small high precision cylindrical gears for car and truck transmissions…

…for a full range of gear design and processing systems

Gear Solutions…

- …to the largest cylindrical gears for today's biggest windpower turbines.

…for a full range of gear design and processing systems

Gear Solutions…

- From quiet, high-precision bevel gear sets for the axles of many of today's most popular cars and trucks…

…for a full range of gear design and processing systems

Gear Solutions…

- …to the highest quality bevel gears to keep aircraft flying.

…for a full range of gear design and processing systems

WORLDWIDE

Gleason

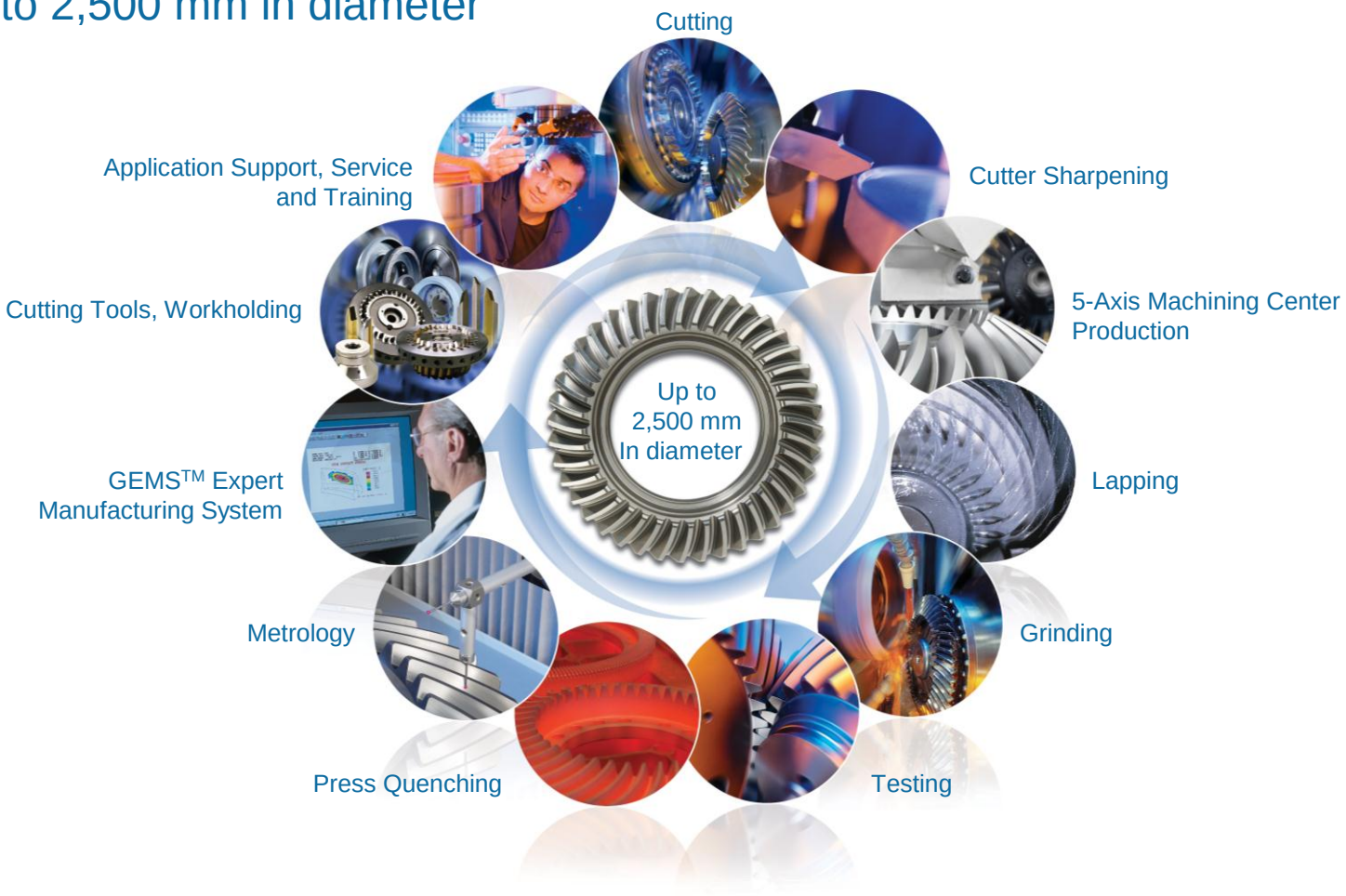
Total Employees: 2,525

THE TOTALGEAR SOLUTIONS PROVIDER

Bevel Gear Solutions

Most Complete Bevel Gear Production Systems

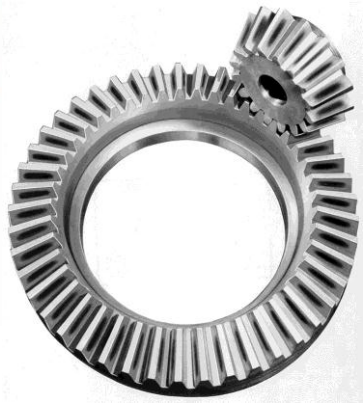
- Up to 2,500 mm in diameter

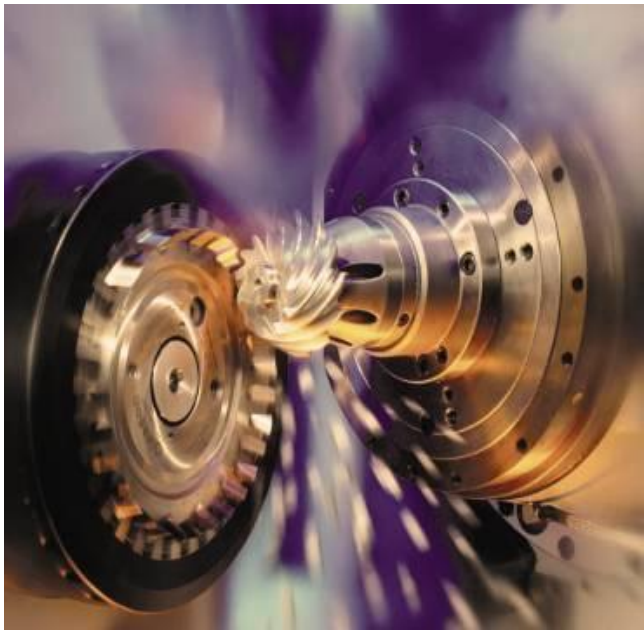


Bevel Gears: Cutting Machines

- Cutting of Spiral Bevel and Straight Bevel gears up to 1,000 mm in diameter

phoenix



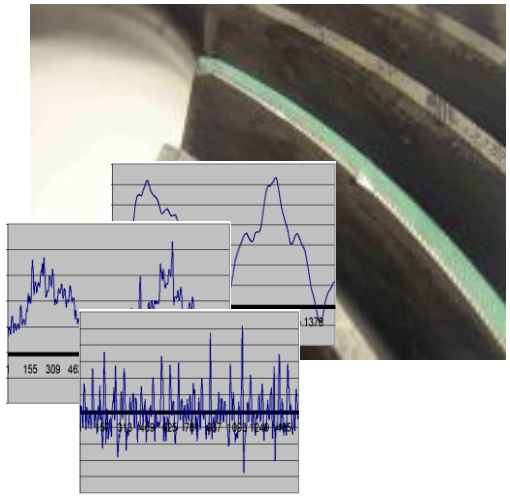


Bevel Gears: Grinding Machines

- Grinding of Spiral Bevel and Straight Bevel gears up to 800 mm in diameter

Bevel Gears: Testing Machines

- Roll testing of bevel gear sets up to 2,500 mm to perform sophisticated diagnostic tests including angular gear applications
- Single Flank Testing (SFT)
- Structure Borne Noise (SBN)



Bevel Gears:
Lapping Machines

- Lapping of bevel gears up to 600 mm in diameter

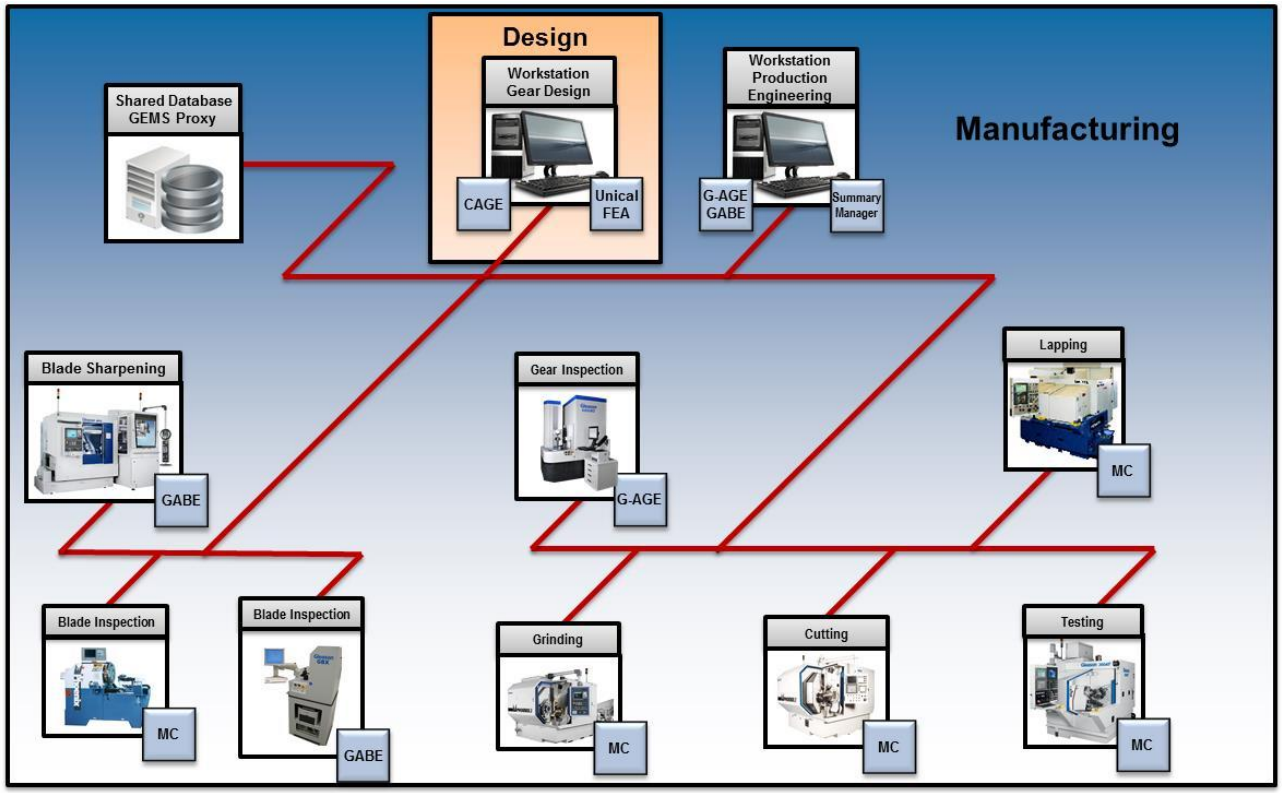
TURBO LAPPER

Bevel Gears:
Auxiliary Equipment

- Blade Profile Grinder (BPG)
- Gleason Blade Inspection (GBX)
- Cutter Build (CB)
- Quench Press Machines

Bevel Gears: Software Solutions

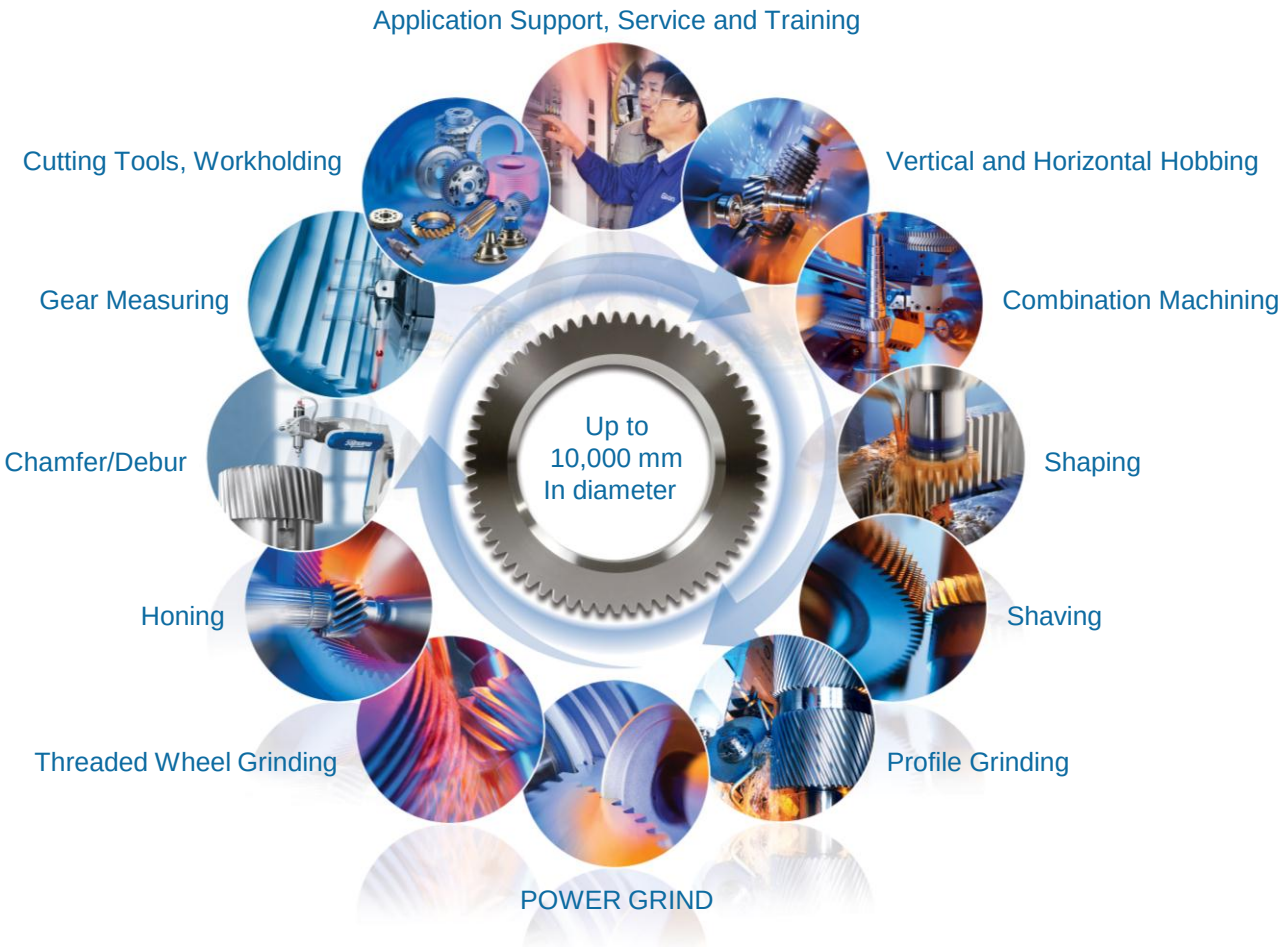
- Gems™
- *CAGE*™
- *G-AGE*™
- *UMC*™
- *FEA*
- Summary Manager
- GABE™

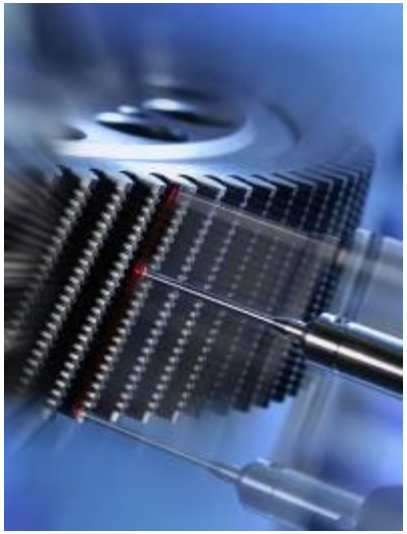


Cylindrical Gear Solutions

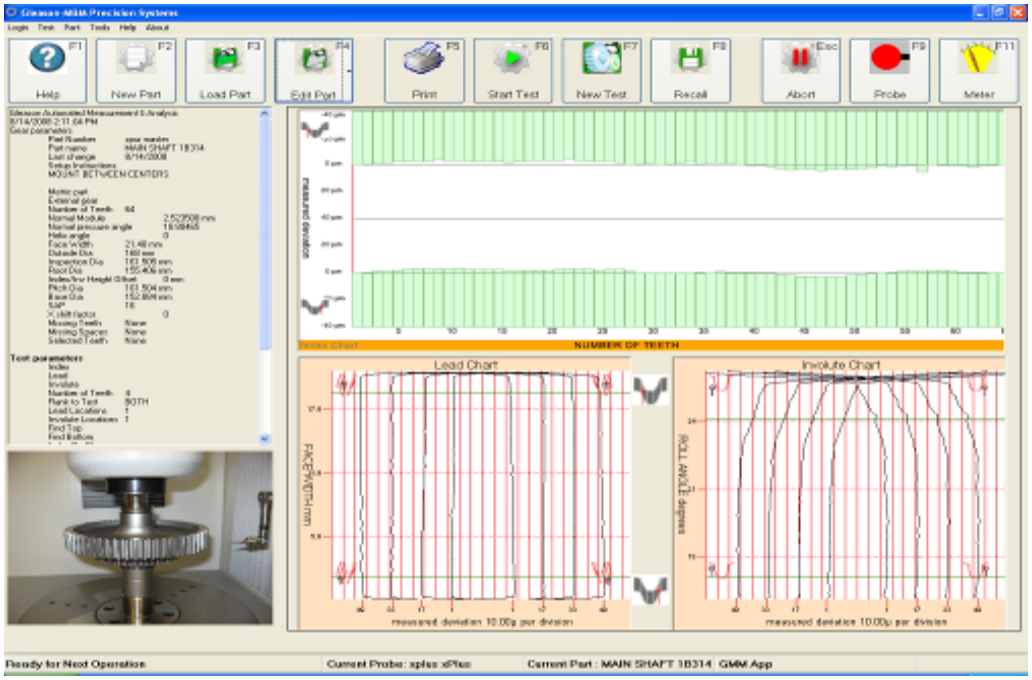
Complete Cylindrical Gear Production Systems

- Up to 10,000 mm in part diameter



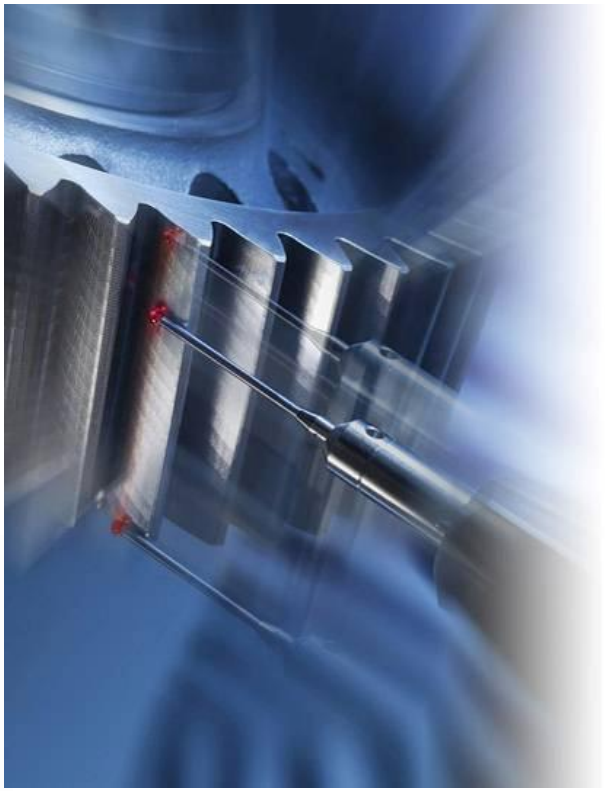


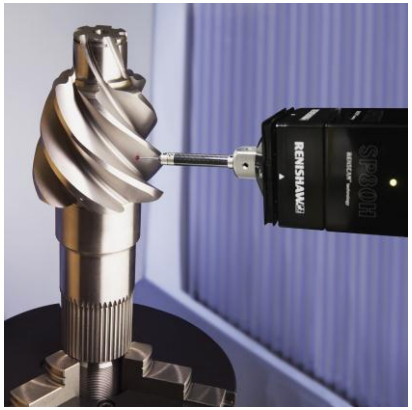
Metrology Solutions



Metrology: Gear Inspection

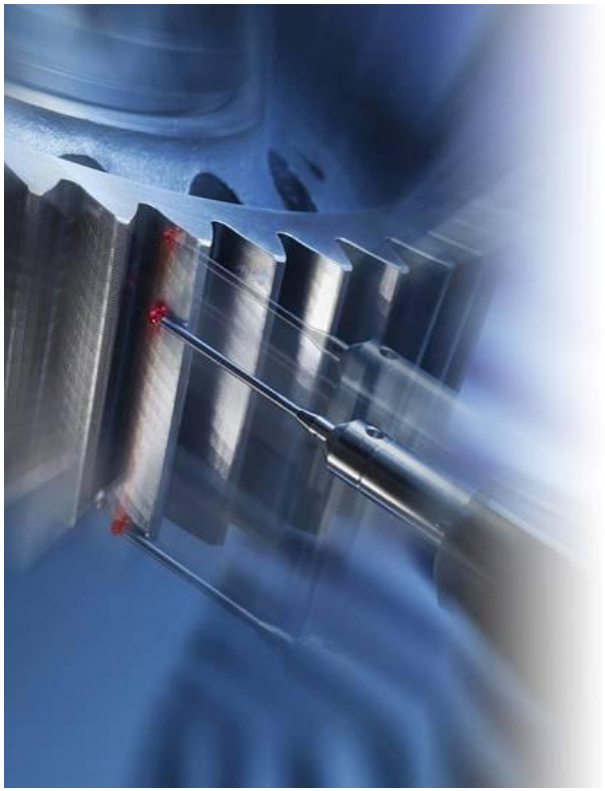
- Analytical gear inspection
- Bevel gears, cylindrical gears, gear tools, rotors
- For gears up to 3000 mm in diameter
- Closed loop inspection and software
- GAMA windows-based software





Metrology: Gear Inspection

- Functional gauges (stand alone and automated)
- Master gears and spline gauges



Tooling Solutions

Gleason Global Services

Training

- Classroom / hands-on training
- Gear School classes
- Operator Training
- Maintenance Training
- Customized Training Packages
- Webinars

Gleason Global Services

Application Development

- Optimizing your gear design and production methods
- Prototyping
- Bevel & cylindrical gear process development
- Tool life studies
- Training

Gleason

Hobbing Production Analysis & Cycle Time Estimate

Customer	IMTS-JMTOF	Machine Model	Genesis 130H
Inquiry #	Unknown	Engineer	PEC-TJM
Workpiece Name	Unknown	Date	12/3/2010 1:39:08 PM
Drawing / Part #	IMTS-JMTOF Demo Job	Production Analysis (PA) #	IMTS-JMTOF Demo Job
Operation #	Unknown	Metric / English	[mm]
Process:			
Hob Process Type	Pre-Roll	Wet / Dry	Dry
Loading	Automatic	Coolant Type	
Pieces / Cycle	1		
Workpiece:			
# of Teeth	34	Whole Depth	3.585
Module [mm]	1.4	Face Width	28.355
Pressure Angle [Deg.]	20	Workpiece Material	Carbon Steel
Helix Angle [Deg.]	21 RH	Brinell Hardness [BHN]	200
Outside Diameter	53.16	Machinability	60%
Tool:			
Tool #	130H IMTS-2006 Hob	Hob Material	REX76 PM
Hob Diameter	65	Coating	Athertek
# of Gashes	16	Thread Length	240
# of Starts / Hand	3 /RH	Overall Length	240
Lead Angle [Deg.]	3.7833	Bore / Shank	Shank
		Hob Style Ref.	

Cutting Data:	Approach	1st Cut
Cutting Direction	Conventional	Conventional
Cutting Depth	3.585	3.585
Cutting Speed [m/min]	165.363	165.363
Hob rpm	800	800
Workpiece rpm	70.588	70.588
Feedrate [mm/rev]	2.4	2.4
Chip Thickness	0.201	0.201
Depth of Feedmarks		0.008
Cutting Length	16.448	33.052
HobbingTime [min]	0.097	0.195

Estimated Times:	min	sec
Loading & Clamping Time	0.08	4.8
Advance/Withdraw/Return Time	0.032	1.9
Sensing/Synchronizing Time	0	0
Misc. Idle Time	0	0
Cutting Time	0.292	17.5
Total Cycle Time	0.404	24.2
Cycle Time Per Piece	0.404	24.2

Comments:

None

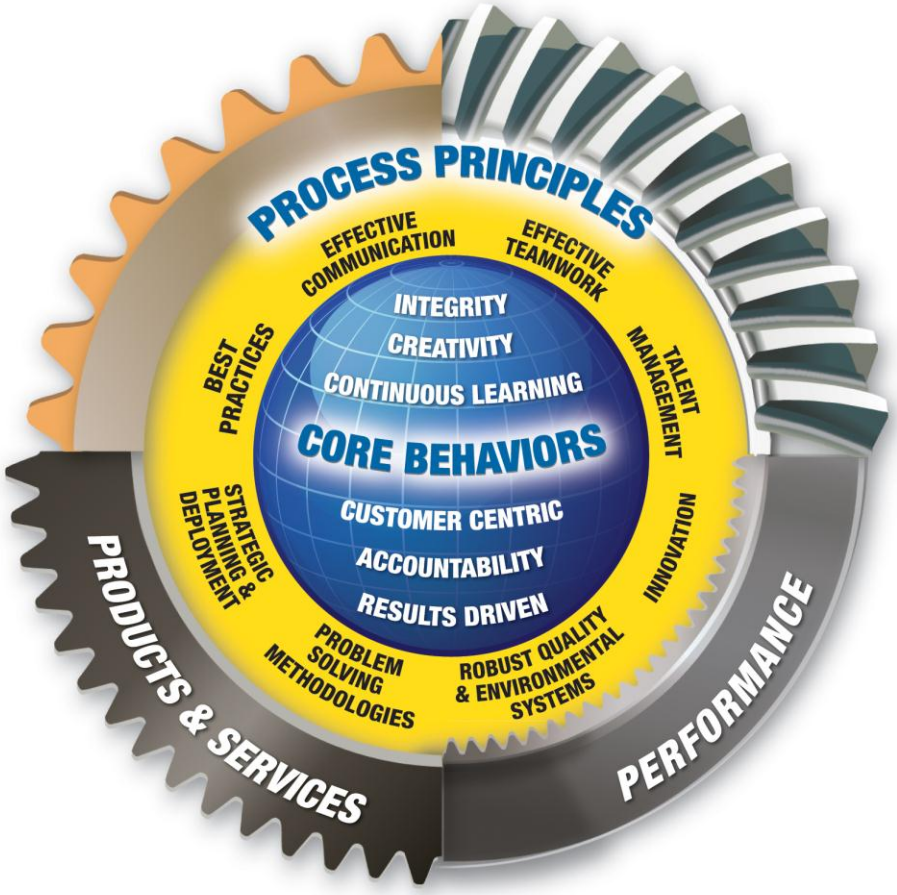
This Production Analysis is based on utilizing Gleason Tooling including work-holding and cutting tools to achieve the required quality with acceptable tool life at the quoted production rates. This cycle time estimate is the result of a careful analysis of your requirements and is, to the best of our knowledge and belief, accurate. It is based on specific assumptions which must be met in production in order to achieve the production analysis results.

IMTS-JMTOF 2006 Demo.hob

Gleason Hob PASS v. 4.0.0.0Beta

Gleason BUSINESS PRINCIPLES

- Driving a culture of continual improvement focused on maximum customer satisfaction



Lean Culture

- Customer Focus
- Implemented throughout our production sites worldwide
- A total, company-wide commitment
- Eliminating waste from all our processes
- Reducing overall lead times

All major global facilities ISO certified

ISO Certificates

- ISO 9001
- ISO 14001
- ISO 17025
- VDA 6.4
- All major global facilities are ISO Certified

ZERTIFIKAT • CERTIFICATE • 認証書 • СЕРТИФИКАТ • CERTIFICADO • CERTIFICAT

America

CERTIFICATE

The Certification Body of
TÜV SÜD AMERICA INC.

hereby certifies that

The Gleason Works
1000 University Ave
Rochester, NY 14692-2970 USA

has implemented a Quality Management System in accordance with:

ISO 9001:2008

The scope of this Quality Management System includes:

Design and Manufacture of Machines, Cutting Tools, Workholding, and Software used in the Production of Bevel and Cylindrical Gears

Certificate Expiry Date: December 6, 2015

Certificate Registration No: 951 07 4413

Effective Date: December 7, 2012

Gary W. Minks
VP, Regulatory Affairs

TÜV SÜD AMERICA INC • 10 Centennial Drive • Peabody, MA 01960 USA • www.TUVamerica.com TÜV®

ZERTIFIKAT • CERTIFICATE • 認証書 • СЕРТИФИКАТ • CERTIFICADO • CERTIFICAT

America

CERTIFICATE

The Certification Body of
TÜV SÜD AMERICA INC.

hereby certifies that

Gleason Cutting Tools Corporation
1351 Windsor Road
Loves Park, IL 61111- 4294 USA

has implemented an Environmental Management System in accordance with:

ISO 14001:2004

The scope of this Environmental Management System includes:

Sales, Design, and Manufacture of Cylindrical and Bevel-Gear Cutting Tools, Work Holding and Contracted Services (Including PVD Coating and Stripping, Heat Treatment, Super-Abrasive Plated Products, Cutting Tool Re-Sharpening Services)

Certificate Expiry Date: December 7, 2015

Certificate Registration No: 951 07 4411

Effective Date: December 8, 2012

Gary W. Minks
VP, Regulatory Affairs

TÜV SÜD AMERICA INC • 10 Centennial Drive • Peabody, MA 01960 USA • www.TUVamerica.com TÜV®

www.gleason.com

Test Matrix

Matrix Conditions

- Lubrited & Non Lubrited
  - Matrix are the same
- Standard & Canadian Conditions
- Reference Oils:
  - Pass
    - TMC 155
    - TMC 152
    - TMC 117
  - Fail
    - TMC 134

Non-Lubrited / Lubrited

Bolded fluids have targets for referencing

- Standard Conditions
  - **8 x 155**
  - 8 x 152
  - **8 x 117**
  - **4 x 134**
- Canadian Conditions
  - 8 x 152
  - 4 x 134
- 40 tests per hardware type = 80 tests total

Test Split

- 80 Tests Total
- Assume 4 labs participate
  - 20 tests each = 10 NL, 10 L
  - Participation references stand

Industry Oil Code (TMC Oil)	Test Version (Standard or Canadian)	Hardware Identification	Lab	Stand	Test Hardware	EOT Date	Conditioning		Test		Test Length	Fill Volume
IND	TVERSION	SERIALNO / Hardware ID	LTMSLAB	LTMSAPP	TESTHARD	LTMSDATE	Speed	Load	Speed	Load	Hours	mL
Phase 1 Test Redesign Matrix:												
134	STANDARD	L-100	B	361	NONLUBRITED	20131012	682	375	124	1650	8.5	950
155	STANDARD	L-32	B	361	NONLUBRITED	20131013	682	375	124	1650	16.5	950
117	STANDARD	L-20	B	361	NONLUBRITED	20131014	682	375	124	1500	16.5	1075
117	STANDARD	L-61	B	361	NONLUBRITED	20131015	682	375	160	1500	14.4	950
117	STANDARD	LX-40	B	361	NONLUBRITED	20131017	682	375	100	1500	16.5	1200
117	STANDARD	L58-58	B	361	NONLUBRITED	20131026	682	375	124	1350	16.5	950
117	STANDARD	L-40	B	361	NONLUBRITED	20131027	682	375	160	1650	16.5	1075
117	STANDARD	L8-38	B	361	NONLUBRITED	20131030	682	375	160	1350	16.5	1200
117	STANDARD	L89-50	B	361	NONLUBRITED	20131031	682	375	100	1350	16.5	1075
117	STANDARD	L23-57	B	361	NONLUBRITED	20131101	682	375	100	1650	16.5	950
117	STANDARD	L7-45	B	361	NONLUBRITED	20131111	682	375	160	1650	14.8	1200
117	STANDARD	L-116-22	B	361	NONLUBRITED	20131112	682	375	100	1350	16.5	950
117	STANDARD	L7-45	B	361	NONLUBRITED	20131105	682	375	160	1350	16.5	1200
117	STANDARD	L108-110	B	361	NONLUBRITED	20131117	682	375	124	1500	16.5	1075
134	STANDARD	L93-39	B	361	NONLUBRITED	20131103	682	375	160	1350	16.5	1200
134	STANDARD	L34-20	B	361	NONLUBRITED	20131109	682	375	124	1500	16.5	1075
134	STANDARD	L10-37	B	361	NONLUBRITED	20131116	682	375	124	1500	16.5	1075
V2 Breakin - Length Experiment:												
117	STANDARD	L75-13	B	361	NONLUBRITED	20131124	682	375	124	1650	16.5	1200
117	STANDARD	L124-26	B	361	NONLUBRITED	20131125	682	375	124	1650	16.5	1200
117	STANDARD	L86-12	B	361	NONLUBRITED	20131128	682	375	124	1650	18	1200
117	STANDARD	L112-8	B	361	NONLUBRITED	20131129	682	375	124	1650	20	1200
117	STANDARD	L7-116	B	361	NONLUBRITED	20131130	682	375	124	1650	22	1200
Standard Conditions:												
134	STANDARD	L12-67	B	361	NONLUBRITED	20131102	682	375	124	1650	16.5	1200
134	STANDARD	L47-31	B	361	NONLUBRITED	20131110	682	375	124	1650	16.5	1200
134	STANDARD		B	361	NONLUBRITED	20131208	682	375	124	1650	16.5	1200
134	STANDARD	L3-35	B	361	NONLUBRITED	20131217	682	375	124	1650	16.5	1200
134	STANDARD	7090310	G		NONLUBRITED	20140114	682	375	124	1650	16.5	1200
134	STANDARD		G		NONLUBRITED	20140122	682	375	124	1650	16.5	1200
134	STANDARD		A		NONLUBRITED							
117	STANDARD	L87-88	B	361	NONLUBRITED	20131029	682	375	124	1650	16.5	1200
117	STANDARD	L44-46	B	361	NONLUBRITED	20131104	682	375	124	1650	16.5	1200
117	STANDARD		B	361	NONLUBRITED	20131208	682	375	124	1650	16.5	1200
117	STANDARD	L71-54	B	361	NONLUBRITED	20131209	682	375	124	1650	16.5	1200
117	STANDARD		G		NONLUBRITED	20140116	682	375	124	1650	16.5	1200
117	STANDARD		A		NONLUBRITED	20140122	682	375	124	1650	16.5	1200
152	STANDARD	LX-64	B	361	NONLUBRITED	20131220	682	375	124	1650	16.5	1200
152	STANDARD		B	361	NONLUBRITED	20131221	682	375	124	1650	16.5	1200
155	STANDARD	L17-53	B	361	NONLUBRITED	20131119	682	375	124	1650	16.5	1200
155	STANDARD	L10-42	B	361	NONLUBRITED	20131214	682	375	124	1650	16.5	1200
Canadian Conditions:												
152	CANADIAN		B	361	NONLUBRITED	20140110	682	375	124	1650	16.5	1200
152	CANADIAN		B	361	NONLUBRITED	20140116	682	375	124	1650	16.5	1200
Standard Lubrited Conditions:												
134	STANDARD		G		LUBRITED	20140118	682	375	124	1650	16.5	1200
117	STANDARD		G		LUBRITED	20140121	682	375	124	1650	16.5	1200

Modified Break In	Test EOT Early?	Pinion Rating					Ring Rating					Broken Tooth	Broken Tooth Location
		WEAR	RIDG	RIPP	SPIT	SCOR	WEARR	RIDGR	RIPPR	SPITR	SCORR		
No	Yes	6	4	5	8	10	4	4	10	9.8	10	Yes	Ring
No	No	7	10	10	9.9	10	7	10	10	9.9	10	No	
No	No	7	7	9	9.9	10	7	9	10	9.9	10	No	
No	Yes	3	3	10	7	6	4	3	10	9	9	Yes	Ring & Pinion
No	No	9	9	10	9.9	10	9	10	10	9.9	10	No	
No	No	7	4	5	9.9	10	7	6	10	9.9	10	No	
No	No	4	3	8	7	6	6	4	6	8	10	Yes	
No	No	7	9	9	9.9	10	7	10	10	10	10	No	
No	No	8	10	10	9.9	10	8	10	10	9.9	10	No	
No	No	8	10	10	9.9	10	9	10	10	9.9	10	No	
No	Yes	4	4	10	9.3	7	3	3	10	9.3	10	Yes	Pinion & Ring
No	No	6	6	5	9.9	10	7	6	10	9.9	10	No	
No	No	7	10	8	9.9	10	7	9	9	10	10	No	
No	No	7	9	9	9.9	10	8	10	10	10	10	No	
No	No	7	9	8	9.9	10	7	9	9	9.9	10	No	
No	No	7	4	10	9.9	10	7	4	10	9.9	10	No	
No	No	7	9	8	9.9	10	8	10	10	10	10	No	
V2	No	8	10	10	9.9	10	8	10	10	9.9	10	No	
V2	No	7	10	10	9.9	10	8	10	10	9.9	10	No	
V2	No	7	8	9	9.9	10	7	10	10	10	10	No	
V2	No	7	5	8	9.9	10	7	6	10	10	10	No	
V2	No	7	5	8	9.9	10	7	7	10	10	10	No	
No	No	6	5	10	9.9	10	7	8	10	10	10	No	
No	No	6	4	9	9.4	10	7	4	10	9.9	10	No	
No	No	6	4	10	9.9	10	7	5	10	9.9	10	No	
No	No	7	**9**	8	9.9	10	7	**9**	10	9.9	10	No	
No	No	8	**9**	8	9.9	10	9	**9**	10	9.9	10	No	
No	No	7	**9**	9	9.9	10	7	**10**	10	9.9	10	No	
No	No	7	8	8	9.9	10	8	10	10	10	10	No	
No	No	6	9	6	9.9	10	7	10	8	10	10	No	
No	No	7	9	9	9.9	10	7	9	10	9.9	10	No	
No	No	7	10	10	9.9	10	7	10	10	9.9	10	No	
No	No	7	9	8	9.9	10	8	10	9	9.9	10	No	
No	No	7	9	7	9.9	10	7	9	9	9.9	10	No	
No	No	7	9	10	9.9	10	8	10	10	10	10	No	
No	No	7	10	10	9.9	10	8	10	10	10	10	No	
No	No	7	10	10	9.9	10	9	10	10	10	10	No	
No	No	7	10	10	9.9	10	7	10	10	9.9	10	No	
No	No	7	10	10	9.9	10	8	10	10	9.9	10	No	
No	No	8	10	10	9.9	10	8	10	10	9.9	10	No	
No	No	7	**9**	9	9.9	10	7	**9**	9	9.9	10	No	
No	No	7	9	9	9.9	10	9	10	10	9.9	10	No	

Free-form Comment
COMMENT
[redacted]
6/24 broken pinion/ring gear teeth
Most ring gear teeth cracked.
[redacted]
[redacted]
[redacted]
[redacted]

Gear Batch	Gear Number	Run Number	Test Version	Hardware Type	Oil	CMIR	EOT Date	Housing	Pinion			
									Wear	Ripple	Ridge	Spitt
3	001	3-110	Standard	Non-lubrited	134	83422	8/2/2013	G-1	6	9	7	9.9
3	007	3-116	Standard	Non-lubrited	134	95815	8/23/2013	G-3	7	9	6	9.9
3	008	3-117	Standard	Non-lubrited	134	95816	8/24/2013	G-1	7	10	6	9.9
3	1354684-18	3-138	Standard	Non-lubrited	134	90200, 90201, 90202	1/9/2014	-	7	10	7	3.0
3	1354684-16	3-139	Standard	Non-lubrited	134	90203, 90204, 90205	1/11/2014	-	6	6	5	9.8
3	1354684-8	3-150	Standard	Non-lubrited	152-2	98621	1/24/2014	-	7	9	9	9.9
3	002	3-111	Standard	Non-lubrited	155-1	95818	8/9/2013	G-1	7	10	9	9.9
3	004	3-113	Standard	Non-lubrited	155-1	95819	8/13/2013	G-3	7	9	9	9.9
3	006	3-115	Standard	Non-lubrited	155-1	95820	8/22/2013	G-2	7	9	9	9.9
3	1354684-12	3-147	Standard	Non-lubrited	155	90207, 90208, 90209	1/20/2014	-	7	10	10	9.9
3	003	3-112	Standard	Non-lubrited	1-B	-	8/11/2013	G-2	7	8	8	9.9
3	1354684-1	3-136	Standard	Non-lubrited	117	96475, 96476	1/7/2014	-	7	9	8	9.9
3	1354684-24	3-137	Standard	Non-lubrited	117	96477, 96478	1/9/2014	-	7	8	8	9.9
3	1354684-15	3-140	Standard	Non-lubrited	117	96474, 96479	1/12/2014	-	7	9	8	9.9
3	1354684-14	3-141	Canadian	Non-lubrited	134	98456	1/13/2014	-	6	7	6	9.0
3	1354684-4	3-145	Canadian	Non-lubrited	152-1	90230, 90231, 90232	1/17/2014	-	7	10	9	9.9
3	1354684-7	3-146	Canadian	Non-lubrited	152-1	90233, 90234, 90235	1/19/2014	-	7	10	9	9.9
3	1354684-13	3-143	Canadian	Non-lubrited	117	98453	1/15/2014	-	7	10	10	10.0
3	1354684-17	3-144	Canadian	Non-lubrited	117	98454	1/16/2014	-	7	10	9	9.9
3	013	3-121	Standard	Non-lubrited	GL-5 off-the-shelf fluid with QPL #	-	9/5/2013	G-2/G-3	7	10	10	9.9
3	1354684-19	3-142	High Temp	Non-lubrited	Commercial fluid; expected to fail.	-	1/14/2014	-	5	6	5	7.0
3	1354684-9	3-148	High Temp	Non-lubrited	Commercial fluid; off-the-shelf; 75W-140	-	1/22/2014	-	7	10	9	9.9
3	1354684-2	3-149	High Temp	Non-lubrited	Commercial fluid; expected to pass.	-	1/23/2014	-	7	10	9	9.9

Gear Batch	Gear Number	Run Number			Oil	CMIR	EOT Date	Housing	Pinion			
									Wear	Ripple	Ridge	Spitt
3	005	3-114	Standard	Non-lubrited	1-B	-	8/14/2013	G-1	7	10	9	9.9
3	009	3-118	Standard	Non-lubrited	Unconfirmed Fluid: 1-B	-	8/26/2013	G-2	7	6	8	9.9
3	010	3-119	Standard	Non-lubrited	Unconfirmed Fluid: 1-B	-	8/27/2013	G-3	7	7	6	9.9
3	011	-	Standard	Non-lubrited	-	-	-	-	-	-	-	-
3	012	3-120	Standard	Non-lubrited	134	95817	8/29/2013	G-1	-	-	-	-
								PASS	5 min	8 min	8 min	9.3 min

	Ring					Comments
Score	Wear	Ripple	Ridge	Spitt	Score	
10	7	10	7	9.9	10	Shutdown at 7hrs 2min for 11:20 min due to high left torque. Restarted and ran through full duration. Chipping on pinion
10	7	9	6	2.0	10	2 broken teeth on ring.
10	7	10	7	9.9	10	Chipping on pinion.
10	7	10	7	3.0	10	Tooth breakage- test terminated at 7hrs 15 min. Chipping on pinion. Broken tooth on pinion. 2 broken teeth on ring. Test temp out for 13 min 13 sec [1.3%].
10	7	7	5	9.9	10	Test temp out for 4 min [0.4%].
10	7	10	10	9.9	10	Test oil temp out 5 min 40 sec [0.7%].
10	7	10	10	10.0	10	
10	7	10	10	10.0	10	Power failure at 4hrs 25min. Shutdown for 14:08 min. Restarted and completed.
10	7	10	10	9.9	10	
10	7	10	10	10.0	10	Test oil temp out for 5 min 40 sec [0.6%].
10	7	10	10	10.0	10	
10	7	9	8	9.9	10	Shutdown for 4 min 41 sec, due to loss of process water (pump failure). Test temp out for 5 min [0.6%].
10	7	10	8	9.9	10	Test temp out for 4 min 20 sec [0.5%]
10	7	10	8	9.9	10	Test temp out for 5 min 20 sec [0.6%].
10	6	7	6	9.9	10	Chipping on pinion. Test temp out for 8 min 41 sec [0.9%]
10	7	10	10	10.0	10	Test oil temp out for 10 min 40 sec [0.8%].
10	7	10	10	9.9	10	Test oil temp out for 7 min 59 sec [0.8%].
10	7	10	10	10.0	10	Test temp out for 10min 59 sec [0.3%].
10	7	10	9	9.9	10	Shutdown for 4 hours 31 min due to loss of process water (pump failure). Test temp out for 9 min 40 sec [0.7%].
10	7	10	10	9.9	10	Test oil temp out for 3 min 19 sec [0.3%].
10	5	6	5	9.8	10	Chipping on pinion.
10	7	10	9	9.9	10	
10	7	10	10	10.0	10	

	Ring					Comments
Score	Wear	Ripple	Ridge	Spitt	Score	
10	7	10	10	10.0	10	Test invalid due to multiple shutdowns. Did not run full 24 hours
10	8	9	9	9.9	10	Pasty oil residue on ring and pinion. Not sludge. Test oil temp out for 4 min [0.4%].
10	7	10	9	9.9	10	Test oil temp out for 3 min 40 sec [0.3%].
-	-	-	-	-	-	Unusual finish observed during CMM evaluation. Returned to Gleason because it had not been shot peened.
-	-	-	-	-	-	EOT at 18 hr 22 min. No rating; broken teeth on ring and pinion; test did not complete.

10 min	5 min	8 min	8 min	9.3 min	10 min