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Committee D02 on PETROLEUM PRODUCTS AND LUBRICANTS

April 30, 2008

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

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

- **February 13, 2008 L-37 Surveillance Panel Meeting conducted at the PRI Headquarters, Apollo Room, Warrendale, PA.**

Please direct any corrections or comments to my attention.

Sincerely,

Donald T. Bartlett, Chairman
L-37 Surveillance Panel
Attachments

Report of Meeting
L-37 Surveillance Panel
Warrendale, PA
PRI Apollo Room
February 13, 2008

Sign-in/Review of Agenda & Membership: The meeting was called to order at 08:10 a.m. The sign-in sheet is included as ***Attachment # 1***. Mr. Fett and Mr. Guzikowski joined via teleconference.

The membership list was reviewed by Mr. Bartlett. All members were recently contacted to confirm any membership changes. All members on the voting list have requested to remain members and maintain their voting rights. See ***Attachment # 2***.

A review of the Agenda was performed with no changes. ***Attachment # 3*** represents a PowerPoint presentation the chairman used for the meeting.

Approval of Minutes The minutes of the November 7th Panel meeting were reviewed.

Motion # 1 ⇒ Mr. Koglin, Second ⇒ Mr. Schenkenberger – Approve the November 7, 2007 Surveillance Panel meeting minutes as written. The motion passed unanimously.

Summary of Meeting Discussions

TMC 127 Reference Oil Replacement - Mr. Lind

Attachment # 4 details the L-37 test results on TMC 127 replacement oil. An oil supplier has provided an 11-test matrix for the replacement oil. These 11 tests were performed at 2 labs, on 4 hardware types, on all 4 types of tests. All tests failed on various parameters ranging from failing on ridging (6) to broken tooth or vibration shutdown. The current TMC 127 oil is down to approximately 10 gallons in the industry and will no longer be available. The replacement oil will be known as TMC 134 and will be the fail oil.

Mr. Lind stated that he is comfortable with the data supplied by the supplier and feels the fluid is comparable to the 134. The question is, how do we implement it? Philosophically, the panel did not want to conduct anymore testing with the current hardware. Mr. Lind offered that we can wait to implement by running a few extra side-by-side comparisons between TMC 127 and TMC 134 with the upcoming non-lubrited and lubrited hardware batches. There is a 5 to 10 year supply of TMC 134 oil now at the TMC. The consensus of the panel was to accept the TMC's recommendation to wait to implement during the hardware matrix approvals. The chairman offered that no acceptance bands would be issued as the fluid will only be used as a discrimination oil.

2008 Plain, Lubrited & Retrofit Hardware Update - Please refer to **Attachment #3** and slides 4 through 11 for further details on this subtopic:

Mr. Bartlett provided an overview of panel and Hardware TF activity for the last 6 months.

Mr. Miller provided background information to the reason for needing to rework the most recent (P4L816/B6L566) Lubrited process. The low case hardening and shallow case depth on the 1st round of pinions was the real issue. One of the optional steel materials allowed on the drawings was softer. Therefore the heat treatment was elevated with a change in the micro geometry that negatively affected the drive side pattern. The changes made to the pinions due to metallurgical differences caused the pinions to change shape, so new (second set) of rings were made due to timing and available at the time to match the pinions. The new lubrited axles will use a "new" alternate lubriting process.
The new process will be outsourced from Dana in the Ft. Wayne area with much tighter controls on the crystal etch size and volume. The retrofit lubrited axles will also use the alternate lubriting process. It was determined that the 'initial' rings (set aside) from the 2005 non-lubrited batch/heat of steel will be used for the new non-lubrited hardware because Dana believes that they are produced to the print and technically suitable for the L-37 test. The panel agreed.

The chairman provided an overview of the number of axles ordered across the three batches. See slide # 6.

Mr. Gropp asked about timing for the orders. Rings will be at Ft Wayne in the 1st part of March. It will likely take until the end of April to begin builds. Since we approved the use of the 'initial' 2005 non-lubrited rings earlier, an additional order of plain axles is going to be ordered. See Slides 5 & 6. Action item is for labs to update purchase orders to include the desired plain inventory and sent to Dana/Mr. Ojanen.

There was much discussion and a series of motions were made:

Motion # 2 ⇒ Mr. Gropp/Mr. Lind – **Non-lubrited axle hardware approval Matrix** (There are only 3 labs that are participating). Conduct non-lubrited hardware matrix as approved last October with the following exception: Conduct only 3 Standard tests (1 each at Afton, Lubrizol, and SwRI) on TMC 127. Conduct 4 Standard tests on TMC 134. Mr. Gropp volunteered Lubrizol to conduct 2 of the TMC 134 runs. The other tests will be one each at SwRI and Afton.
The Motion carried with a vote of 5 for, 0 opposed, and two abstentions. Note: refer to the hand note changes for slide 7.
Mr. Gropp elaborated that the industry should run the TMC 127 first, and run the TMC 134 runs later in the mix.

Motion # 3 ⇒ Mr. Gropp/Mr. Lind – **Retrofit Lubrited axle hardware approval Matrix** (there are 4 labs that are participating). For the lubrited hardware matrix, run as planned from October with the exception of adding 4 TMC 134's for Standard L-37 test.

Mr. Koehler expressed some concerns about whether the additional tests on TMC134 are needed for the lubrited hardware. He feels we will demonstrate the comparison sufficiently in the non-lubrited matrix. Mr. Lind shared that data will show that TMC 127 performs differently on lubrited hardware than non-lubrited hardware and expressed concern over not looking at the new hardware which is expected to perform differently than previous batches.

Mr. Gropp asked how we are going to use TMC 127 or TMC 134 for the future. Mr. Bartlett reminded the panel that the decision was to use only 127 for bringing in a new batch order and not setting bands with LTMS. Many issues contributed to this decision including the fact that we were running low on the failing fluid.
Action Item: Determine when to run 134 on the new and retrofit lubrited hardware.

The motion failed with a vote of 1 for, 3 opposed, and 2 abstentions. Refer to slide 8, matrix stays unmodified.

Motion # 4 ⇒ Mr. Gropp/Mr. Lind - **New Lubrited axle hardware approval Matrix** (there are 2 labs that are participating). Conduct matrix as approved last October with the following exception: Each lab run 1 additional test on the TMC 134 reference fluid.
The motion passed with a vote of 2 for, 1 opposed, and 4 abstentions. Refer to slide 9, matrix stays unmodified. The panel expressed comments at earlier meetings that since the hardware are being built at the same time; similar performance is expected with this batch.

Action Item: See Slides # 10 and 11. Hardware TF visits are in place.

***Transition to L-37-1* - Mr. Miller – See Attachment # 5**

Dana recommends that the hardware be updated as they will no longer support production of the current hardware after this year. Dana will provide several axles to review and develop new test conditions to meet the J2360 stressed conditions. Electric motor upgrade has also been proposed by SWRI to improve test control & adaptability.

The proposed axle design is a current production style axle. This matches what is currently being used in the field. The gear uses the more modern manufacturing method of 3 axis (face hobing). The ratio of the proposed axle is 4.11:1 which is reduced from the old 5.86:1. The new axle is used in the Ford Econoline van model line.

There are dimensional differences between the current axle and the proposed. The new axle is metric in design. The new axle is a wider axle with wider spring pad mounts. The spring pad mounts are welded at an angle relative to the output plane. The axle tubes are also larger. The new mounting flange could be replaced with a yolk, the spline size is the same, and the current yolk may be able to be used. The axle shafts are held in by c-clips inside the differential, which differs from the current design.

Mr. Schenkenberger expressed concern over the wider spring pads and the pinion nose flex. Mr. Miller remarked that the larger tube diameter may improve this, but cannot confirm at this point.

Mr. Koglin expressed concern over the additional width relative to the L-42 as some labs use 1 rig for both. This could create issues as the current L-37 and L-42 pads share similar mounting widths.

Action Item – Mr. Miller to provide the proposed axle fill volume, & bolt pattern on the axle shaft.

The loading design consideration is higher for the new axle mainly due to the ratio. The initial look was with keeping the test length the same, the contact stress and number of mesh cycles the same. However, this gives us a high bending stress on the tooth and high pinion bearing stress. The torque must be increased by ~ 42% to arrive at the same contact pressure on the tooth.

Mr. Koglin expressed concern over the limitation on the dynamometer curve and torque capacity at the slow speeds.

One option is to develop a new 3-axis face hobed gear set at the current ratio of 5.86:1. This would reduce the stresses and make it a non-issue.

Dana believes that using miners rule and other predictions, the stress can be elevated to create gear distress without operating in a stress region that destroys teeth or pinion bearings. This sums to running at lower loads at longer periods of time to achieve the same result.

Mr. Koehler raised the question of "Do we want to stay with the model 60 type axle?" We are leading ourselves to using a bigger axle, more energy in the axle and may be oversized for the goals of the test. Or should we step down in size, rather than up in size?

Mr. Fett picked the new axle as the highest ratio model 60 available.

The panel agrees that a smaller axle may be more appropriate for reduced test cost, more ratio availability, and easier test conditions to run. Mr. Miller commented that new model 44 production axle type may also be the wider track / wider mounting pads.

Action Item – Mr. Miller will look at the model 44-axle size with the same goal to evaluate if the smaller axle is appropriate.

Mr. Gropp expressed concern over OEM / LRI opposition to an axle model change if the current design has close ties to light and heavy-duty axles in the field.

Attachment # 6 is a presentation provided by Mr. Koehler. We did not have time for review.

Review January 2008 Gear Calibration Work Shop - Mr. Lind – See Attachment # 7 for pinion data and Attachment # 8 for ring data.

Mr. Lind presented the Rater Calibration data from the January workshop. He challenged the panels & specifically the labs to reduce their rater variability. The current effort of reducing the industry variability has not worked, so Mr. Lind feels that the individual lab engineers and management needs to step up.

Mr. Lind will be bringing the raters charts to lab visits and will be sharing them with the labs. This is a new directive from Mr. Lind and Mr. Farber. The labs don't have a problem with this, and look forward to working with Mr. Lind to help address this issue.

Mr. Gropp expressed concern over the current system, if it should be changed to reflect outliers at the workshops to affect a rater's calibration in the system.

Mr. Koglin raised the concern that some of the outliers may not be due to a specific rater's ability but due to a difficult pinion.

Mr. Lind commented that even though several pinions / rings look poorly, compared with the introduction of RCMS and the workshops, the data has improved. Mr. Lind forces outliers at the workshops to be defended by the raters. He feels that this has improved variation.

These following are examples of the ratings. **Mr. Lind** is concerned with several of the gears and the ratings he sees.

Review of Pinions:

- Set 1C – Mr. Lind feels that a 7.0 ridging is an outlier.

Review of Rings:

The rings have no targets; however variation is noted in red.

- Set 1C – Ridging, Ripple and Wear all are variable. Mr. Lind is concerned with a 6.0 to 10.0 rating.

***Gear Teeth Chipping Definition* - Chairman Bartlett**

A previous action item was to address rating issues with two of the RCMS pinion 44 and 45 (pulled the RCMS at a previous meeting). Some raters were formally calling the anomalies at the top land as chipping and others as pitting or broken teeth. Mr. Fett believes this is chipping and is caused from excessive compressive stress built into the gear from the shot peening process.

The chairs request of the panel is to come to a conclusion about a definition. Mr. Smith feels that a definition should be defined and the pinions placed back in active service. The panel discussed possible rating definitions to address the chipping vs. pitting. The general consensus is that it should be considered chipping, and not rated as pitting. The chair suggests a TF recommend a wording / rating aid to address this issue by the April SP meeting.

A motion made by Mr. Smith "Define chipping and put the RCMS pinions 44 and 45 back into use died because of no second.

The panel struggled over building a definition. Mr. Gropp said that the definition will not work if we do not pin down a defined location. Mr. Lind said that we could possibly use something such as "If pitting spreads into the crown of the tooth." The chairman pulled the issue off the table and will bring it forward at a later date due to time constraints.

Motion # 5 ⇒ Mr. Smith, second ⇒ Mr. Koglin. Move to adjourn the meeting at 11:08. Motion passed unanimously.

Respectfully submitted,

Donald T. Bartlett

Donald T. Bartlett
L-37 Surveillance Panel Chairman

ASTM L-37 Surveillance Panel Membership/Mailing List

Meeting Date: February 13, 2008

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* Initial to indicate attendance at subject meeting

Attachment 1
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ASTM L-37 Surveillance Panel Membership/Mailing List

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Meeting Date: February 13, 2008

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L-37 Surveillance Panel Voting Members

Donald Bartlett	The Lubrizol Corporation (Chairman)
Tom Bryson	Volvo Powertrain Corporation
Juan Buitrago	Chevron Oronite Company
Allen Comfort	AMSTA-TR-D/210 US Army Tacom-Tardec
John Dharte	American Axle & Manufacturing
Brian Koehler	Southwest Research Institute
Cory Koglin	Afton Chemical Company
Don Lind	ASTM Test Monitoring Center
Jim Linden	GMR Research and Development
Thelma Marougy	Eaton Corporation
Bruce McGlone	ArvinMeritor Materials Engineering
Kenny Miller	Dana Corporation
Salvatore Rea	Infineum
Dale Smith	Intertek - PARC Technical Services
Paula Vettel	D.A. Stuart Company

Lubrizol

L-37 Surveillance Panel

PRI Headquarters,
Warrendale, Pa.

February 13, 2008

Donald Bartlett

Lubrizol

L-37 SP Agenda

I.	Call to Order, Agenda, & Membership Review	
II.	SP Minutes to Approve: ✓ November 7, 2007 SP Meeting	
III.	TMC 127 Reference Oil Replacement	15 min
IV.	2008 Green, Lubrited & Retrofit HDW Update	20 min
V.	L-37-1 Development – Miller	45 min
VI.	Review January 2008 Gear Calibration WS – Lind	20 min
VII.	Pitting/Spalling vs. Chipping RCMS Pinions 44 and 45	20 min
VIII.	New Business	
IX.	Adjournment	

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Lubrizol

L-37 Surveillance Panel Voting Members

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Allen Comfort	AMSTA-TR-D/210 US Army Tacom-Tardec
John Dharte	American Axle & Manufacturing
Brian Koehler	Southwest Research Institute
Cory Koglin	Afton Chemical Company
Kenny Miller	Dana Corporation
Don Lind	ASTM Test Monitoring Center
Jim Linden	GMR Research and Development
Thelma Marougy	Eaton Corporation
Bruce McGlone	ArvinMeritor Materials Engineering
Salvatore Rea	Infineum
Dale Smith	PARC Technical Services
Paula Vettel	D.A. Stuart Company

Total 15 Voting Members

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Attachment 3
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Lubrizol

TMC 127 Ref Oil Replacement

- TMC 127 is used only as a discrimination oil – Fail
- Replacement oil will be TMC 134 – Fail oil - discrimination
- Review data – Lind
- How do we implement TMC 134 ?
- Do we run TMC 134 in the hardware approval matrix ?

Lubrizol

2008 Hardware Status to Date

- Dana statements and agreements with ASTM to date:
  - Purchased one heat steel for all non-lubrited and lubrited pinions.
  - Purchased one heat steel for all lubrited rings.
  - Non-lubrited rings will use rings from the 2005 batch/heat of steel.
  - Will "same batch lot" order all associated parts for new axle assembly builds.
- Green - new axle assembly cost is $ 992.00
- Lubrited - Retrofit of 2007 B6L566 and 'other' parts
  - At no cost to labs
  - Labs to pay shipping one way
  - Axles to use the "Alternate" lubriting process
- Lubrited - new axles assembly cost is $ 1005.00
  - Axles to use the "Alternate" lubriting process

Lubrizol

2008 Hardware Order Information

Axle Type	Total Order	Ring Code	Pinion Code	Labs
Plain	898	P4T813	New - y	3
Lub - Retrofit	975	New - x	New - y	4
Lub - New	234	New - x	New - y	2
Total	2107			

Additional order of Plain Axles

Afton - 40-50
Lubrizol - 80-96
SwRI - 40-50

Attachment 3
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Agreement 1 – Oct. 25th 2007 SP Telecom Mtg.

- ✓ Non-Lubrited Hardware Matrix – 3 Labs
- ✓ Conduct the standard ~~44~~ 47 - test approval matrix
  - 3 » ~~4~~ Standard test on TMC 127 or 134
  - » 8 Standard test on TMC 151
  - » 8 Standard test on TMC 152
  - » 8 Standard test on TMC 153
  - » 8 Canadian test on TMC 152
  - » 8 Canadian test on TMC 153

4 STANDARD TMC 134

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MODIFIED

Lubrizol

Agreement 2 – Oct. 25th 2007 SP Telecom Mtg.

- ✓ Lubrited Retrofit Hardware Matrix – 4 Labs
- ✓ What ever the bulk of the hardware build is (retrofit or all new lubrited assembly builds), the labs will conduct the standard 44 - test matrix
  - » Consensus was the retrofit plus all new axle assemblies would be of the same heat of steel
  - » 4 Standard test on TMC 127 or 134
  - » 8 Standard test on TMC 151
  - » 8 Standard test on TMC 152
  - » 8 Standard test on TMC 153
  - » 8 Canadian test on TMC 152
  - » 8 Canadian test on TMC 153

no TMC 134

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NOT Modified

Lubrizol

Agreement 3 – Oct. 25th 2007 SP Telecom Mtg.

- ✓ New Lubrited Hardware Matrix – 2 Labs
- ✓ For the smaller subset of lubrited hardware builds, each lab who orders a portion of this smaller subset will conduct 6 more tests as follows
- ✓ It was further stipulated that: If only one lab orders the smaller subset of hardware, this lab must run the six tests in duplicate
  - » 1 Standard test on TMC 127 or 134
  - » 1 Standard test on TMC 151
  - » 1 Standard test on TMC 152
  - » 1 Standard test on TMC 153
  - » 1 Canadian test on TMC 152
  - » 1 Canadian test on TMC 153

2 STANDARD TMC 134

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Modified

Attachment 3
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Lubrizol

Lab HTF Visit to Maumee Facility

- Wednesday, March 5, 2008
  - Review and document the lubrited retrofit assembly process
  - Tour the area shop performing the retrofit
  - Develop plan for return and re-distribution
  - Document expectations
  - Address other necessary items to insure success

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Lab HTF Visit to Ft. Wayne

- Thursday, March 6, 2008.
  - Ft. Wayne agreed to not cut any material for the three axle batches until after this meeting
  - Review the drawings and re-validate any changes required before proceeding.
  - Will Focus on the 2005 non-lubrited gear batch successes (P4L792/V1L417) and review any changes and any line changes made by Ft. Wayne since that batch
  - Review the heat treating process
  - Review the alternate lubrited process
  - Resolve any issues with contact pattern position i.e. - L1 vs. L2 and L3 (procedure specified)

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Discussions - Transition to L-37-1

- Current steel being used in production today is 5124.
- Have the newer 3-axis gear design vs. 2-axis design
- Could be procured with either a 4.10 or 3.73 ratio vs. 5.86
- Phase 1
  - Dana to provide a small quantity of current production axles (about a pallet) for matrix testing
  - Use current engine/transmissions/operating conditions
  - Labs conduct limited tests on identified reference oils
  - Evaluate distress

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Attachment 3
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Reference 3/13/08

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Discussions - Transition to L-37-1

- Phase 2
  - Labs will want to use the current stand configuration for L-37 work since we have ordered approximately 3-4 years worth of axles.
  - Use current engine/transmission specified in D6121
  - Dana and industry to work together on operating conditions and test length to yield SAE J2360 distress equivalence
  - More matrix testing to develop a tie to history
- Phase 3
  - Suggestions for electric motor vs. gasoline engine power plant
- Dana Presentation - Miller

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L-37 SP Agenda

I.	Call to Order, Agenda, & Membership Review	
II.	SP Minutes to Approve: ✓ November 7, 2007 SP Meeting	
III.	TMC 127 Reference Oil Replacement	15 min
IV.	2008 Green, Lubrited & Retrofit HDW Update	20 min
V.	L-37-1 Development – Miller	45 min
VI.	Review January 2008 Gear Calibration WS – Lind	20 min
VII.	Pitting/Spalling vs. Chipping RCMS Pinions 44 and 45	20 min
VIII.	New Business	
IX.	Adjournment	

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L-37 SP Agenda

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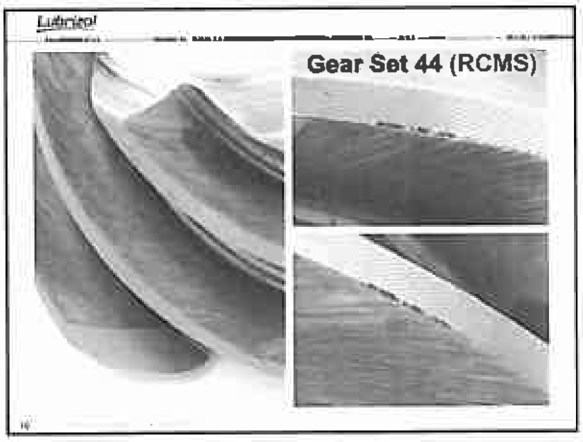
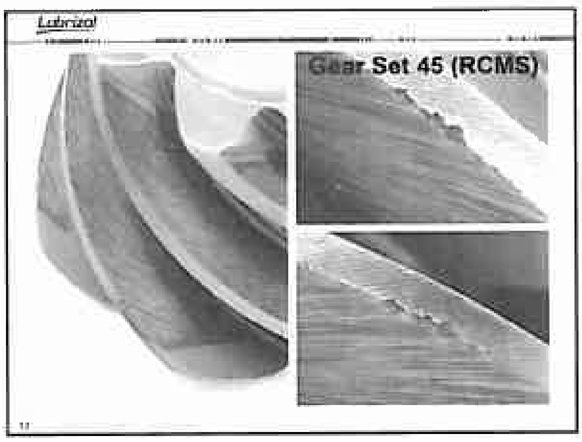
Reference 3/13/08





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Pitting/Spalling vs. Tooth Chipping

- RCMS Pinions 44 and 45 –
- Greg Fett comments –
  - Believes that the anomaly at the top of the L37 gear teeth is chipping
  - Is a result of the wear on the tooth face and the compressive residual stress from the shot peening operation
  - The shot peening operation puts a considerable amount of compressive residual stress in the corner of the tooth tip
  - Shot peening tends to make it want to crack or pop off
  - When there is wear on the tooth face the stress is relieved on one side only which tends to cause these cracks
  - These are not normal pitting which is associated with localized high contact stresses or poor lubricant performance.

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Reference 2/13/08

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Pitting/Spalling vs. Tooth Chipping

Panel Direction ?

- **Define the contact area around the crown ?**
- **Write a description for chipping ?**
- **Excluded and note in comments section ?**
- **Put pinions back into RCMS ?**

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Thank You !

- 8 Hardware TF Teleconferences Since Nov SP Mtg
  - All discussions documented
  - Will be included with Feb SP meeting minutes
- Dana
- TMC
- Labs

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Attachment 3
Page 7 of 7
Reference 2/13/08

L-37 Test Results on TMC 127 Replacement

Lab	Hardware Batch	Hardware Type	Test Version	Pinion Ratings: Wear	Rippling	Ridging	Pitting/Spalling	Scoring	Comments
A	V1L351/P4T771	Nonlubrited	Standard	6	7	5	9.9	10	Ring failed Ridging (5).
A	V1L417/P4L792	Nonlubrited	Standard	7	5	4	8.0	10	Ring failed Ridging (5).
B	V1L417/P4L792	Nonlubrited	Standard	6	8	4	3.0	10	Ring failed Ridging (4). One broken ring tooth.
A	V1L417/P4L792	Nonlubrited	Canadian	6	4	6	9.9	10	Ring failed Ridging (6).
B	V1L417/P4L792	Nonlubrited	Canadian	6	6	6	9.7	10	Ring failed Ridging (6).
A	L247/T758A	Lubrited	Standard	4	7	4	3.0	10	One broken ring tooth. Ring failed Ridging (5) and Pitting/Spalling (8.0).
B	L247/T758A	Lubrited	Standard	3	9	3	3.0	10	Ring failed Ridging (5). One broken pinion tooth.
A	B6L566/P4L816	Lubrited	Standard	6	7	7	9.3	10	Ring failed Ridging (7). Chipping on four pinion teeth.
B	B6L566/P4L816	Lubrited	Standard	-	-		-	-	Test terminated at 12 hours due to vibration. One cracked ring tooth.
A	L247/T758A	Lubrited	Canadian	4	8	9	9.3	10	Ring failed Ridging (7). Chipping on five pinion teeth.
A	B6L566/P4L816	Lubrited	Canadian	-		-	-		Test terminated at 20 hours due to vibration. Numerous broken pinion and **ring teeth.**

Attachment 4
Page 1?31
Reference 2/13/08

Notes: 1) Failing distress parameters are highlighted

2) The B6L566/P4L816 batch of lubrited hardware was not approved for use in this test

OHS Product Engineering

L37 Surveillance Panel meeting: Presentation to look at potential new axle for L37 lube test. The data provided compares existing hypoid hardware (L37) with potential new hardware for lube testing (L37-1). The comparison includes dimensional/physical as well as power transmission capacity parameters. Also a overview of test conditions required to provide equivalent results is provided.

Kenny Miller, Gear Engineering — February 13, 2008

what is the fill Volume?

L37 axle P/N = 060AA100-2
L37-1 axle P/N = 2004681-5

February 13, 2008

Comparison of strength/durability factors & stresses, L37 (current) to L37-1 (new)

	Gleason Z-factor$_{PINION}$ (Hertzian)	Gleason Q-factor$_{PINION}$ (Lewis parabola)	Gleason Q-factor$_{GEAR}$ (Lewis parabola)	Contact stress* S_C (lbs/in^2)	Pinion stress* S_B (lbs/in^2)	Gear stress* S_B (lbs/in^2)
L37	4788.19	8.17100	1.58244	404,305	58,313	66,146
L37-1	3192.67	4.76199	1.53040	404,306	76,366	100,624

* L37 values shown are for current test torque and speed [3,480 ft-lbs (both sides) and 80 output RPM]..
L37-1 conditions are at torque that is matching the contact stress of L37.

Note: total axle torque (both sides) for current L37 test is 41,800 in-lbs (3,480 ft-lbs).

Test conditions for L37-1 to acquire equivalent contact pressure and equivalent pinion cycles

Output speed = 114.3 RPM

Axle output torque = 5,479 ft-lbs

DANA Off Highway Systems

Attachment 5
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Reference 2/13/08
February 13, 2008

L37 axle P/N = 060AA100-2
L37-1 axle P/N = 2004681-5

Comparison of physical dimension, L37 (current) to L37-1 (new)

Units = inches, Values = nominals

	1 axle shaft flange (face-to-face)	2 axle housing (flange-to-flange)	3 spring pads (center-to-center)	4 hypoid offset	5 pinion center-to-center of of spring pads	6 pinion flange description	7 axle tube flange description	8 pinion flange face-to-center of axle	9 carrier-to-spring pad rotation	10 axle tube diameter
L37	62.000	55.680	40.056	1.125	.500	U-joint yoke	(6) .385"-.390" holes 4.00 circle	N/A	0°	2.750
L37-1	66.470	58.974	48.920	1.125	1.860	Flange type, 8 holes (M12-1.75_4.25" dia.)	(4) .651"-.657" holes* 5.79" circle	12.235	9.28° **	3.500

* assymetric hole positioning
** pinion up

Smith - need Bolt Circle Size
8 Bolt circle

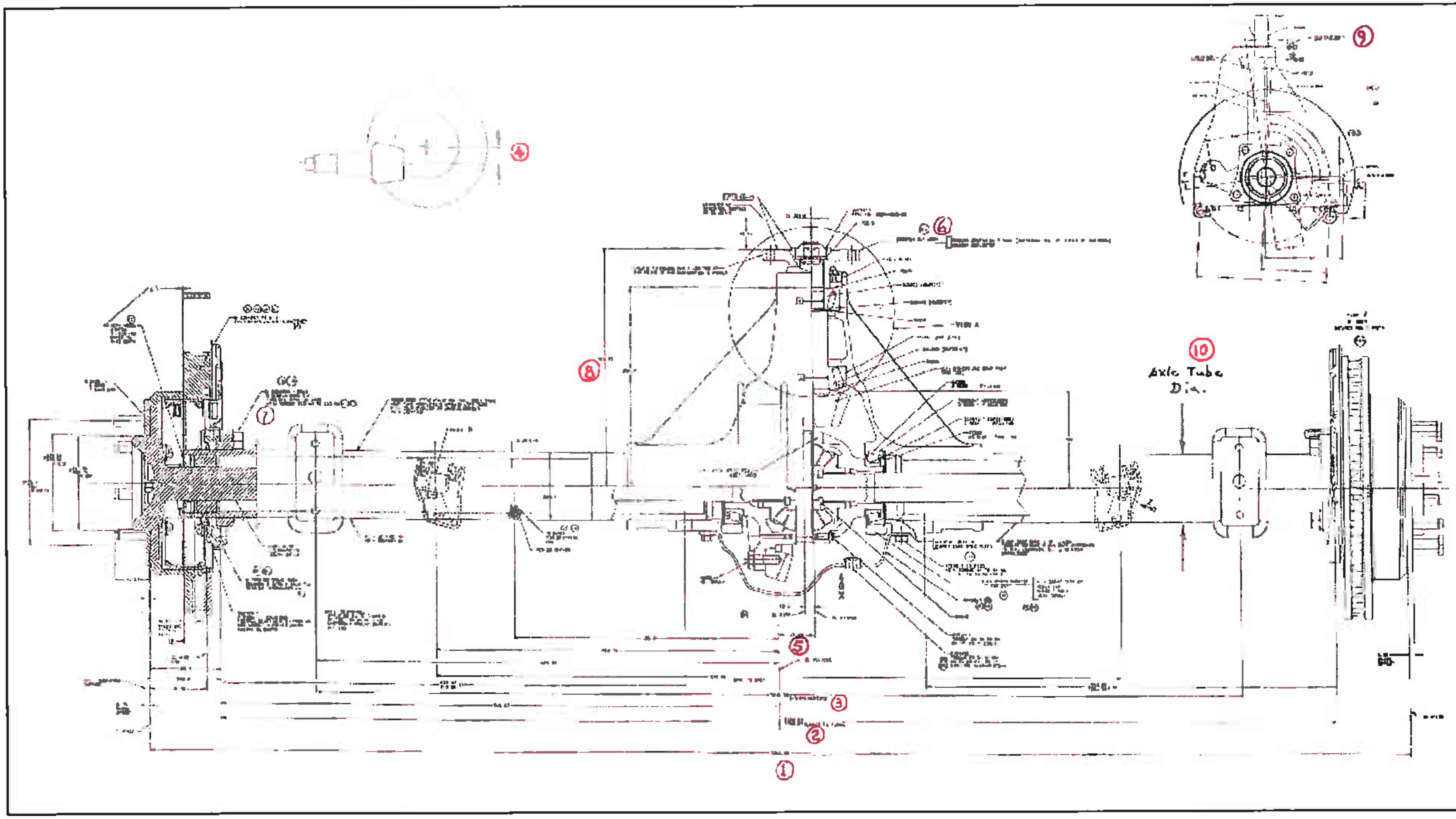
- new axle has C clips
- Today only lubricated
- needs different shaft seals

DANA Off Highway Systems

DANA 100 Since 1904

L37 axle P/N = 060AA100-2
L37-1 axle P/N = 2004681-5

February 13, 2008



Attachment 5
Page 5 of 5
Reference 2/13/08

February 13, 2008

THAT'S IT !
DISCUSSION / QUESTIONS ?

L-37 S.P. Presentation
Next Generation L-37

- By: Brian Koehler; SwRI
- Feb. 13, 2008
- PRI, Warrendale, PA

SwRI Proposes Electric Drive

- SwRI proposes an Electric Motor and variable speed drive for the next generation of L-37 test

Why Now?

- L-37 axles after 2008 will have significantly different gear ratio
- Axle gears will also have different machining process and likely different metal
- Test conditions will have to be changed to adjust for above

Attachment 1
Page 3
Reference 2/13/08

Why Electric?

- Better drive durability
- Better drive control precision
- Safer than fueled engine
- Simpler stand design
- Lower energy cost
- Unlimited speed control points within speed range
  - We will use direct drive (no gear box)

Negatives?

- Mainly price:
- One time investment of $29,000 to $36,000 for motor and drive.
- Plus price of electrical service and service filtering if needed
- Will have to make slight compromise on max. and min. pinion speed range.
  - Existing L-37 min. and max. speeds require larger motor and drive to be met.
  - Slight compromise could down size power requirements significantly.

Suggestions (in this order)

- Dana to spec. out conditions for new axle
- SwRI will work through a drive and motor supplier to make hardware recommendation
- Labs will meet to discuss min. need.
  - Some may want more capability for other uses.
- Labs to purchase same drive and motor make and model?
- Use reference oils to tie new to old

Attachment 6
Page 2 of 3
Reference 2/13/03

Example

- For existing L-37:
- 460 Volt, 3 phase, 400 amp service needed
- Drive and motor would be in 200 to 250 HP Range
  - With small speed range compromise

Attachment 6
Page 3 of 3
Reference 2/3/29

ASTM Gear Calibration Workshop
Richmond, VA January 15, 16, 17 & 18, 2008

L-37 PINION GEARS

SET #	DISTRESS	6	7	10	11	22	25	29	30	MAX	MIN	AVG	Std Dev	Pinion #	RCMS Pinion Mean
1C	Ridging	6.0	5.0	6.0	7.0	6.0	7.0	5.0	6.0	7.00	5.00	6.00	0.756	1	5.4
1C	Rippling	7.0	6.0	7.0	8.0	6.0	7.0	7.0	7.0	8.00	6.00	6.88	0.641		7.8
1C	Wear	5.0	6.0	6.0	6.0	6.0	6.0	5.0	6.0	6.00	5.00	5.75	0.463		5.9
1C	Spitting	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.90	9.90	9.90	0.000		9.91
1C	Scoring	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.00	10.00	10.00	0.000		
2C	Ridging	9.0	8.0	9.0	9.0	9.0	9.0	9.0	9.0	9.00	8.00	8.88	0.354	7	9.2
2C	Rippling	9.0	9.0	8.0	10.0	8.0	9.0	10.0	10.0	10.00	8.00	9.13	0.835		8.6
2C	Wear	6.0	6.0	6.0	6.0	7.0	7.0	6.0	8.0	8.00	6.00	6.50	0.756		7.8
2C	Spitting	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.8	9.90	9.80	9.89	0.035		9.87
2C	Scoring	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.00	10.00	10.00	0.000		
3C	Ridging	5.0	5.0	6.0	5.0	7.0	6.0	5.0	5.0	7.00	5.00	5.50	0.756	15	5.6
3C	Rippling	6.0	9.0	9.0	9.0	8.0	9.0	9.0	9.0	9.00	6.00	8.50	1.069		8.6
3C	Wear	5.0	5.0	5.0	5.0	6.0	6.0	5.0	6.0	6.00	5.00	5.38	0.518		5.4
3C	Spitting	7.0	8.0	8.0	8.0	8.0	8.0	8.0	7.0	8.00	7.00	7.75	0.463		7.56
3C	Scoring	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.00	10.00	10.00	0.000		
4C	Ridging	8.0	7.0	7.0	8.0	8.0	8.0	8.0	8.0	8.00	7.00	7.75	0.463	25	8.1
4C	Rippling	6.0	7.0	6.0	8.0	7.0	7.0	7.0	7.0	8.00	6.00	6.88	0.641		7.6
4C	Wear	5.0	7.0	6.0	6.0	6.0	6.0	6.0	7.0	7.00	5.00	6.13	0.641		6.7
4C	Spitting	9.8	9.7	9.9	9.9	9.9	9.9	9.9	9.9	9.90	9.70	9.86	0.074		9.9
4C	Scoring	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.00	10.00	10.00	0.000		
5	Ridging	10.0	10.0	10.0	10.0	9.0	9.0	9.0	9.0	10.0	9.0	9.50	0.535	26	9.80
5	Rippling	10.0	9.0	10.0	10.0	9.0	9.0	9.0	9.0	10.0	9.0	9.38	0.518		9.30
5	Wear	9.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	9.0	8.0	8.13	0.354		8.80
5	Spitting	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.90	0.000		9.98
5	Scoring	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.00	0.000		
6	Ridging	10.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	10.0	9.0	9.13	0.354	33	9.00
6	Rippling	10.0	9.0	9.0	10.0	9.0	9.0	9.0	9.0	10.0	9.0	9.25	0.463		9.20
6	Wear	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.00	0.000		6.30
6	Spitting	3.0	3.0	2.0	2.0	3.0	2.0	6.0	1.0	6.0	1.0	2.75	1.488		2.33
6	Scoring	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.00	0.000		
7	Ridging	8.0	7.0	7.0	7.0	7.0	7.0	8.0	6.0	8.0	6.0	7.13	0.641	38	7.30
7	Rippling	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.00	0.000		9.20
7	Wear	6.0	7.0	6.0	6.0	7.0	7.0	6.0	6.0	7.0	6.0	6.38	0.518		6.70
7	Spitting	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.90	0.000		9.92
7	Scoring	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.00	0.000		
8	Ridging	9.0	8.0	9.0	8.0	8.0	9.0	9.0	9.0	9.0	8.0	8.63	0.518	39	8.70
8	Rippling	9.0	8.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	8.0	8.88	0.354		8.50
8	Wear	6.0	6.0	6.0	6.0	6.0	7.0	6.0	6.0	7.0	6.0	6.13	0.354		6.80
8	Spitting	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.90	0.000		9.92
8	Scoring	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.00	0.000		

Attachment 2
Page 1 of 7
Reference 2/13/08

ASTM Gear Calibration Workshop

Richmond, VA January 15, 16, 17 & 18, 2008

L-37 PINION GEARS

SET #	DISTRESS	6	7	10	11	22	25	29	30	MAX	MIN	AVG	Std Dev	Pinion #	Pinion Mean
9	Ridging	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.00	0.000	41	9.30
9	Rippling	10.0	10.0	9.0	10.0	9.0	9.0	10.0	9.0	10.0	9.0	9.50	0.535		9.30
9	Wear	7.0	7.0	7.0	8.0	7.0	6.0	8.0	6.0	8.0	6.0	7.00	0.756		6.80
9	Spitting	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.90	0.000		9.92
9	Scoring	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.00	0.000		
10	Ridging	9.0	8.0	8.0	8.0	8.0	8.0	9.0	8.0	9.0	8.0	8.25	0.463	42	8.80
10	Rippling	9.0	7.0	7.0	8.0	7.0	6.0	8.0	7.0	9.0	6.0	7.38	0.916		6.80
10	Wear	6.0	6.0	6.0	6.0	7.0	6.0	6.0	6.0	7.0	6.0	6.13	0.354		6.00
10	Spitting	9.9	9.9	9.9	9.9	9.9	9.8	9.9	9.6	9.9	9.6	9.85	0.107		9.80
10	Scoring	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.00	0.000		
11	Ridging	9.0	7.0	8.0	8.0	9.0	8.0	8.0	8.0	9.0	7.0	8.13	0.641	59	New
11	Rippling	7.0	5.0	6.0	5.0	6.0	5.0	6.0	6.0	7.0	5.0	5.75	0.707		Pinion
11	Wear	5.0	5.0	5.0	6.0	6.0	6.0	6.0	6.0	6.0	5.0	5.63	0.518		No
11	Spitting	9.0	9.0	8.0	8.0	8.0	9.0	9.0	8.0	9.0	8.0	8.50	0.535		STATS
11	Scoring	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.00	0.000		
12	Ridging	9.0	8.0	8.0	9.0	8.0	9.0	10.0	9.0	10.0	8.0	8.75	0.707	55	8.70
12	Rippling	10.0	8.0	9.0	10.0	9.0	9.0	9.0	9.0	10.0	8.0	9.13	0.641		9.20
12	Wear	7.0	7.0	7.0	7.0	7.0	7.0	7.0	6.0	7.0	6.0	6.88	0.354		7.00
12	Spitting	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.90	0.000		9.90
12	Scoring	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.00	0.000		
RERATE															
R1/5	Ridging	10.0	10.0	9.0	10.0	9.0	9.0	9.0	10.0	10.0	9.0	9.50	0.535	26	9.80
R1/5	Rippling	10.0	8.0	9.0	10.0	9.0	9.0	9.0	10.0	10.0	8.0	9.25	0.707		9.30
R1/5	Wear	9.0	8.0	7.0	8.0	8.0	8.0	8.0	8.0	9.0	7.0	8.00	0.535		8.80
R1/5	Spitting	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.90	0.000		9.98
R1/5	Scoring	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.00	0.000		
R2/6	Ridging	9.0	8.0	9.0	9.0	8.0	9.0	9.0	9.0	9.0	8.0	8.75	0.463	33	9.00
R2/6	Rippling	10.0	8.0	9.0	9.0	9.0	9.0	9.0	9.0	10.0	8.0	9.00	0.535		9.20
R2/6	Wear	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.00	0.000		6.30
R2/6	Spitting	3.0	3.0	3.0	2.0	3.0	2.0	3.0	1.0	3.0	1.0	2.50	0.756		2.33
R2/6	Scoring	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.00	0.000		
R3/7	Ridging	8.0	7.0	7.0	7.0	7.0	8.0	8.0	7.0	8.0	7.0	7.38	0.518	38	7.30
R3/7	Rippling	9.0	8.0	9.0	10.0	9.0	9.0	9.0	9.0	10.0	8.0	9.00	0.535		9.20
R3/7	Wear	6.0	7.0	6.0	6.0	7.0	7.0	6.0	6.0	7.0	6.0	6.38	0.518		6.70
R3/7	Spitting	9.9	9.9	9.9	9.9	9.9	9.9	9.0	9.9	9.9	9.0	9.79	0.318		9.92
R3/7	Scoring	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.00	0.000		
R4/10	Ridging	8.0	8.0	8.0	8.0	8.0	9.0	9.0	9.0	9.0	8.0	8.38	0.518	42	8.80
R4/10	Rippling	8.0	7.0	7.0	7.0	7.0	6.0	8.0	7.0	8.0	6.0	7.13	0.641		6.80
R4/10	Wear	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.00	0.000		6.00
R4/10	Spitting	9.9	9.9	9.8	9.8	9.9	9.8	9.0	9.6	9.9	9.0	9.71	0.304		9.80
R4/10	Scoring	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.00	0.000		

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L-37 RING GEARS

SET #	DISTRESS	6	7	10	11	22	25	29	30	MAX	MIN	AVG	Std Dev
1C	Ridging	4.0	6.0	5.0	5.0	6.0	6.0	5.0	5.0	6.0	4.0	5.25	0.707
	Rippling	8.0	8.0	8.0	8.0	9.0	9.0	6.0	10.0	10.0	6.0	8.25	1.165
	Wear	5.0	6.0	5.0	5.0	7.0	7.0	6.0	7.0	7.0	5.0	6.00	0.926
	Spitting	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.90	0.000
	Scoring	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.00	0.000
2C	Ridging	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.00	0.000
	Rippling	9.0	10.0	10.0	10.0	9.0	9.0	10.0	10.0	10.0	9.0	9.63	0.518
	Wear	6.0	8.0	8.0	9.0	8.0	7.0	8.0	8.0	9.0	6.0	7.75	0.886
	Spitting	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.90	0.000
	Scoring	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.00	0.000
3C	Ridging	7.0	8.0	9.0	9.0	9.0	8.0	8.0	9.0	9.0	7.0	8.38	0.744
	Rippling	10.0	10.0	9.0	10.0	9.0	9.0	9.0	10.0	10.0	9.0	9.50	0.535
	Wear	7.0	8.0	8.0	8.0	9.0	7.0	7.0	8.0	9.0	7.0	7.75	0.707
	Spitting	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.90	0.000
	Scoring	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.00	0.000
4C	Ridging	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.00	0.000
	Rippling	10.0	10.0	9.0	10.0	9.0	9.0	9.0	10.0	10.0	9.0	9.50	0.535
	Wear	8.0	7.0	8.0	9.0	8.0	8.0	7.0	8.0	9.0	7.0	7.88	0.641
	Spitting	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.90	0.000
	Scoring	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.00	0.000
5	Ridging	3.0	3.0	3.0	3.0	4.0	3.0	4.0	4.0	4.0	3.0	3.38	0.518
5	Rippling	7.0	8.0	10.0	9.0	9.0	10.0	9.0	8.0	10.0	7.0	8.75	1.035
5	Wear	5.0	4.0	4.0	4.0	5.0	4.0	6.0	5.0	6.0	4.0	4.63	0.744
5	Spitting	9.0	9.0	8.0	8.0	8.0	9.0	8.0	8.0	9.0	8.0	8.38	0.518
5	Scoring	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.00	0.000
6	Ridging	9.0	8.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	8.0	8.88	0.354
6	Rippling	9.0	10.0	9.0	10.0	9.0	9.0	9.0	10.0	10.0	9.0	9.38	0.518
6	Wear	7.0	7.0	6.0	6.0	7.0	7.0	7.0	7.0	7.0	6.0	6.75	0.463
6	Spitting	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.90	0.000
6	Scoring	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.00	0.000
7	Ridging	8.0	7.0	8.0	8.0	8.0	9.0	10.0	9.0	10.0	7.0	8.38	0.916
7	Rippling	9.0	9.0	10.0	10.0	9.0	9.0	9.0	9.0	10.0	9.0	9.25	0.463
7	Wear	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.00	0.000
7	Spitting	9.9	9.9	10.0	9.9	9.9	9.9	10.0	9.9	10.0	9.9	9.93	0.046
7	Scoring	10.0	8.0	10.0	10.0	9.0	10.0	10.0	10.0	10.0	8.0	9.63	0.744
8	Ridging	9.0	9.0	9.0	9.0	10.0	9.0	10.0	9.0	10.0	9.0	9.25	0.463
8	Rippling	10.0	10.0	10.0	10.0	10.0	9.0	10.0	10.0	10.0	9.0	9.88	0.354
8	Wear	8.0	8.0	8.0	8.0	8.0	7.0	9.0	8.0	9.0	7.0	8.00	0.535
8	Spitting	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.90	0.000
8	Scoring	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.00	0.000

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L-37 RING GEARS

SET #	DISTRESS	6	7	10	11	22	25	29	30	MAX	MIN	AVG	Std Dev
9	Ridging	9.0	9.0	9.0	9.0	10.0	9.0	10.0	9.0	10.0	9.0	9.25	0.463
9	Rippling	9.0	10.0	10.0	10.0	9.0	9.0	9.0	10.0	10.0	9.0	9.50	0.535
9	Wear	8.0	8.0	7.0	8.0	7.0	7.0	7.0	8.0	8.0	7.0	7.50	0.535
9	Spitting	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.90	0.000
9	Scoring	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.00	0.000
10	Ridging	10.0	10.0	10.0	9.0	10.0	10.0	10.0	10.0	10.0	9.0	9.88	0.354
10	Rippling	10.0	10.0	10.0	10.0	9.0	10.0	10.0	10.0	10.0	9.0	9.88	0.354
10	Wear	8.0	7.0	7.0	8.0	7.0	7.0	7.0	7.0	8.0	7.0	7.25	0.463
10	Spitting	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.90	0.000
10	Scoring	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.00	0.000
R1/5	Ridging	3.0	3.0	3.0	3.0	3.0	3.0	5.0	4.0	5.0	3.0	3.38	0.744
R1/5	Rippling	7.0	8.0	10.0	10.0	9.0	10.0	9.0	9.0	10.0	7.0	9.00	1.069
R1/5	Wear	5.0	5.0	3.0	3.0	5.0	4.0	6.0	5.0	6.0	3.0	4.50	1.069
R1/5	Spitting	9.0	9.0	8.0	8.0	8.0	9.0	8.0	8.0	9.0	8.0	8.38	0.518
R1/5	Scoring	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.00	0.000
R2/8	Ridging	9.0	9.0	9.0	9.0	9.0	9.0	10.0	9.0	10.0	9.0	9.13	0.354
R2/8	Rippling	10.0	10.0	10.0	10.0	10.0	9.0	10.0	10.0	10.0	9.0	9.88	0.354
R2/8	Wear	8.0	7.0	8.0	8.0	8.0	7.0	8.0	8.0	8.0	7.0	7.75	0.463
R2/8	Spitting	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.90	0.000
R2/8	Scoring	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.00	0.000
R3/9	Ridging	10.0	8.0	9.0	10.0	10.0	9.0	10.0	10.0	10.0	8.0	9.50	0.756
R3/9	Rippling	9.0	9.0	9.0	10.0	9.0	9.0	9.0	10.0	10.0	9.0	9.25	0.463
R3/9	Wear	8.0	7.0	7.0	8.0	7.0	7.0	7.0	8.0	8.0	7.0	7.38	0.518
R3/9	Spitting	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.90	0.000
R3/9	Scoring	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.00	0.000

Attachment 8
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