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Committee D02 on PETROLEUM PRODUCTS AND LUBRICANTS

August 25th, 2011

Reply to:
Galen Greene
The Lubrizol Corporation
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Wickliffe, OH 44092
(440) 347-2394
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ggre@lubrizol.com

ASTM D02.B0.03 L-37 Surveillance Panel
Members and Guests:

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

- **August 10th, 2011 L-37 Surveillance Panel Meeting**

Please direct any corrections or comments to my attention.

Sincerely,

Digitally signed by Galen Greene
Date: 2011.08.25 13:47:33 -04'00'

Galen Greene, Chairman
L-37 Surveillance Panel

Report of Meeting
L-37 Surveillance Panel Meeting
PRI Headquarters – Warrendale, PA

August 10th, 2011

Attendees:

SwRI -	**Koehler**
Lubrizol -	**Greene**, Gropp, Venhoff, Hamilton
Afton -	**Koglin**, Bell, Higuchi, Kearney
Intertek -	**Smith**
TMC -	**Parke**
US Army -	Dwornick
Meritor -	**McGlone**
Chevron -	**Zakarian**
Volvo Powertrain -	**Bryson**, Athey
ExxonMobil -	Eliot, Kanga

Voting Members in **BOLD**
TC = Teleconference

The meeting was called to order at 2:00 pm EDT.

1.0 Approval of Minutes:

- **May 11th, 2011 Surveillance Panel Meeting (Warren, MI)**

Motion # 1 → Mr. Zakarian / 2nd Mr. Koglin to approve the minutes as presented. Motion for approval was passed with a vote of 6-Yes, 0-No, and 1-Abstentions.

2.0 Summary of Meeting Discussions

2.1 Hardware Update

At the May meeting, the Hardware Task Force reported out the status of the investigation on the pilot batch of Lubrited hardware. The initial efforts concentrated around the historical L-37 conditions. These conditions produced spalling and broken teeth on the passing oil TMC 152. The group decided to explore two additional options:

1. Explore Lubriting the ring only
2. Explore a shortened 20 hour test (while maintaining both ring and pinion Lubrited)

The data from the pilot investigation is attached in appendix 2. The group discussed both approaches. The mild fail oil results on ring only Lubrited hardware (CMIR 73563) concerned several in the group. It was discussed that this was the first result obtained on the fail oil with ring only hardware. Since this initial result, the data has looked more in line with expectation. It was also discussed that ring only was somewhat of an unknown in the L-37. On the 20 hour test, the group was more comfortable with the fail oil results. They also were happy with the discrimination between the fail oil and the pass oil TMC 152-1. After further discussion, it was decided that ring only Lubriting was a possible secondary option, but the group will first concentrate on the 20 hour test as the primary option.

For the continuation of 20 hour investigation the group decided that several other tests were needed. The following tests were proposed and agreed to:

LZ to run TMC 152-1 STD
Afton to run TMC 152-1 CAN

SwRI to run TMC 152-1 CAN
Intertek to run TMC 155 STD

Another point of discussion was whether any runs from the pilot batch runs could be used for the full approval matrix if the conditions match the final approval matrix conditions. The following motion was proposed:

Motion # 2 → Mr. Zakarian / 2nd Mr. Smith – Motion to include any pilot batch runs that match the final approval matrix conditions as long as the data aligns with the full batch data. The motion passed with a vote of Yes-6, No-0, Abstensions-1.

There was also a discussion on the distribution of Lubrited vs non-Lubrited hardware in the full batch. There are currently outstanding POs from each lab broken down into Lubrited and non-Lubrited. It was discussed that each labs split of NL to Lub can be changed.

ACTION ITEM: Labs to review their existing POs and confirm if the split between Lubrited to non-Lubrited reflects their current need. Also, labs are to check their inventory of Lubrited axles for retrofit so a proper count can be given to Dana.

2.2 Next Generation L-37 Test

At the last panel meeting, two labs presented proposals for a next generation test. Both labs had updated information regarding test development. Afton's update is provided in attachment 3 and Lubrizol's update is provided in attachment 4. AAM hardware has been sent to all other labs and each lab is making progress to run these tests. The labs should have data to review before the next surveillance panel meeting in November. The group had a discussion about the two proposals but more data is pending. The discussion will continue in the future. It does appear that progress is being made toward the next generation L-37 test.

2.3 Broken Teeth Definition

The group began to discuss some suggested changes to the broken teeth definition but time ran out and the discussion was not finished. It will be moved to a future meeting.

3.0 Adjournment

Motion to Adjourn by Mr. Smith, 2nd Mr. Venhoff. Meeting Adjourned at 5:15 pm EDT

Respectfully submitted,

Digitally signed by Galen Greene
Date: 2011.08.25 13:47:14 -04'00'

Galen Greene
L-37 Surveillance Panel Chairman

1

ASTM L-37 Surveillance Panel Membership/Mailing List

Meeting Date: August 10th, 2011

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ASTM L-37 Surveillance Panel Membership/Mailing List

Meeting Date: August 10th, 2011

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* Initial to indicate attendance at subject meeting

3

ASTM L-37 Surveillance Panel Membership/Mailing List

Meeting Date: August 10th, 2011

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ASTM L-37 Surveillance Panel Membership/Mailing List

Meeting Date: August 10th, 2011

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				Phone: Fax: E-Mail:
				Phone: Fax: E-Mail:
				Phone: Fax: E-Mail:

* Initial to indicate attendance at subject meeting

Attachment 2

IND	TVERSION	PINBAT	RINGBAT	SERIALNO	MATCHNO	LTMSLAB	LTMSAPP	TESTKEY	LTMSDATE	WEAR	RIDG	RIPP	SPIT	SCOR	WEARR	RIPPR	RIDGR	SPITR	SCORR	
Both Ring and Pinion Lubrited (24 Hour Test)																				
134	STANDARD	V1L528	P4T883A	JUSA398	0P	D	2A	73551-L37	20110308	5	5	9	9.4	10	6	6	9	9.8	10	
134	STANDARD	V1L528	P4T883A	JUSA3956	1X	B	1	75514-L37	20110311	6	4	9	8	10	7	5	9	9.9	10	
155	STANDARD	V1L528	P4T883A	ASTM0100	5L	A	4	80859-L37	20110311	7	8	8	9.9	10	7	9	9	9.9	10	
155	STANDARD	V1L528	P4T883A	JUSA3	0A	B	1	78147-L37	20110324	6	8	8	9.8	10	7	9	9	9.9	10	
152-1	CANADIAN	V1L528	P4T883A	JUSA3952	0L	D	2A	80854-L37	20110311	7	7	9	9.9	10	8	10	10	10	10	
152-1	CANADIAN	V1L528	P4T883A	ASTM 0088	5H	A	4	80857-L37	20110312	6	7	7	9.9	10	8	9	9	9.9	10	
152-1	CANADIAN	V1L528	P4T883A	ASTM0087	0H	A	4	80858-L37	20110331	6	7	7	9.8	10	6	8	9	9.9	10	
152-1	STANDARD	V1L528	P4T883A	JUSA3988	2N	D	2A	73559-L37	20110306	7	7	9	9.9	10	8	10	10	9.9	10	Reduced load
152-1	STANDARD	V1L528	P4T883A	ASTM0093	1N	A	4	73571-L37	20110309	7	8	8	9.9	10	8	9	9	9.9	10	
152-1	STANDARD	V1L528	P4T883A	JUSA3976	7A	B	1	76954-L37	20110323	3	3	9	3	10	5	5	10	9.5	10	2 broken teeth
152-1	STANDARD	V1L528	P4T883A	JUSA3948	2L	D	2A	80855-L37	20110330	6	7	9	5	10	7	8	10	9.9	10	
152-1	STANDARD	V1L528	P4T883A	N/A	0X	B	1	80862-L37	20110406	6	5	8	9.7	10	7	8	10	9.9	10	Broken teeth
152-1	STANDARD	V1L528	P4T883A	JUSA3752	7X	D	2A	81559-L37	20110610	6	8	7	6	10	8	9	10	9.9	10	
152-1	STANDARD	V1L528	P4T883A	ASTM 0120	7P	A	4	81562-L37	20110615	6	9	8	9.9	10	7	10	9	9.9	10	
Ring Only (24 Hour Test)																				
134	STANDARD	V1L528	P4T883A	JUSA3704	2V	A	4	73563-L37	20110703	7	8	7	9.8	10	7	9	9	9.9	10	Ring Only
134	STANDARD	V1L528	P4T883A	JUSA3696	7V	G	1	71472-L37	20110707	4	3	7	7	10	6	3	10	9.8	10	Ring only; broken teeth
134	STANDARD	V1L528	P4T883A	JUSA3692	2C	B	1	78859-L37	20110715	6	5	9	7	10	7	6	9	9.9	10	Ring only
134	STANDARD	V1L528	P4T883A	N/A	0T	A	4	73564-L37	20110722	6	9	5	9.8	10	8	9	9	9.9	10	Ring only
152-1	STANDARD	V1L528	P4T883A		2J	D	2A	81560-L37	20110625	7	8	7	9.9	10	8	10	9	9.9	10	Ring only
152-1	STANDARD	V1L528	P4T883A	JUSA A3718	7P	B	1	81564-L37	20110625	6	10	10	9.9	10	7	10	10	10	10	Ring only
20 Hour Ring and Pinion Both Lubrited																				
134	STANDARD	V1L528	P4T883A	JUSA3732	7V	G	1	71473-L37	20110721	4	4	5	6	10	4	5	4	9.7	10	20 hour; ring & pinion
134	STANDARD	V1L528	P4T883A	JUSA3728	1J	B	1	78860-L37	20110802	6	6	8	9.7	10	7	7	10	9.9	10	20 hour; ring & pinion
134	STANDARD	V1L528	P4T883A			A				5	5	5	9.7	10	6	8	7	9.9	10	20 hour; ring & pinion
152-1	STANDARD	V1L528	P4T883A	JUSA0736	2P	B	1	83051-L37	20110716	6	9	8	9.7	10	8	10	9	9.9	10	20 hour
152-1	STANDARD	V1L528	P4T883A			D				6	9	8	9.9	10	7	10	10	9.9	10	20 hour
20 Hour Ring only Lubrited																				
152-1	STANDARD	V1L528	P4T883A	JUSA-3708	2P	B	1	83050-L37	20110710	7	9	9	9.9	10	9	10	10	9.9	10	20 hour; ring only

Attachment 3

L37-1 Next Generation development
C. Koglin

8-10-2011

Passion for Solutions™

Attachment 3

Review

- Parts made by Gleason Works
- Same ratio as current axle 5.86
- Similar contact stress
- Steel is 8620
- Ground gear set
  - Consistency part-to-part
- Can be installed into current Model 60 housing/or custom test box

Attachment 3

Goals And Background

- **Link to history desired**
  - Evolutionary, not revolutionary
  - Appeals to conservative thinkers
  - Commercial claims of GL-5 lubricants are long-lived and must be comparable over time
- **Bridge between passenger car and commercial vehicle applications**
- **Avoid the unknowns in formulation**
  - Years of experience and data link to these conditions

Attachment 3

Questions To Answer

- **Can a more consistent gear set be created that mimics current hardware?**
  (*what formulators want*)
  - Uses available tooling
  - Similar design parameters
  - With and without lubriting
- **Can we employ an electric motor and obtain the same basic information?**
  (*what test engineers want*)
- **Can we avoid slight build variations changing the results?**

Attachment 3

Batch 1 initial results

Info

- **Gleason Improved tooth design**
  - Increased spiral angle
- **Peened**
  - S170 (.017” dia) media
- **Known J2360 passing oil with many many tests**
  - Field trial
- **Referenced Fired engine**

Results

- **One pinion tooth cracked x3 runs**
- **At fillet (base of tooth)**
- **No collateral crack damage**
- **Ratings are**
  - Wear-7
  - Ridging-8
  - Rippling-9/10

Gleason and Afton engineering determined tooth bending was primary failure mode
Increasing the peening duration deemed a logical next step

Attachment 3

Batch 1-phase 2 results

Info

- **Peened again**
  - S170 media
  - Time duration increased 225-250 % total time
  - Goal-build residual compressive stress on tooth surface to reduce fatigue cracking
- **Same test oil**
- **Fired engine**

Results

- **No pinion teeth cracked**
  - Two tests non-lubrited
  - Two tests lubrited
- **Non-lubrited Ratings are**
  - Wear-7
  - Ridging-8
  - Rippling-9/10
- **Lubrited Rating are**
  - Wear-7
  - Ridging-8
  - Rippling-9/10

Increased peening time eliminated tooth cracking
Therefore, testing on electric motor and TMC reference oil warranted

Attachment 3

Batch 2 initial results

Info

- **Batch 2 – same design**
- **Peened 200%**
  - S170 media
  - Controlled rotational speed and stroke speed
  - 2 nozzles
  - 6 Strokes = 200%
- **Electric motor**
- **TMC Passing Reference Oil**
  - Looking for historical data

Results

- **Three of four non-lubrited tests had cracks**
  - One pinion tooth only
  - Mid-tooth to toe broken section
  - No collateral damage
  - Possible cause case crushing and/or bending fatigue

Although peening duration was thought to be sufficient, the ragged edge was found
Questions raised include both tooth design (thickness) , peening duration, and case depth
Electric motor vs fired engine

Attachment 3

Batch 2-path 1 Info And Results

Info

- Batch 2 – same design
- Peened 200%
- Same as batch 2-two additional runs on fired engine
- TMC Passing Reference Oil

Results

- Ratings are similar to electric motor
- No tooth breakage

Key ratings for wear rippling and ridging are the same, regardless of torque source

Attachment 3

Batch 2-path 2 Info And Results

Info

- Batch 2 – same design
- Peened 300%
- Electric motor
- TMC Passing Reference Oil

Results

- 2 of 3 results complete
- No broken teeth
- Similar ratings as prior runs

Sensitivity of results to residual compressive stresses is viewed as a risk
Peening operation has inherent variability (shadows, time, ricochet, velocity)

Afton CHEMICAL

Passion for Solutions™

Next Steps

- **Batch 3**
  - Thicker pinion tooth (non-standard design)
  - Modify contact pattern under load-more elongated
  - 100% peen to start
  - Possible change to case depth
- **Continued comparisons after gear design and processing finalized**
  - Lubrited vs. non-lubrited
  - Fired engine vs. electric motor
  - Passing vs. failing TMC reference oils

Attachment 3

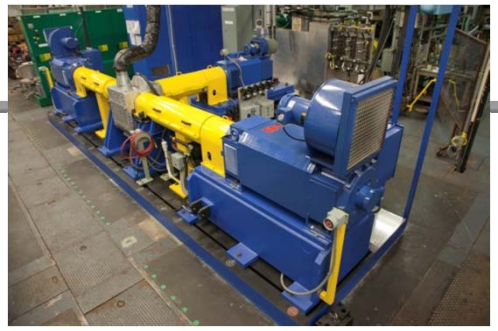
Interpretations

- **There is a path forward with Dana 60 – like gear design**
  - Improve pinion tooth resistance to cracking/breaking
  - Reducing reliance on peening is a key to the gear design
- **Electric motor offers many advantages**
- **Pinion/Ring supplier can make changes quickly and will work with customers to obtain desired goals**

Next Generation L-37 Test Investigation

8/10/2011

Lubrizol



Review

- Lubrizol presented some initial test work on a possible next generation L-37 test at the May meeting
- Testing was conducted on an electric motored T-type test stand
- Test axle was an AAM Zeta 218mm RDM
- The goal was to relate the Zeta 218mm axle to the current L-37 test
  - This was done by matching PV values for each application
  - This takes sliding speed and contact pressure into account
- An update on additional testing follows

Lubrizol

Results from Lubrited hardware

Oil Description	Pass/Fail	PINION GEAR WEAR MERIT	PINION GEAR RIPPLING MERIT	PINION GEAR RIDGING MERIT	PINION GEAR SURFACE FATIGUE PITT/SPALL MERIT	RING GEAR WEAR MERIT	RING GEAR RIPPLING MERIT	RING GEAR RIDGING MERIT	RING GEAR SURFACE FATIGUE PITT/SPALL MERIT
Pass Oil	PASS	7	10	9	9.5	8	10	10	9.9
Pass Oil	PASS	7	10	9	9.9	8	10	10	9.9
Pass Oil	PASS	7	10	9	9.6	8	10	10	9.9
Fail Oil	FAIL	6	9	4	9.9	7	9	5	9.9
Fail Oil	FAIL	7	7	5	9.9	7	7	6	9.9
Fail Oil	FAIL	7	7	6	9.9	7	9	6	10

Lubrizol

Results from non-Lubrited hardware

Oil Description	Pass/Fail	PINION GEAR WEAR MERIT	PINION GEAR RIPPLING MERIT	PINION GEAR RIDGING MERIT	PINION GEAR SURFACE FATIGUE PITT/SPALL MERIT	RING GEAR WEAR MERIT	RING GEAR RIPPLING MERIT	RING GEAR RIDGING MERIT	RING GEAR SURFACE FATIGUE PITT/SPALL MERIT
Pass Oil	PASS	7	10	9	9.9	7	10	10	9.9
Pass Oil	PASS	7	10	9	9.9	8	10	10	9.9
Pass Oil	PASS	7	10	10	9.9	7	10	10	9.9
Fail Oil	FAIL	7	6	4	9.9	7	7	7	9.9
Fail Oil	FAIL	7	9	4	9.9	7	9	5	9.9
Fail Oil	FAIL	7	9	5	9.9	7	10	5	9.9

Lubrizol

J2360 Quality Oil A (SAE 75W-XX)

Oil Description	Pass/Fail	Test Hardware	VERSION	PINION GEAR WEAR MERIT	PINION GEAR RIPPLING MERIT	PINION GEAR RIDGING MERIT	PINION GEAR SURFACE FATIGUE PITT/SPALL MERIT	RING GEAR WEAR MERIT	RING GEAR RIPPLING MERIT	RING GEAR RIDGING MERIT	RING GEAR SURFACE FATIGUE PITT/SPALL MERIT
Oil A	PASS	LUBRITED	STD	7	10	9	9.9	7	10	10	9.9
Oil A	PASS	NON-LUBRITED	STD	7	10	9	9.7	8	10	10	9.9
Oil A	PASS	LUBRITED	CAN	7	10	9	9.9	7	10	10	9.9
Oil A	PASS	NON-LUBRITED	CAN	7	9	9	9.9	7	9	10	9.9

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J2360 Quality Oil B (SAE 75W-XX)

Oil Description	Pass/Fail	Test Hardware	VERSION	PINION GEAR WEAR MERIT	PINION GEAR RIPPLING MERIT	PINION GEAR RIDGING MERIT	PINION GEAR SURFACE FATIGUE PITT/SPALL MERIT	RING GEAR WEAR MERIT	RING GEAR RIPPLING MERIT	RING GEAR RIDGING MERIT	RING GEAR SURFACE FATIGUE PITT/SPALL MERIT
Oil B	PASS	LUBRITED	STD	7	10	10	9.9	7	10	10	9.9
Oil B	PASS	NON-LUBRITED	STD	7	9	9	9.9	7	10	10	9.9
Oil B	PASS	LUBRITED	CAN	7	10	10	9.9	8	10	10	10
Oil B	PASS	NON-LUBRITED	CAN	7	10	10	9.9	7	10	10	9.9

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J2360 Quality Oil C (SAE 80W-XX)

Oil Description	Pass/Fail	Test Hardware	VERSION	PINION GEAR WEAR MERIT	PINION GEAR RIPPLING MERIT	PINION GEAR RIDGING MERIT	PINION GEAR SURFACE FATIGUE PITT/SPALL MERIT	RING GEAR WEAR MERIT	RING GEAR RIPPLING MERIT	RING GEAR RIDGING MERIT	RING GEAR SURFACE FATIGUE PITT/SPALL MERIT
Oil C	PASS	LUBRITED	STD	7	10	9	9.9	7	10	10	9.9
Oil C	PASS	NON-LUBRITED	STD	7	10	10	9.9	7	10	10	9.9

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Oils of less than J2360 Quality

Oil Description	Pass/Fail	Test Hardware	VERSION	PINION GEAR WEAR MERIT	PINION GEAR RIPPLING MERIT	PINION GEAR RIDGING MERIT	PINION GEAR SURFACE FATIGUE PITT/SPALL MERIT	RING GEAR WEAR MERIT	RING GEAR RIPPLING MERIT	RING GEAR RIDGING MERIT	RING GEAR SURFACE FATIGUE PITT/SPALL MERIT
Oil D	FAIL	NON-LUBRITED	STD	7	9	6	9.6	8	10	9	9.9
Oil E	FAIL	LUBRITED	STD	7	8	6	9.9	7	10	7	9.9
Oil E	FAIL	NON-LUBRITED	STD	7	9	6	9.9	7	10	9	9.9