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INTERNATIONAL
Standards Worldwide

Committee D02 on PETROLEUM PRODUCTS AND LUBRICANTS

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November 16th, 2009

Reply to:
Galen Greene
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(440) 347-2878 (FAX)
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:

- **November 11th, 2009 L-37 Surveillance Panel Meeting conducted at the US Army TACOM Facility in Warren, MI.**

Please direct any corrections or comments to my attention.

Sincerely,

Galen Greene, Chairman
L-37 Surveillance Panel

Report of Meeting
L-37 Surveillance Panel Meeting
US Army TACOM
Warren, MI

November 11th, 2009

Attendees:

Dana -	**Miller (TC)**, Guzikowski (TC)
SwRI -	**Koehler**
Lubrizol -	Bartlett (TC), Gropp, **Greene**
Afton -	**Koglin**, Higuchi, Bell
Intertek-Parc -	**Smith**
TMC -	**Lind**
Chevron -	**Haire**
US Army -	**Comfort**
Arvin Meritor -	**McGlone**
ExxonMobil -	**Eliot**

TC = Teleconference
Voting Members in **BOLD**

The meeting was called to order at 2:03 pm. 10 voting members present.

1.0 Approval of Minutes:

- **August 12, 2009 Surveillance Panel Meeting**

Motion # 1 → Mr. Koglin/second Mr. Smith to approve the minutes as presented. Motion for approval was passed with a vote of 8 for, 0 opposed, and 0 abstentions.

2.0 Summary of Meeting Discussions

2.1 Hardware Status

2.1.1 Review of Pilot Matrix Results

The chairman reviewed the pilot testing the labs have done to date. Discussion regarding the recent testing:

- Guzikowski – Reviewed Dana metallurgical analysis of gears set 7L (run on TMC 152-1, broken pinion tooth). See attachments 2 and 3 for report. This part met all metallurgical specifications. Nothing in metallurgical analysis points to the reason for failure.
- Miller – Reviewed FEA analysis of the same gear 7L and compared it to a good result on that same oil. The FEA analysis shows that these two gear sets are essentially the same and they also line up with the 2005 shelf master. See attachment 4 for FEA analysis of gear set 7L.
- Koglin – looks like micro-pitting is leading to spalling, would more lapping prevent these failures? Guzikowski commented that there would likely be no stress change, maybe a slight geometry change. Miller commented that anything that smoothes the surface will likely improve overall gear performance. Smoothing the surface would mainly help ridging, ripping, and wear.
- Koehler – We tried to prevent the top land chipping (a minor problem with the 2005 batch) by changing the shot peening operation. Is this change causing the problems we are seeing? Guzikowski stated that if the parts were over shot peened, you can get cracking on the gear teeth. He stated that with the metallurgical analysis, there is no evidence that shot peening caused the failures.
- **ACTION ITEM:** Miller to lead review within Dana of all changes made since 2002. This includes any changes in parts, steel, manufacturing processes, etc.

- **Final Comments from Panel on the 2009 Lubrited and Non-Lubrited batch**
  - **Lubrited –** General consensus was that we cannot accept the batch as is. More pilot matrix testing would need to be done to proceed. Lubrited does look slightly better than non-lubrited on the most recent iteration, which is different than expectation
  - **Non-Lubrited –** General consensus was we cannot accept the batch as is. More pilot matrix testing would need to be done to proceed. There were some tests with broken teeth and some with severe spalling.

2.1.2 Discussion of Next Steps

Lubrizol presented some additional work they had done on a reduced load procedure using the 2008 hardware (P4L870A/V1L500 and P4T813/V1L500). This work was a continuation of the work the SwRI had started just before the 2008 batch was rejected for normal loading testing. Lubrizol testing was done on several Lubrizol internal "pass" style oils and a discrimination oil. Presentation is attached (attachment 5). Lubrizol was willing to donate some tests to start a full approval matrix on this 13% reduced load procedure. If successful, only the 2006 lubrited hardware would need to be retrofitted. All 2008 non-lubrited and lubrited axles currently have this batch of hardware installed. Lubrizol saved all the remaining 2008 ring and pinions and has them stored for future retrofitting if needed. Comments of panel:

- Lind – questioned the success of the SwRI reduced loading data. Bartlett provided some of the final data points on this work. General consensus was that the panel rejected the hardware as it felt the best chance of success at that time was to start with a new batch of hardware. Since the new batch of hardware hasn't been successful to date, Lubrizol asked we consider the reduced loading work on an industry level. Little work was done higher than 11% reduced contact stress.
- The Panel discussed what oils to run and how to proceed.

Motion # 2 → Mr. Koglin/second Mr. Haire. Using the Lubrizol reduced load procedure of 13% contact stress reduction (1213 ft. lbs. wheel loading), LZ and Afton are each to run 2 TMC 134 runs on the 2008 lubrited hardware batch. The Hardware Task Force group will meet after these are run to discuss next steps and consider running further tests on TMC 153 or 152. Motion for approval was passed with a vote of 10 for, 0 opposed, and 0 abstentions.

2.2 Review of TMC 153 Historic Data

The panel took a short amount of time reviewing historical data on TMC 153 from two recent lubrited batches and two recent non-lubrited batches. It should be noted that on the lubrited data, the V1L686 batch was rejected (2006 batch). The group will consider these data points when reviewing any future test data with TMC 153. See attachment 6.

2.3 Calibration Frequency

It was asked that the group review the calibration and referencing frequency for the D6121 test method. The group discussed moving the time or number of hours between references. The TMC expressed concern over extending any reference requirement as it currently takes a minimum of 6 months to detect a 1 standard deviation severity shift within the industry. The group discussed just referencing on one hardware type as a way to reduce this. It was decided that we should still use both hardware types at this time (once more approved hardware is available).

Motion # 3 → Mr. Koglin/second Mr. Koehler. Section 9.3.3, raise 2 month requirement for reference test frequency to 4 months, and leave every other requirement unchanged. This change is effective as of the labs next reference. Motion for approval was passed with a vote of 8 for, 0 opposed, and 2 abstentions.

2.4 Contact Pattern Study

Due to time constraints, the contact pattern study review was postponed to a later date.

3.0 Adjournment

Motion to adjourn → Mr. Bell/second Mr. Smith

Meeting Adjourned at 4:50 pm

Respectfully submitted,

Galen Greene
L-37 Surveillance Panel Chairman

ASTM L-37 Surveillance Panel Membership/Mailing List

Meeting Date: November 11th, 2009

Attachment 1
Page 1 of 5
Reference

Initials*	Name	Voting Status	Company Name & Address	Phone/Email Info
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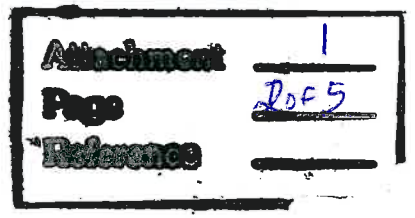
TC	Bartlett, Don	Non Voting	The Lubrizol Corporation 29400 Lakeland Boulevard Wickliffe, Ohio 44092	Phone: 440-347-2388 Fax: 440-347-2878 E-Mail: donald.bartlett@lubrizol.com
DB	Bell, Don	Non Voting	Afton Chemical 500 Spring Street Richmond, VA 23219	Phone: 804-788-6332 Fax: 804-788-6243 E-Mail: don.bell@aftonchemical.com
	Brosnan, Bridget	Non-Voting	RDTA-DP/MS110 6501 East 11 Mile road Warren, MI 48397-5000	Phone: 586-574-4221 Fax: 586-574-4224 E-Mail: bridget.brosnan@us.army.mil
	Bryson, Tom	Voting	Mack Trucks 13302 Pennsylvania Avenue Hagerstown, Maryland 21740	Phone: 301-790-6744 Fax: 301-790-5605 E-Mail: thomas.bryson@volvo.com
A.C.	Comfort, Allen	Voting	RDTA-PD/MS110 Tank Automotive & Armament 6501 East 11 Mile road Warren, MI 48397-5000	Phone: 586-~~574~~-4225 (282) Fax: 586-~~574~~-4244 → 282 E-Mail: allen.s.confort@us.army.mil
	Dharte, John	Voting	American Axle & Manufacturing 2965 Technology Drive Rochester Hills, MI 48309-3589	Phone: 248-299-6478 Fax: 248-299-6581 E-Mail: Dhartej@aam.com
S.E.	Eliot, Stephen	Non Voting	ExxonMobil Lubricants & Specialties 18486 Lanier Island Sq. Leesburg, Virgina 20176	Phone: 703-669-9916 Fax: 703-669-9917 E-Mail: stephen.w.eliot@exxonmobil.com

* Initial to indicate attendance at subject meeting

ASTM L-37 Surveillance Panel Membership/Mailing List

Meeting Date: November 11th, 2009



Initials*	Name	Voting Status	Company Name & Address	Phone/Email Info
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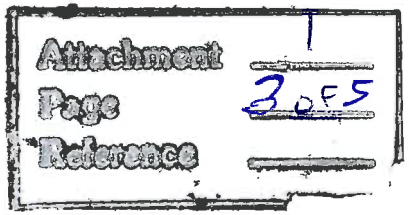
MJH	Haire, Mike	Voting	Chevron Global Lubricants 100 Chevron Way, Rm 71-7302 Richmond, California 94802	Phone: 510-242-2740 Fax: 510-242-3758 E-Mail: mhaire@chevron.com
SJH	Higuchi, Sam	Non Voting	Afton Chemical 500 Spring Street Richmond, VA 23218	Phone: 804-788-5375 Fax: 804-788-6358 E-Mail: samuel.higuchi@aftonchemical.com

* Initial to indicate attendance at subject meeting

ASTM L-37 Surveillance Panel Membership/Mailing List

Meeting Date: November 11th, 2009



Initials*	Name	Voting Status	Company Name & Address	Phone/Email Info
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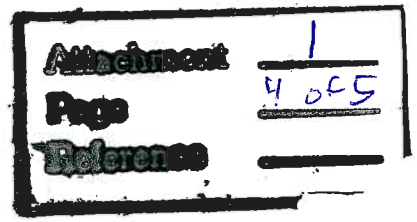
ASTM L-37 Surveillance Panel Membership/Mailing List

Meeting Date: November 11th, 2009



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TC	Miller, Kenny	Voting	Dana Corporation 1293 Glenway Drive Statesville, NC 28677	Phone: 704-878-5762 Fax: 704-878-5735 E-Mail: Kenny.miller@dana.com
	Pappademos, Lou	Non Voting	Dana Corporation Fort Wayne, IN	Phone: Fax: E-Mail: lou.pappademos@dana.com
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	Smith, Dale	Voting	Intertek - PARC Technical Services, Inc. 100 William Pitt Way Pittsburgh, PA 15238	Phone: 412-423-1120 , ext 403 Fax: 412-826-5443 E-Mail: Dale.Smith@intertek.com
	Song, HaiQing	Non Voting	Research Institue of Petroleum Processing No. 18, XueYan Road, PO Box 914-19 Beijing 10083 P.R. China	Phone: 011-86-10-8236-8182 Fax: 011-86-10-6231-1290 E-Mail: songhq@ripp-sinopec.com

* Initial to indicate attendance at subject meeting

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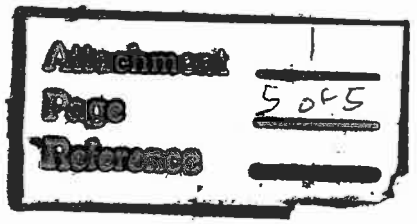
Meeting Date: November 11th, 2009



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	Xie, JingChun	Non Voting	Lanzhou Lube Oil R&D Institute No. 369 Yumen Streat, XiGu District Lanshou 730060, GanSu Province P.R. China	Phone: 011-86-931-793-3713 Fax: 011-86-139-9319-2560 E-Mail: xiejingchun_rhy@petrochina.com.cn
	Zakarian, Jack	Non Voting	Chevron Products 100 Chevron Way Richmond, CA 94802	Phone: 510-242-3595 Fax: 510-242-3758 E-Mail: jaza@chevron.com
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				Phone: Fax: E-Mail:
				Phone: Fax: E-Mail:
				Phone: Fax: E-Mail:
				Phone: Fax: E-Mail:

* Initial to indicate attendance at subject meeting

Attachment #2

MATERIALS ENGINEERING LAB REPORT

DANA HOLDING CORPORATION
3939 TECHNOLOGY DR.
MAUMEE, OHIO 43537

LAB NO.	: **2009-0793**	**PART NO.**	: 060GP105
PART NAME	: PINION – HYPOID DRIVE FIN	**PRINT REV.**	: D
REP. TITLE	: GEAR, PINION	**MODEL**	: N/A
MARKINGS	: PM DANA D3 060GP105 41 7 VIL528 00 7L	**HEAT CODE**	: VIL528
MATERIAL	: STEEL PER SA E8625	**MFG. DATE**	: 04/24/09
VENDOR	: DANA FORT WAYNE	**SAMP. REQ.**	: N/A
CUSTOMER	: ASTM	**VIN**	: N/A
TAR NO.	: N/A	**MAR NO.**	: 4382
JOB NO.	: N/A	**SAMP. REQ.**	: N/A
TEST ENG.	: N/A	**REC'D DATE**	: 11/3/09
REQ. BY	: JOE GUZIKOWSKI	**REP. DATE**	: 11/10/09
REP. BY	: NATHAN OVERHOLT	**NO. OF PAGES**	: 5

ADD. COMMENTS : EVALUATE FRACTURE ON PINION TOOTH AND MATERIAL.
RING GEAR MARKINGS: 7L 04 24 09 DANA D 060GR105 P4T883A 41 7

COPIES : GREG FETT, DANA COMBS

REQUEST : EVALUATE FRACTURE ON PINION TOOTH AND PERFORM MATERIAL ANALYSIS ON RING GEAR AND PINION. PHOTODOCUMENT, MAG PARTICLE, AND MATERIAL ANALYSIS.

REASON : ASTM L-37 PRE-SCREENING TEST SAMPLE 67341 FAILED AT AFTON USING A PASS OIL 152-1.

RESULTS :

VISUAL INSPECTION

THE PINION WAS RECEIVED WITH ONE BROKEN TOOTH. THE TOOTH FAILED MID TOOTH AT THE ROOT TOWARD THE TOP OF THE TOOTH. THERE WAS A HARD LINE OF CONTACT OBSERVED AT THE BOTTOM OF THE CONTACT PATTERN. PITTING OCCURRED ALONG THIS LINE OF CONTACT AND LED IN TO THE FAILURE ON THE TOOTH. THIS LINE OF CONTACT WAS OBSERVED ON THREE TEETH, FIGURES 8-10.

MAGNETIC PARTICLE INSPECTION

ASTM E709-01

MAGENTIC PARTICLE INSPECTION REVEALED TWO CRACKS ACROSS THE TOP OF THE FAILED TOOTH AND ON THE TOOTH NEXT TO IT, FIGURE 5.

MICROHARDNESS VALUES

ASTM E 384-08

500 GF LOAD CONVERTED TO HRC.

DEPTH IN	ROOT PINION (HRC)	PITCH PINION (HRC)
0.002	65	61
0.004	62.3	60
0.006	61	59
0.008	60	59
0.010	60	58
0.020	58	58
0.030	55	42
0.040	52	45
0.050	52	38
0.060	49	30
0.070	42	29
0.080	39	39
0.090	37	28
0.100	34	28

LAB REPORT
2009-0793

CASE DEPTH: **SAE J423 FEB. 1998**

EFFECTIVE CASE DEPTH MEASURED AT 50 HRC USING A 500G LOAD AND CONVERTING VICKERS TO HRC.

	ROOT PINION	PITCH PINION
CASE DEPTH (IN)	0.025”	0.055”
SPECIFICATION	0.025" - 0.065"	0.050" - 0.065”

SURFACE HARDNESS **ASTM E384-08**

500G VICKERS CONVERTED TO HRC, MEASURED AT 0.004” AND 0.006”.

LOCATION	PINION GEAR (HRC)	SPECIFICATION
PITCH	62, 61	61-63 HRC
ROOT	60, 59*	

*BELOW SPECIFICATION BUT WITHIN TYPICAL DANA SURFACE HARDNESS SPECIFICATION OF 57-66 HRC.

CORE HARDNESS **ASTM E18-08**

DIRECT HRC ON MICRO SAMPLE.

	PITCH (HRC)	ROOT (HRC)	1/8” BELOW ROOT (HRC)
PINION GEAR	37	29	28
SPECIFICATION	--	25-43 HRC	--

*ABOVE SPECIFICATION

CHEMICAL ANALYSIS **ASTM E415-08**

THE CHEMISTRY OF THE SAMPLE WAS DETERMINED BY OPTICAL EMISSION SPECTROSCOPY.

ELEMENT	PINION GEAR	SAE 8625	RESIDUAL ELEMENTS PER ES-PM-FW0001**
C	0.25	0.23 - 0.28	--
MN	0.79	0.70 - 0.90	--
P	0.012	0.035 MAX	--
S	0.017	0.040 MAX	--
SI	0.28	0.15 - 0.35	--
NI	0.47	0.40 - 0.70	--
CR	0.45	0.40 - 0.60	--
MO	0.18	0.15 - 0.25	--
CU	0.21	-	0.35 MAX
AL	0.025	-	0.015-0.050
SN	0.013	-	0.025 MAX
V	0.003	-	0.020 MAX
NB	0.003	-	0.010 MAX
ZR	0.001	-	0.010 MAX
B	0.0003	-	0.0005 MAX
TI	0.002	-	0.010 MAX
PB	0.000	-	0.010 MAX
CA	0.0008	-	0.0030 MAX
N	0.008	-	0.015 MAX
AS	0.005	-	0.010 MAX
ZN	0.002	-	0.030 MAX
SB	0.000	-	0.010 MAX
**D.I.	2.21	2.40 - 2.70	--

***FOR REFERENCE ONLY*

MICROSTRUCTURE

THE CASE MICROSTRUCTURE CONSISTS OF MARTENSITE, AND THE CORE MICROSTRUCTURE CONSISTS OF TRANSFORMATION PRODUCTS.

CONCLUSION : THE PINION IS AT THE MINIMUM CASE DEPTH AT THE ROOT, AND IT MEETS ALL OTHER SPECIFICATIONS. THE FAILURE IS DUE TO PITTING AND SPALLING ON ONE TOOTH. ADDITIONAL TEETH SHOW AN AREA OF HIGH LOCALIZED CONTACT STRESS NEAR THE TOE END AT THE BOTTOM OF CONTACT. A LINE OF PITTING IS PRESENT AT THE TOP OF THIS AREA. THIS IS BELIEVED TO BE THE CAUSE OF THE FAILURE.

LAB REPORT
2009-0793

RELATED MET REPORTS :	**LAB NUMBER**	**REPORT TITLE**
	2009-0794	RING GEAR

FIGURE 1: PINION AS RECEIVED.

FIGURE 2: END OF PINION.

FIGURE 3: ALTERNATIVE VIEW OF PINION SHOWING CONTACT PATTERN.

FIGURE 4: PINION SHOWING TOOTH FAILURE.

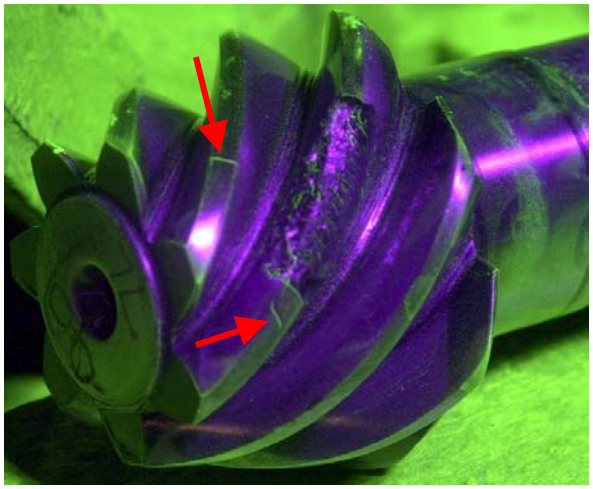


FIGURE 5: MAGNETIC PARTICLE INSPECTION OF PINION, ARROWS INDICATING CRACKS.

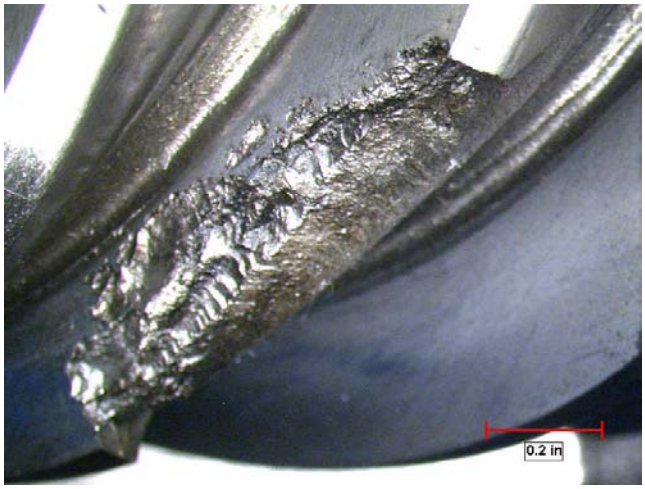


FIGURE 6: CLOSE-UP OF FAILED TOOTH, CONCAVE FACE OF TOOTH.

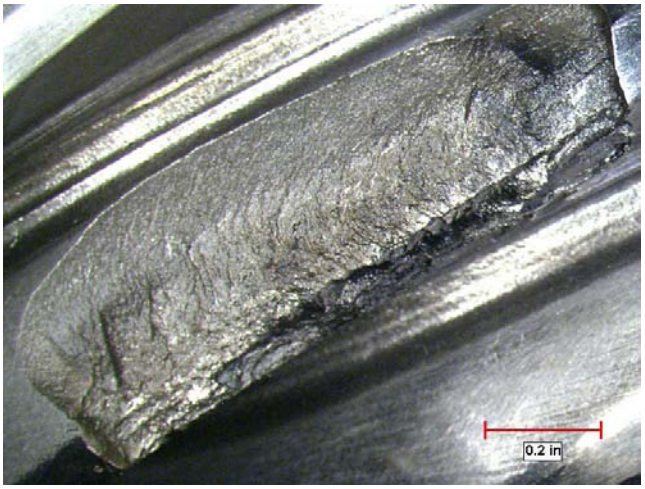


FIGURE 7: CLOSE-UP OF FAILED TOOTH, CONVEX FACE OF TOOTH.

FIGURE 8: PITTING SPALLING FAILURE ON THE LEFT. NOTE AREA OF LOCALIZED HIGH CONTACT STRESS AT BOTTOM OF CONTACT WITH PITTING AT THE TOP.

FIGURE 9: AREA OF LOCALIZED HIGH CONTACT STRESS AT THE BOTTOM OF CONTACT WITH LINE OF PITTING AT THE TOP.

FIGURE 10: AREA OF LOCALIZED HIGH CONTACT STRESS AT THE BOTTOM OF CONTACT WITH LINE OF PITTING AT THE TOP.

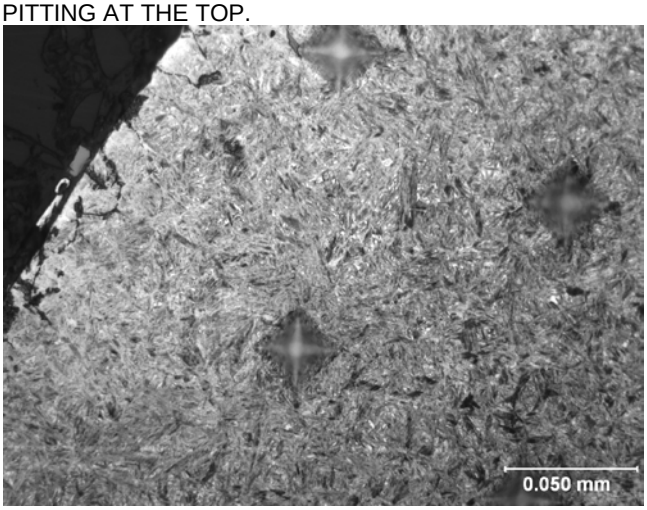


FIGURE 11: CASE MICROSTRUCTURE AT THE PITCH, 500X, 2% NITAL ETCHANT.

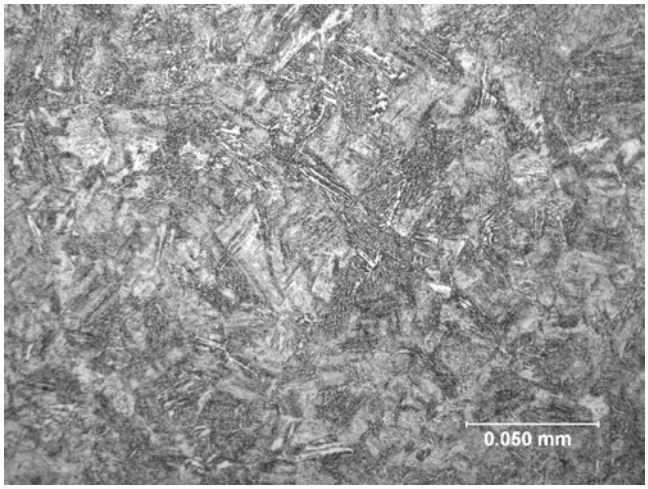


FIGURE 12: CORE MICROSTRUCTURE, AT THE PITCH, 500X, 2% NITAL ETCHANT.

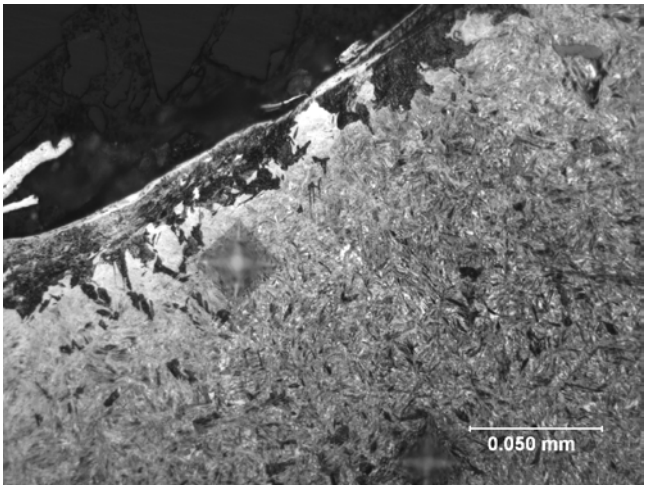


FIGURE 13: CASE MICROSTRUCTURE, AT THE ROOT, 500X, 2% NITAL ETCHANT.

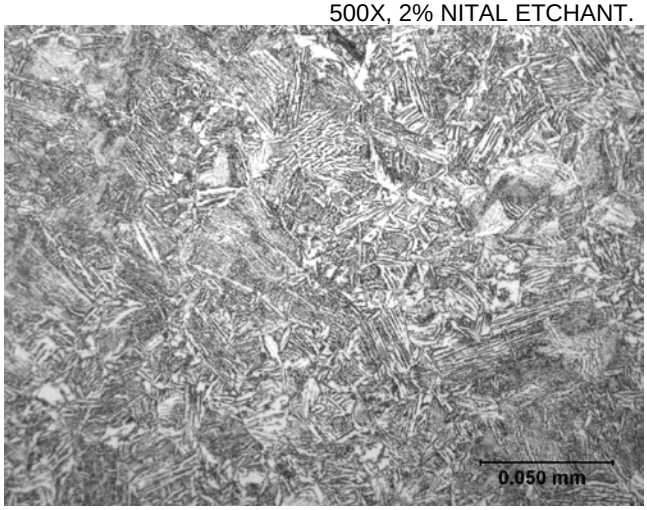


FIGURE 14: CORE MICROSTRUCTURE, AT THE ROOT, 500X, 2% NITAL ETCHANT.

Attachment #3

MATERIALS ENGINEERING LAB REPORT

DANA HOLDING CORPORATION
3939 TECHNOLOGY DR.
MAUMEE, OHIO 43537

LAB NO.	**: 2009-0794**	**PART NO.**	**:** 060GR105
PART NAME	**:** GEAR – HYPOID DRIVE FIN	**PRINT REV.**	**:** D
REP. TITLE	**:** GEAR, RING	**MODEL**	**:** N/A
MARKINGS	**:** 7L 04 24 09 DANA D 060GR105 P4T883A 41 7	**HEAT CODE**	**:** P4T883A
MATERIAL	**:** STEEL PER SAE 8620A	**MFG. DATE**	**:** 04/24/09
VENDOR	**:** DANA FORT WAYNE	**SAMP. REQ.**	**:** N/A
CUSTOMER	**:** ASTM	**VIN**	**:** N/A
TAR NO.	**:** N/A	**MAR NO.**	**:** 4382
JOB NO.	**:** N/A	**SAMP. REQ.**	**:** N/A
TEST ENG.	**:** N/A	**REC'D DATE**	**:** 11/3/09
REQ. BY	**:** JOE GUZIKOWSKI	**REP. DATE**	**:** 11/10/09
REP. BY	**:** NATHAN OVERHOLT	**NO. OF PAGES**	**:** 4

ADD. COMMENTS : EVALUATE FRACTURE ON PINION TOOTH AND MATERIAL.
PINION MARKINGS: PM DANA D3 060GP105 41 7 VIL528 00 7L

COPIES : GREG FETT, DANA COMBS, JOE

REQUEST : EVALUATE FRACTURE ON PINION TOOTH AND PERFORM MATERIAL ANALYSIS ON RING GEAR AND PINION. PHOTODOCUMENT, MAG PARTICLE, AND MATERIAL ANALYSIS.

REASON : ASTM L-37 PRE-SCREENING TEST SAMPLE 67341 FAILED AT AFTON USING A PASS OIL 152-1.

RESULTS :

VISUAL INSPECTION
THE RING GEAR WAS RECEIVED WITH OUT ANY NOTICABLE CRACKS OR FAILURES. THERE WAS HEAVY CONTACT NOTICED NEAR THE TOP OF THE RING GEAR TEETH, FIGURES 4&5.

MAGNETIC PARTICLE INSPECTION **ASTM E709-01**
MAGENTIC PARTICLE INSPECTION REVEALED NO CRACKS OR FAILURES.

MICROHARDNESS VALUES **ASTM E 384-08**
500 GF LOAD CONVERTED TO HRC.

DEPTH IN	ROOT RING GEAR (HRC)	PITCH RING GEAR (HRC)
0.002	61	61
0.004	60	62
0.006	60	59
0.008	60	59
0.010	59	57
0.020	57	54
0.030	55	52
0.040	52	46
0.050	50	37
0.060	48	37
0.070	46	31
0.080	45	30
0.090	44	30
0.100	45	30

LAB REPORT
2009-0794

CASE DEPTH: **SAE J423 FEB. 1998**

EFFECTIVE CASE DEPTH MEASURED AT 50 HRC USING A 500G LOAD AND CONVERTING VICKERS TO HRC.

	ROOT RING GEAR	PITCH RING GEAR
CASE DEPTH (IN)	0.033”	0.049”
SPECIFICATION	0.020-0.055"	0.040" – 0.055"

SURFACE HARDNESS **ASTM E384-08**

500G VICKERS CONVERTED TO HRC, MEASURED AT 0.004” AND 0.006”.

LOCATION	RING GEAR (HRC)	SPECIFICATION
PITCH	60	58-60 HRC
ROOT	62*, 59	

*ABOVE SPECIFICATION BUT WITHIN TYPICAL GEAR SURFACE HARDNESS OF 57-66 HRC.

CORE HARDNESS **ASTM E18-08**

DIRECT HRC ON MICRO SAMPLE.

	PITCH (HRC)	ROOT (HRC)	1/8” BELOW ROOT (HRC)
RING GEAR	43	36	32
SPECIFICATION	NOT SPECIFIED	25-43 HRC	NOT SPECIFIED

*ABOVE SPECIFICATION

CHEMICAL ANALYSIS **ASTM E415-08**

THE CHEMISTRY OF THE SAMPLE WAS DETERMINED BY OPTICAL EMISSION SPECTROSCOPY.

ELEMENT	RING GEAR	SAE 8620A	RESIDUAL ELEMENTS PER ES-PM-FW0001**
C	0.21	0.18 - 0.23	--
MN	0.88	0.80 MIN	--
P	0.009	0.035 MAX	--
S	0.027	0.040 MAX	--
SI	0.28	0.15 - 0.35	--
NI	0.43	0.40 - 0.70	--
CR	0.50	0.50 MIN	--
MO	0.20	0.20 MIN	--
CU	0.20	-	0.35 MAX
AL	0.025	-	0.015-0.050
SN	0.009	-	0.025 MAX
V	0.004	-	0.020 MAX
NB	0.001	-	0.010 MAX
ZR	0.001	-	0.010 MAX
B	0.0004	-	0.0005 MAX
TI	0.003	-	0.010 MAX
PB	0.000	-	0.010 MAX
CA	0.0008	-	0.0030 MAX
N	0.007	-	0.015 MAX
AS	0.005	-	0.010 MAX
ZN	0.002	-	0.030 MAX
SB	0.000	-	0.010 MAX
**D.I.	2.26	2.05 - 2.55	--

***FOR REFERENCE ONLY*

MICROSTRUCTURE

THE CASE MICROSTRUCTURE CONSISTS OF MARTENSITE, AND THE CORE MICROSTRCUTRE CONSISTS OF TRANSFORMATION PRODUCTS.

CONCLUSION : THE RING GEAR MEETS SPECIFICATION. AN AREA OF LOCALIZED HIGH CONTACT STRESS WAS NOTED ABOVE THE PITCH LINE WITH GROOVES OR LINES IN THE SLIDING DIRECTION, FIGURES 4&5.

RELATED MET REPORTS :	LAB NUMBER	REPORT TITLE
	2009-0793	PINION GEAR

FIGURE 1: RING GEAR AS RECEIVED.

FIGURE 2: RING GEAR TEETH, SHOWING CONTACT PATTERN.

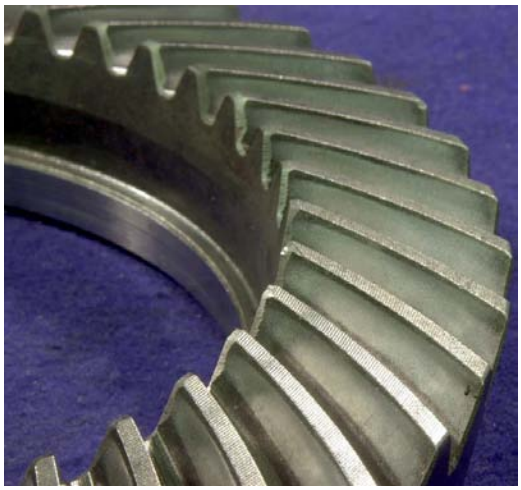


FIGURE 3: ALTERNATIVE VIEW OF RING GEAR TEETH, SHOWING CONTACT PATTERN.

FIGURE 4: CLOSE-UP OF RING GEAR TEETH, SHOWING AREA OF LOCALIZED HIGH CONTACT STRESS AND GROOVES OR LINES PRESENT ABOVE PITCH LINE.

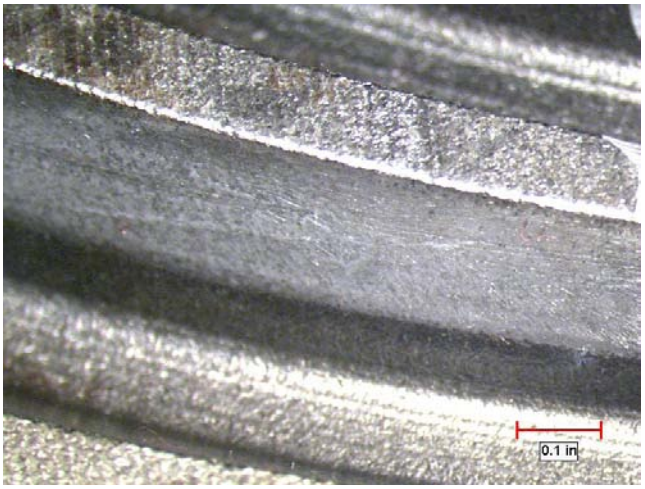


FIGURE 5: CLOSE-UP OF RING GEAR TEETH, SHOWING AREA OF LOCALIZED HIGH CONTACT STRESS AND GROOVES OR LINES PRESENT ABOVE PITCH LINE.

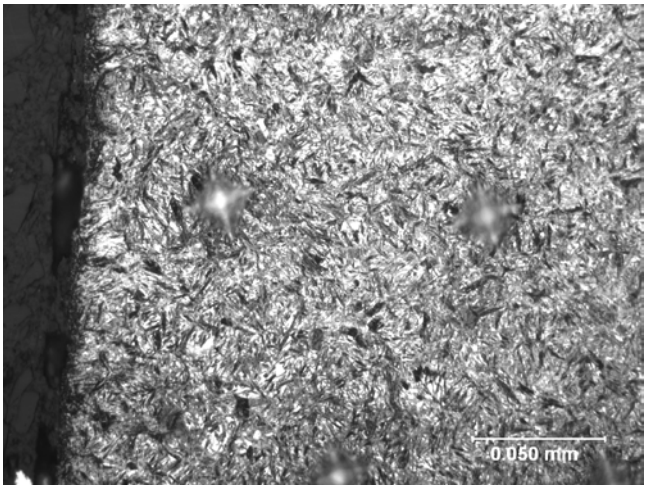


FIGURE 6: CASE MICROSTRUCTURE, AT THE PITCH, 500X, 2% NITAL ETCHANT.

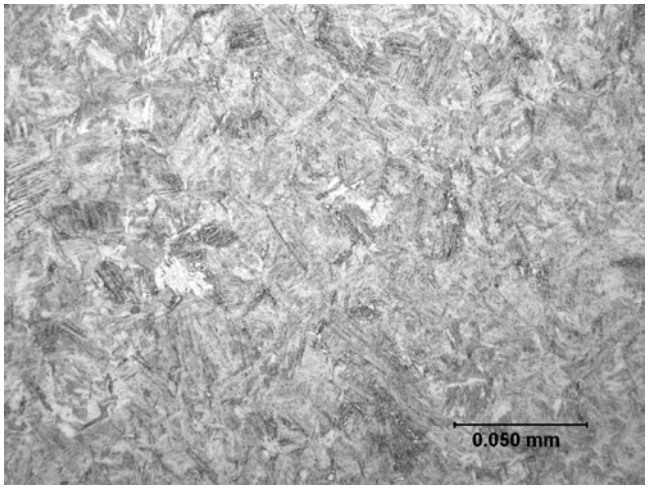


FIGURE 7: CORE MICROSTRUCTURE, AT THE PITCH, 500X, 2% NITAL ETCHANT.

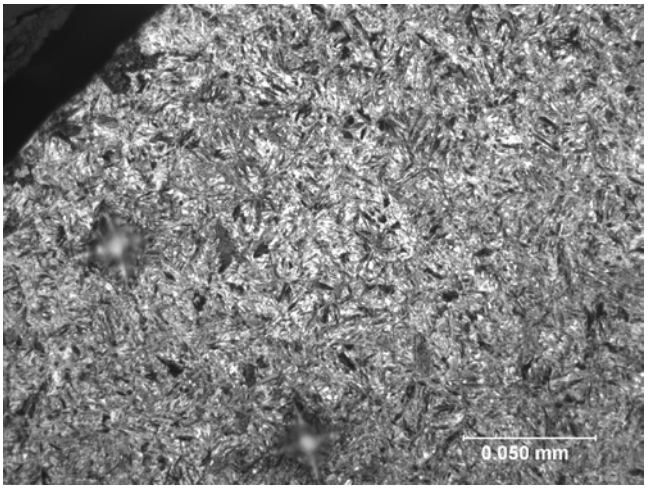


FIGURE 8: CASE MICROSTRUCTURE, AT THE ROOT, 500X, 2% NITAL ETCHANT.

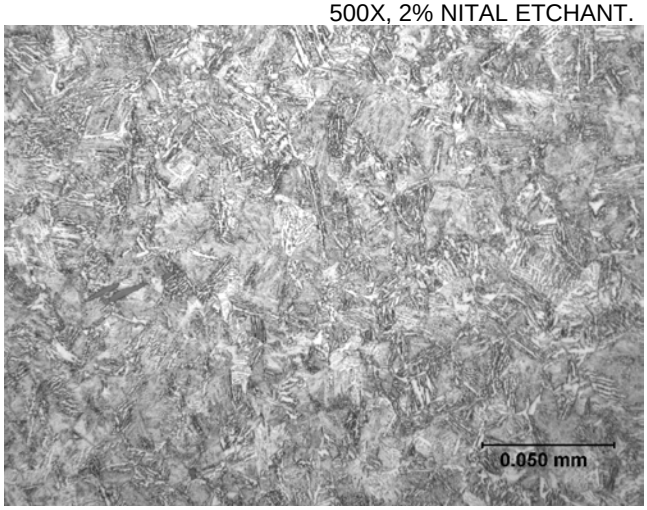
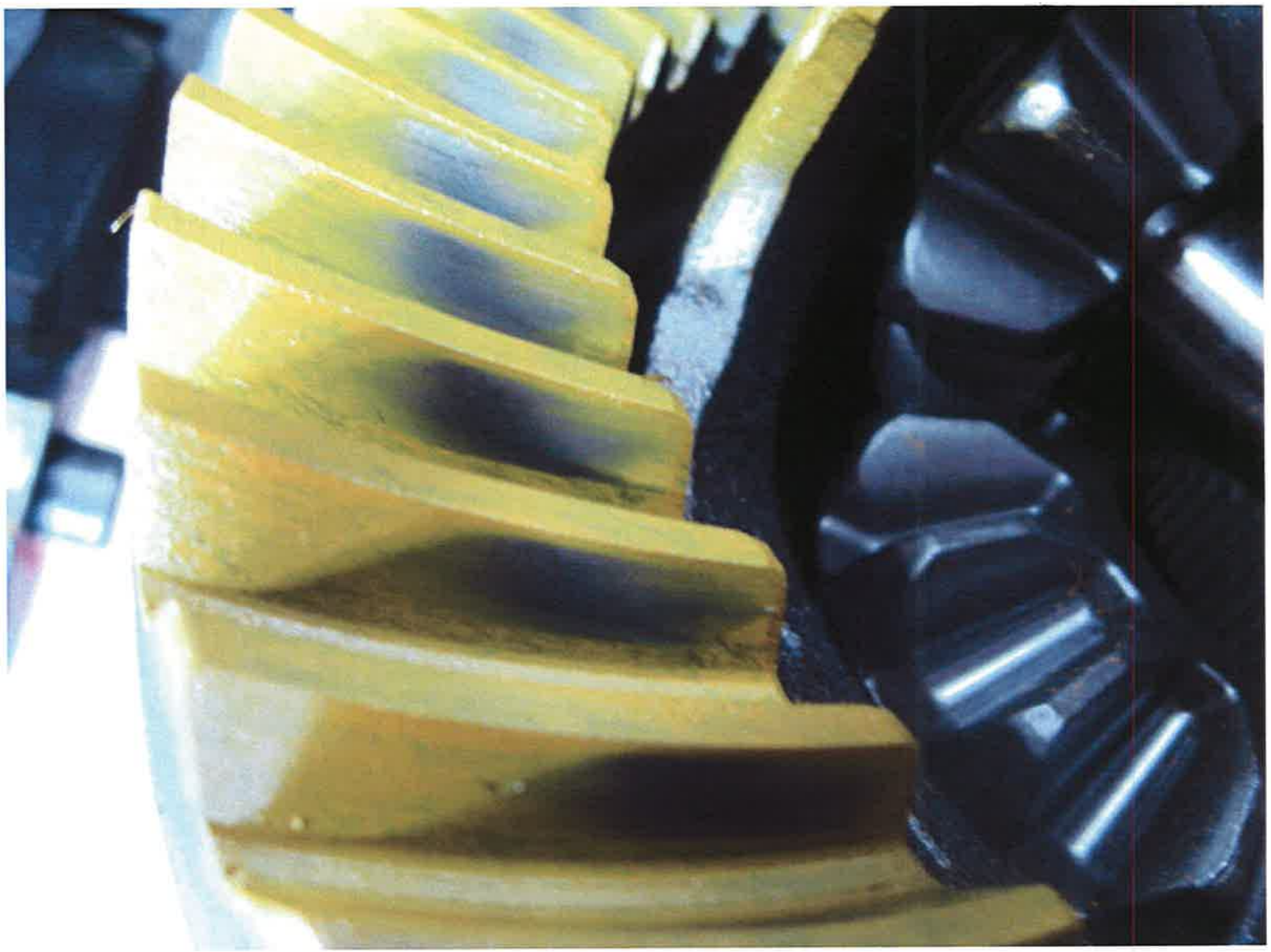


FIGURE 9: CORE MICROSTRUCTURE, AT THE ROOT, 500X, 2% NITAL ETCHANT.

Axle S/N:	0062	P/N:	060GA105X
Match No:	7L	Pinbat:	V1L528
Oil:	152-1	Gearbat:	P4T883A
Testkey:	67341	Lab:	E

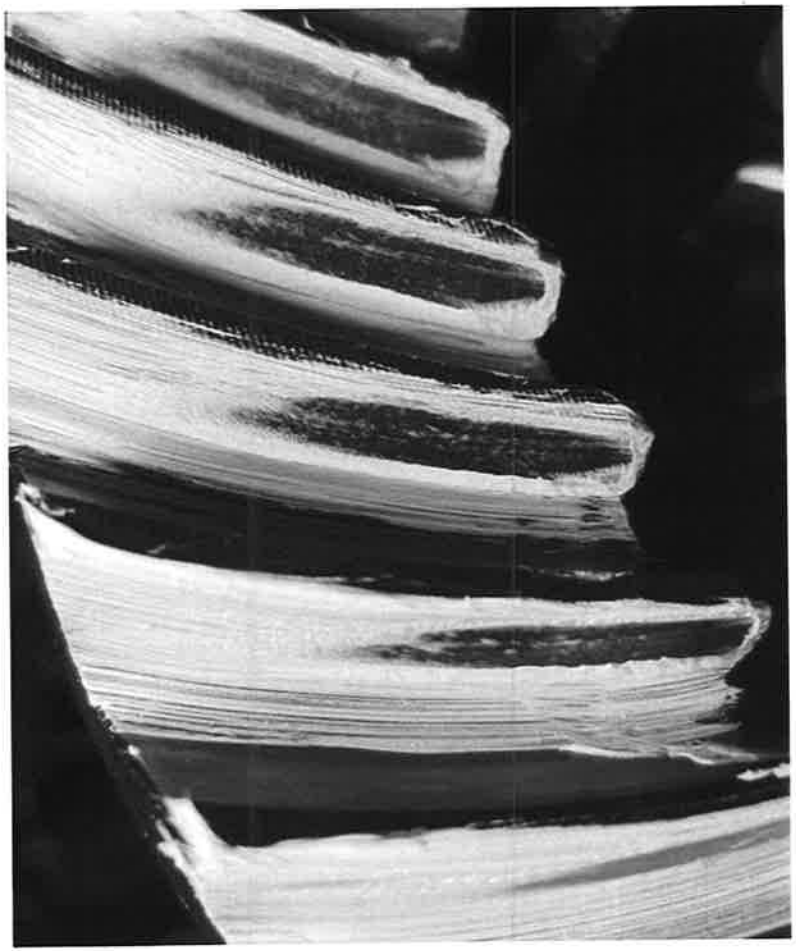


Attachment #4

Axle Serial number ASTM 62 **Pin/Ring batch** V1L528/P4T883A
Fluid Code CMIR 67341 **Axle type** Non-lubrited
Notes: Broken Pinion Tooth

Before Test contact pattern

After test contact pattern

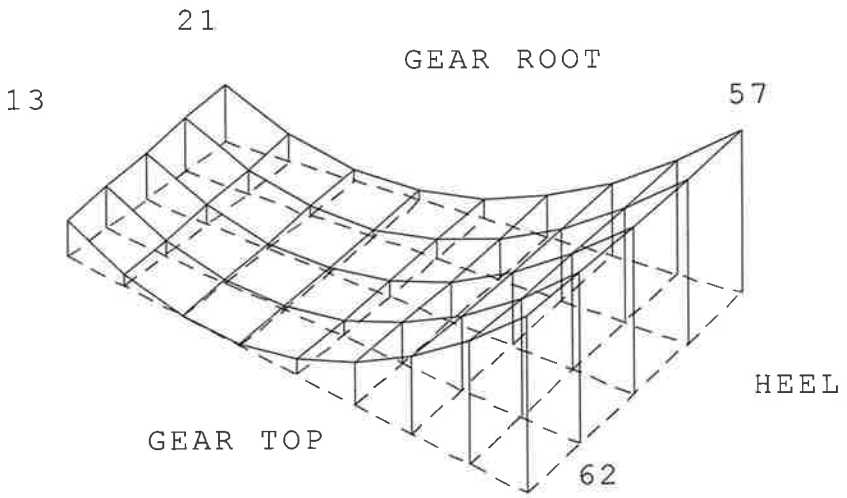


L37 Gear set pattern

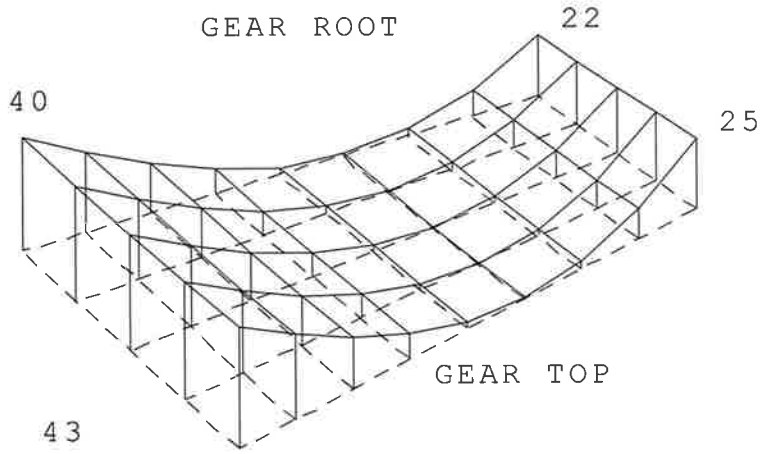
Attachment #4

EASE-OFF

DRIVE SIDE



COAST SIDE



SCALE

each division = .0020 inch
dimensions shown in 1/10000 inch

* EASE-OFF ZEROED AT MINIMUM VALUE

* EDGE REDUCTION BASED ON UC FILLET CALCULATIONS

* TOPREM/FLANKREM CALCULATED

FILE NAME: RDWRK/REVERSE-7L5

DANA CORP-SPICER OFF-HIGHWAY DIV
SUMMARY NO. S060586A
RATIO: 7 X 41
DATE: 11/ 4/2009 15:55 HOURS

T727 version: 2 10.0

Attachment #4

INPUT FILE: REVERSE-7L5
OUTPUT FILE: REVERSE-7L5out
GEAR TORQUE: 3480.000 lb-ft
11\05\2009 VERSION 8.19 time:08:16am

V= 0.0000 in E= -.01295 in
H= 0.0000 in P= 0.00907 in
G= 0.0000 in G= 0.00392 in
cmf= 1.0000 A= 0.00071 ra
Separation factor= 0.00025

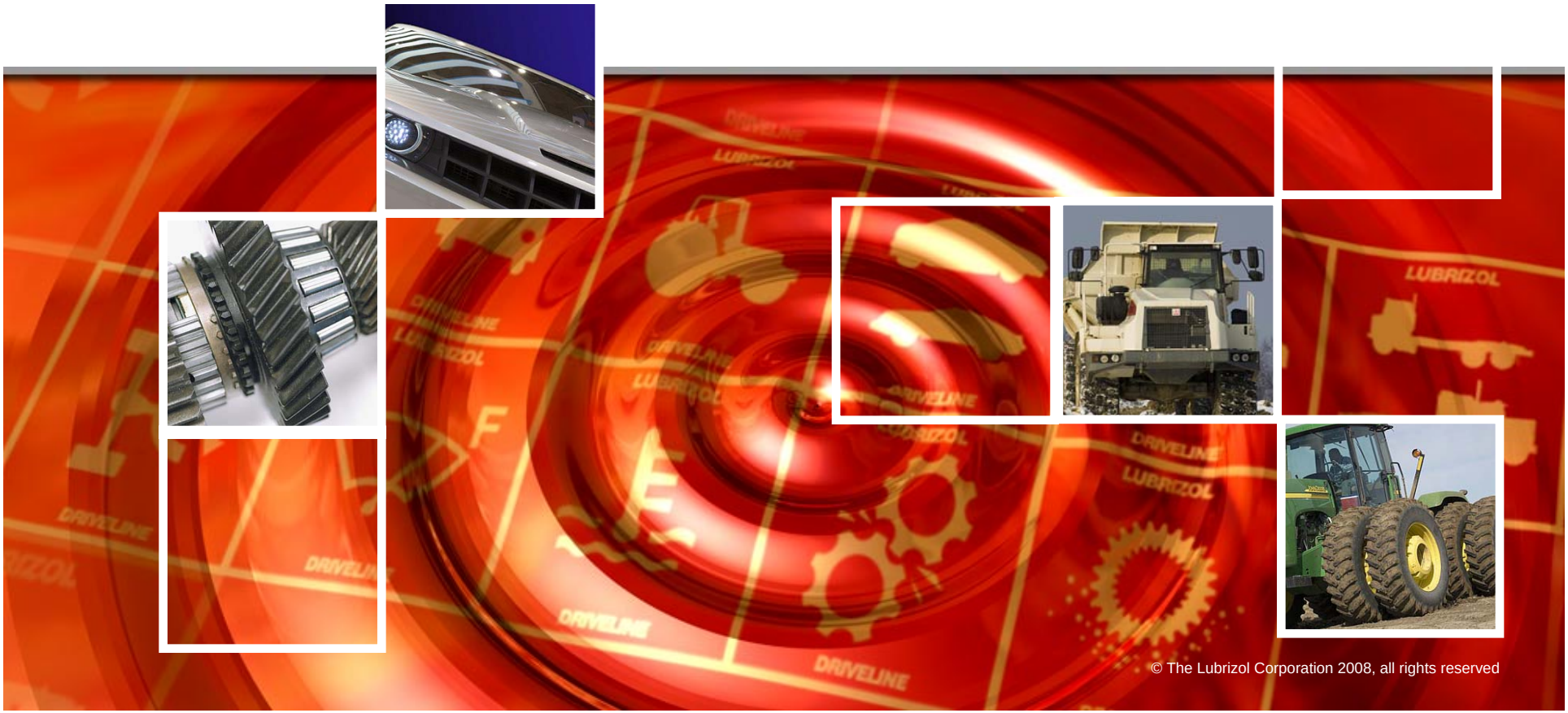
GEAR CONTACT STRESS

Attachment #4

Attachment #5

Reduced Load L-37 Development

Galen Greene
The Lubrizol Corporation
11/11/2009



Lubrizol

Agenda

- Review Lubrizol reduced load testing
- Discuss next steps

Scope/Goal

- Determine if a reduced loading procedure can be developed on the rejected 2008 batch
- Use existing SwRI data on reduced loading tests as a starting point

Lubrizol

Hardware Numbers

Axle Type	Gearset Count	Housing Count	Ring Code	Pinion Code	Labs
Lub - 2006	956	956	P4L816	B6L566	4
Lub - 2008	1182	226	P4L870A	V1L500	2
Lub - 2009	0 (1182)	0	P4T883A	V1L528	4
Plain - 2008	985	985	P4T813	V1L500	3
Plain - 2009	0 (985)	0	P4T883A	V1L528	3

- Development work was done on 2008 batch since it has the largest amount of hardware already produced
- Using the 2008 hardware batch also minimizes the retrofitting
- Lowest cost option

Lubrizol

Reduced Loading Development

- Previous data was analyzed to determine a starting point
  - All development was on 2008 Lubrited and Non-Lubrited Hardware
- It was decided to start between 11% and 14% contact stress reduction
- 13% contact stress reduction seemed to show promise in initial testing
- Conditions:

	Wheel Torque (ft. lbs.)	Wheel Torque Reduction (%)	Contact Stress (psi)	Contact Stress Reduction (%)	Wheel Speed (rpm)
Standard L-37	1740	-	300,000	-	80
Reduced Loading L-37	1213	30%	261,500	13%	80

Attachment #5

13% Reduced Contact Stress Test Results

- Lubrited

Oil	TESTHARD	Test Version	PINION BATCH	RING BATCH	PINION GEAR WEAR	PINION GEAR RIPPLING	PINION GEAR RIDGING	PINION GEAR PITTING / SPALLING	PINION GEAR SCORING
75W-90 Factory Fill Oil	Lubrited	Standard RL	V1L500	P4L870A	7	9	8	9.8	10
75W-90 Factory Fill Oil	Lubrited	Standard RL	V1L500	P4L870A	7	9	8	9.8	10
75W-90 Factory Fill Oil	Lubrited	Standard RL	V1L500	P4L870A	8	9	9	9.5	10
MIL-PRF-2105E Approved 80W-90 Oil	Lubrited	Standard RL	V1L500	P4L870A	7	9	9	8	10
MIL-PRF-2105E Approved 80W-90 Oil	Lubrited	Standard RL	V1L500	P4L870A	8	9	9	9.7	10
MIL-PRF-2105E Approved 80W-90 Oil	Lubrited	Standard RL	V1L500	P4L870A	7	9	9	9.3	10
LZ In-House Discrimination Oil	Lubrited	Standard RL	V1L500	P4L870A	7	7	7	7	10
LZ In-House Discrimination Oil	Lubrited	Standard RL	V1L500	P4L870A	6	10	5	9.6	10

- Non-Lubrited

Oil	TESTHARD	Test Version	PINION BATCH	RING BATCH	PINION GEAR WEAR	PINION GEAR RIPPLING	PINION GEAR RIDGING	PINION GEAR PITTING / SPALLING	PINION GEAR SCORING
75W-90 Factory Fill Oil	Non-Lubrited	Standard RL	V1L500	P4T813	7	9	8	9.6	10
75W-90 Factory Fill Oil	Non-Lubrited	Standard RL	V1L500	P4T813	7	10	8	9.7	10
MIL-PRF-2105E Approved 80W-90 Oil	Non-Lubrited	Standard RL	V1L500	P4T813	7	10	9	9.9	10
LZ In-House Discrimination Oil	Non-Lubrited	Standard RL	V1L500	P4T813	6	8	6	9.9	10
LZ In-House Discrimination Oil	Non-Lubrited	Standard RL	V1L500	P4T813	7	7	4	9.9	10

Lubrizol

13% Reduced Contact Stress Test Results

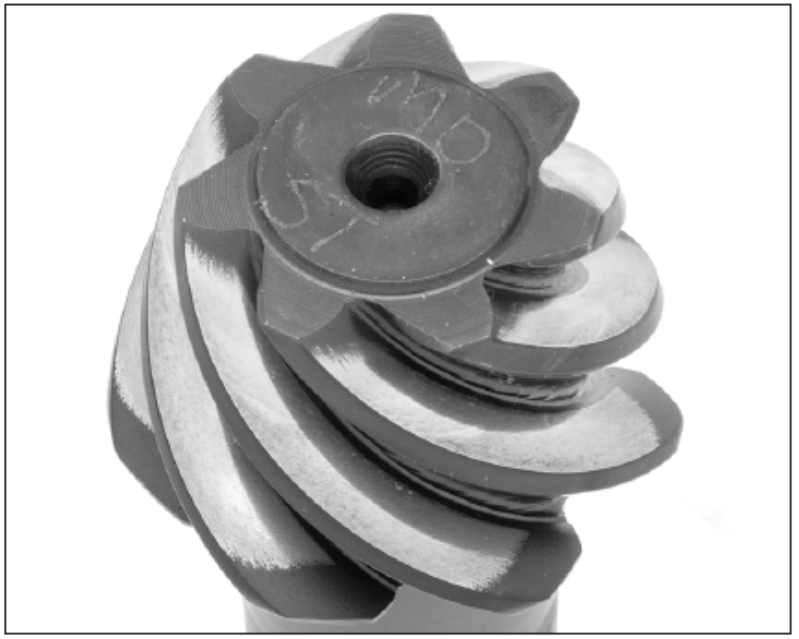
Canadian Tests (200 °F Oil Temp)

- SAE J2360 Approved 75W-140 Factory-Fill Oil

Oil	TESTHARD	Test Version	PINION BATCH	RING BATCH	PINION GEAR WEAR	PINION GEAR RIPPLING	PINION GEAR RIDGING	PINION GEAR PITTING / SPALLING	PINION GEAR SCORING
Approved FF Oil	Lubrited	Canadian RL	V1L500	P4L870A	7	9	8	8	10
Approved FF Oil	Non-Lubrited	Canadian RL	V1L500	P4T813	8	9	9	9.9	10

Photos of Lubrited Tests with Spalling

80W-90 Oil



75W-140 Oil

- Spalling is mild compared to spalling we have seen recently
- Both tests had spalling of 8 on one tooth and 9 on another

Lubrizol

Conclusions

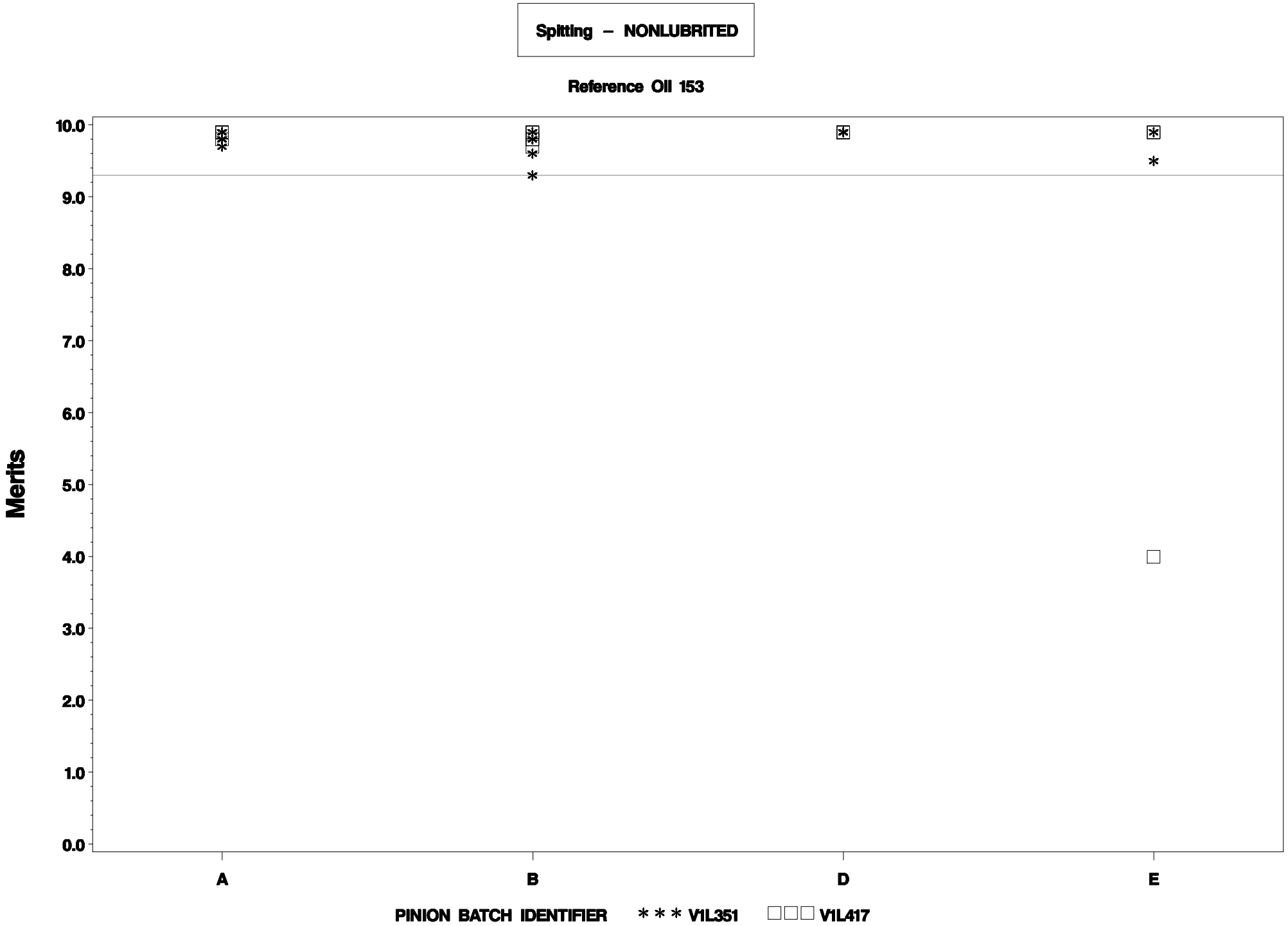
- Lubrizol is fairly confident that this reduced load version of the test represents the previous test accurately
- Lubrizol has run numerous tests on this procedure

Lubrizol Proposal

- Lubrizol is willing to donate some additional testing on TMC reference oils to start an approval matrix of this procedure
- After these tests are complete a panel TC will be called to review data and decide if the industry should continue the full validation matrix
- If results continue to look strong, approval matrix could be run in ~1-2 months

Attachment #6

L – 37 Reference Oil 153 Performance by LTMSLAB



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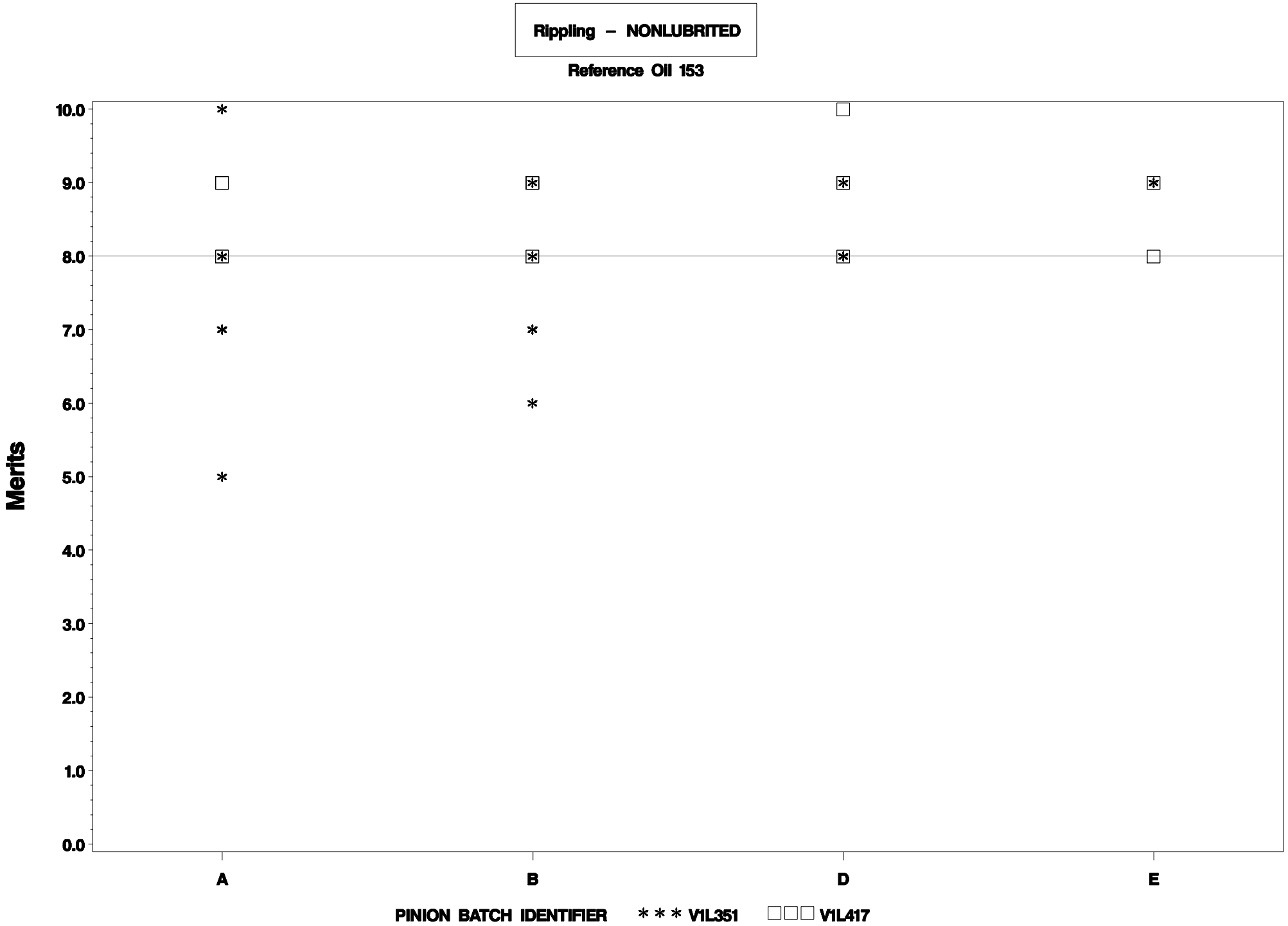
L – 37 Reference Oil 153 Performance by LTMSLAB



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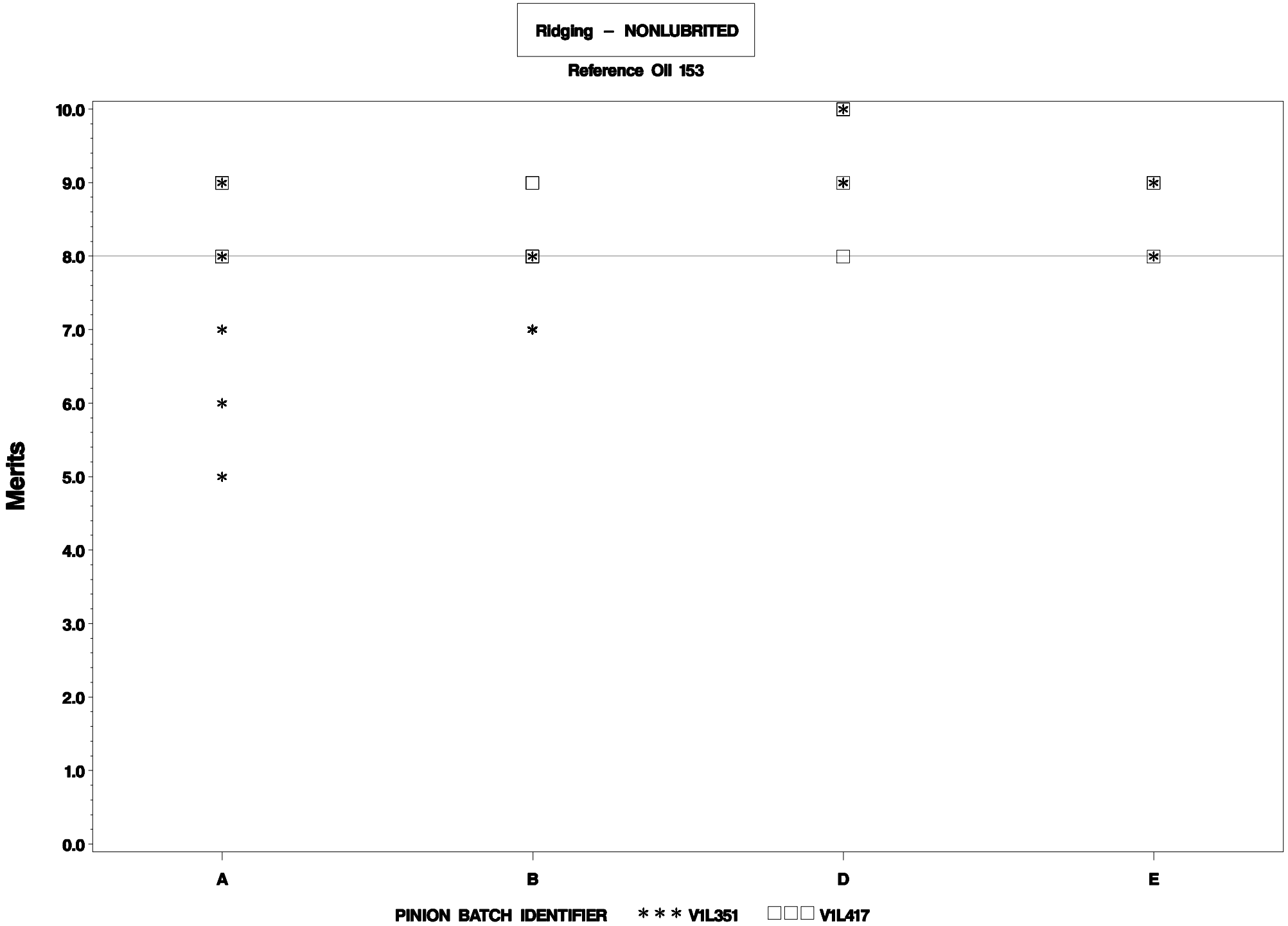
L – 37 Reference Oil 153 Performance by LTMSLAB



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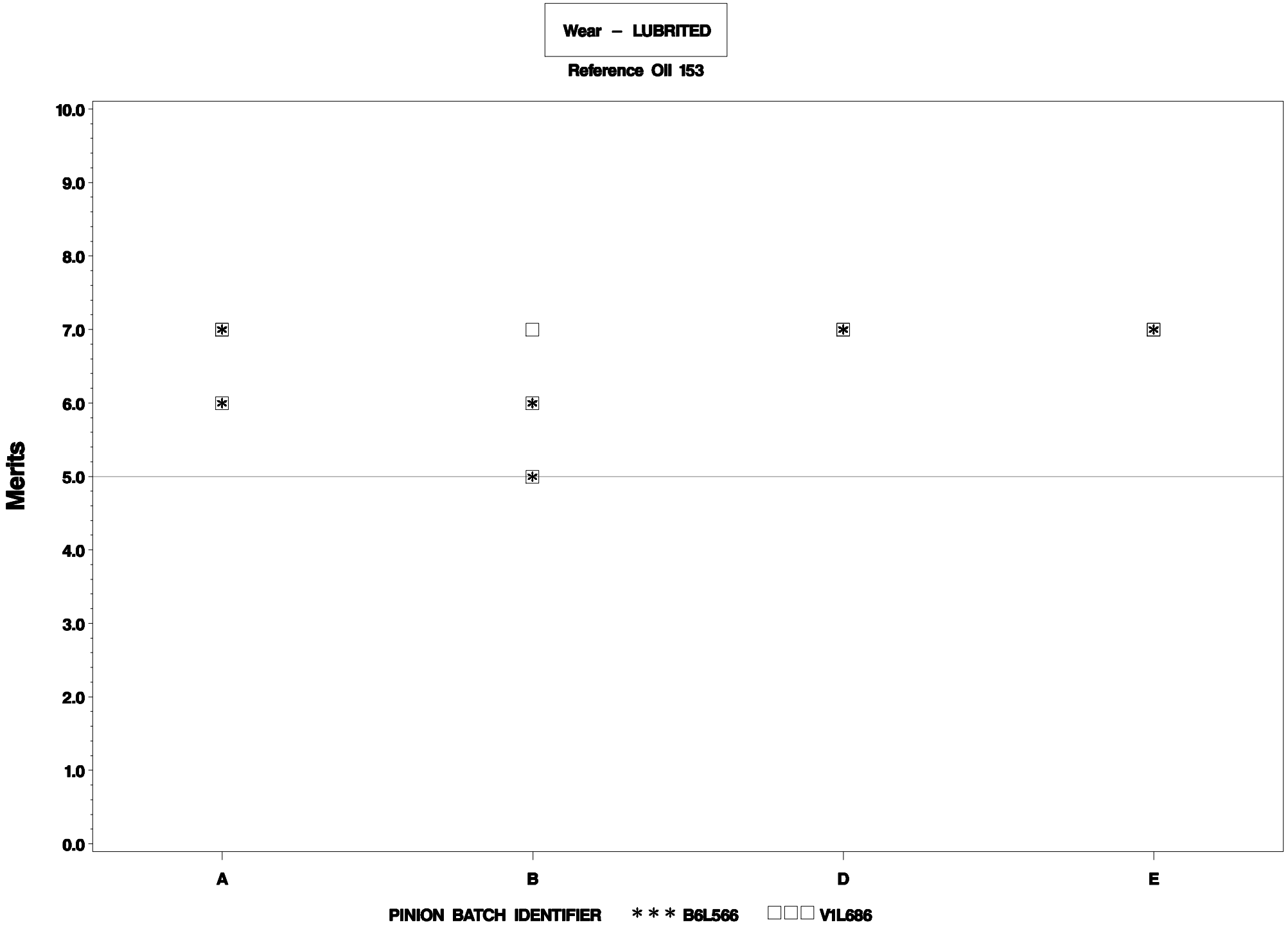
L-37 Reference Oil 153 Performance by LTMSLAB



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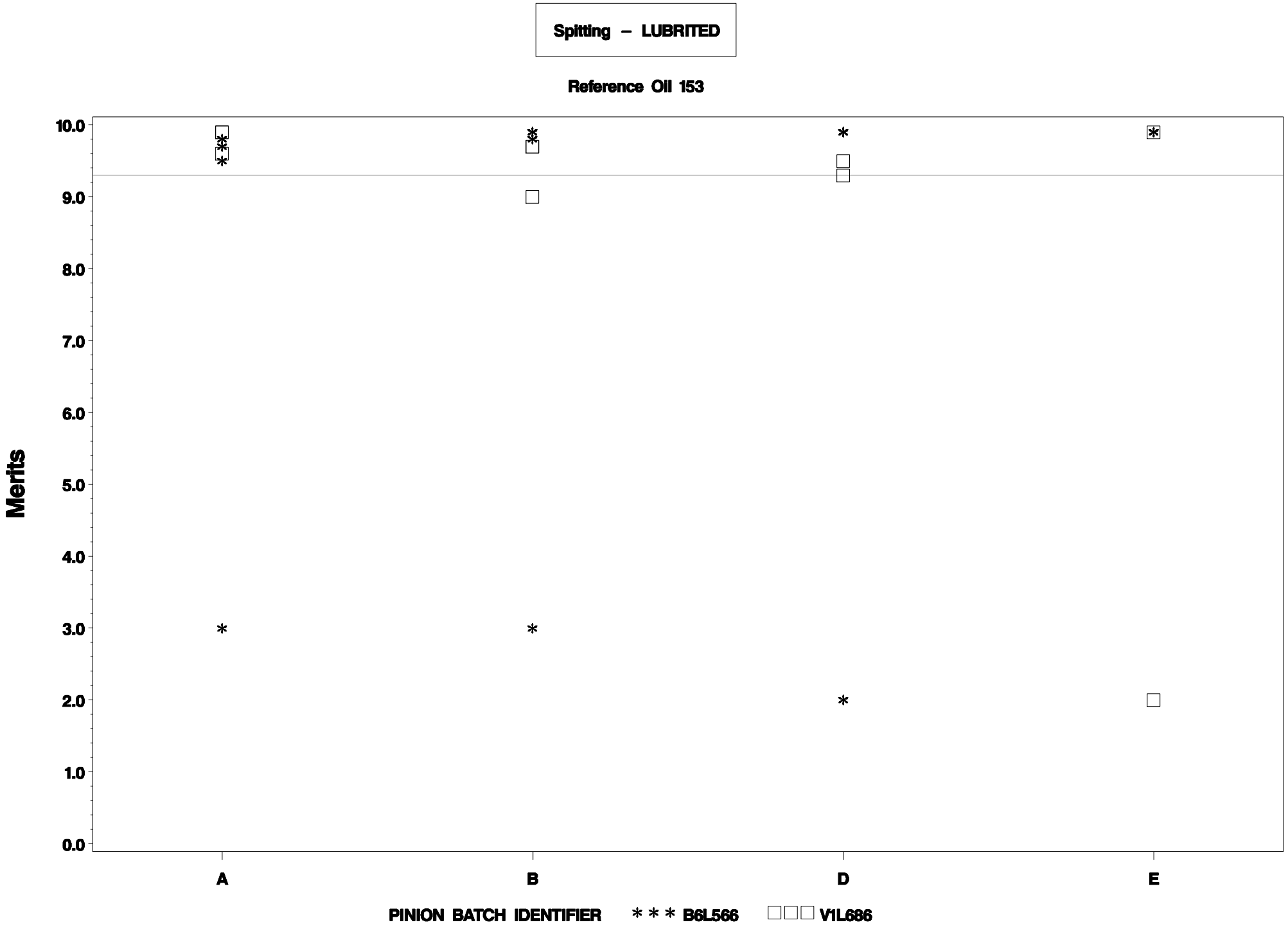
L – 37 Reference Oil 153 Performance by LTMSLAB



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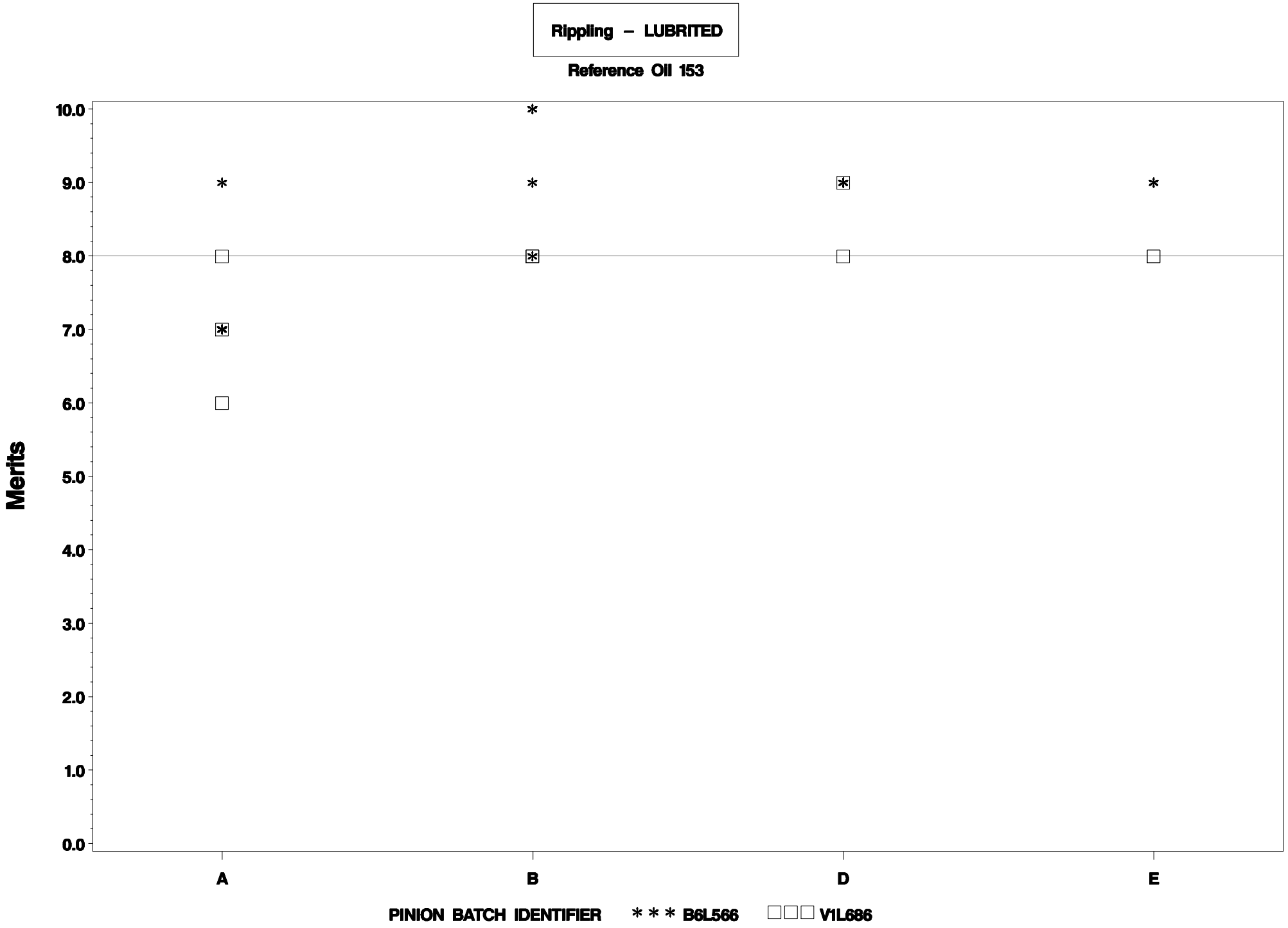
L-37 Reference Oil 153 Performance by LTMSLAB



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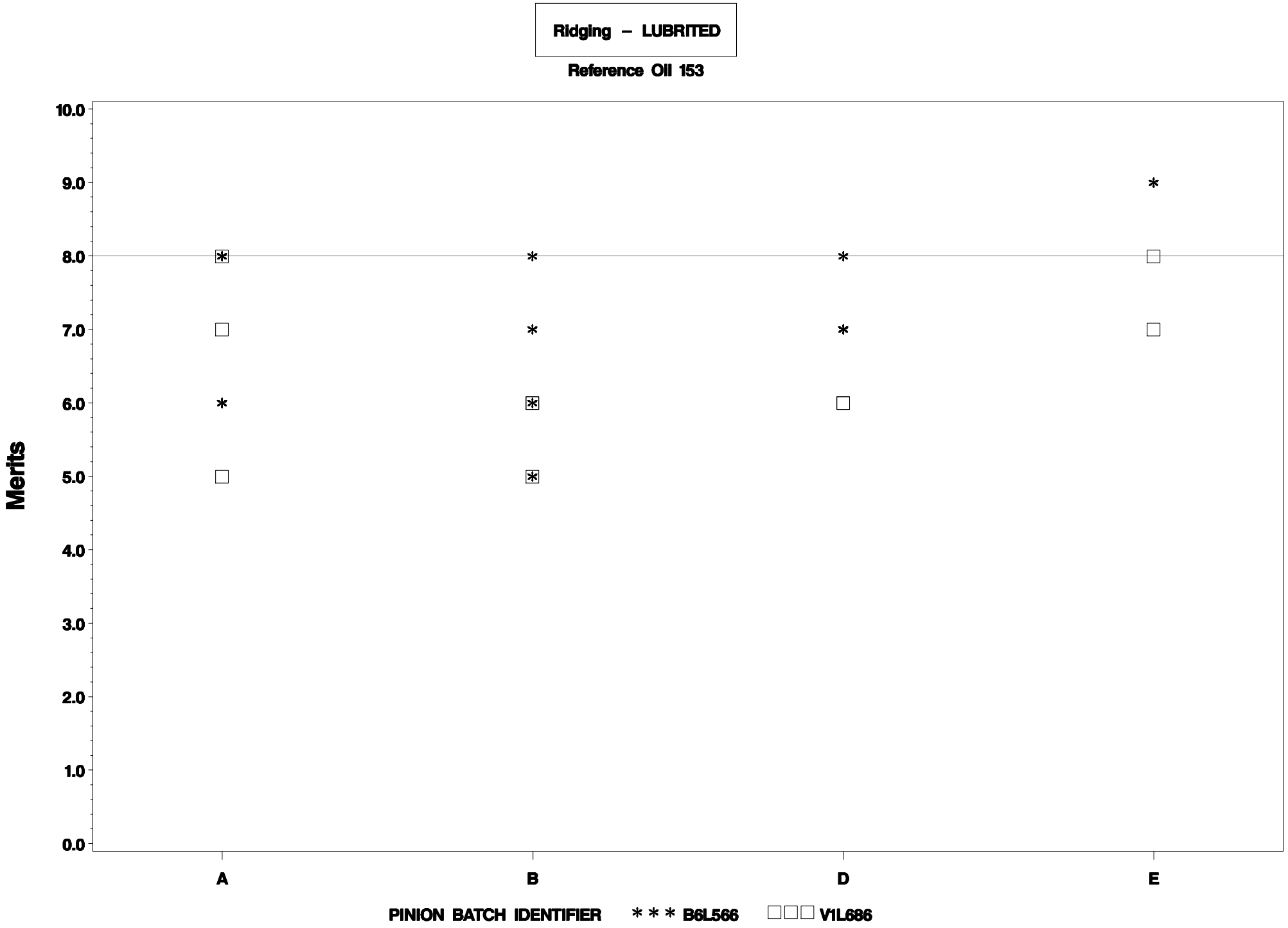
L – 37 Reference Oil 153 Performance by LTMSLAB



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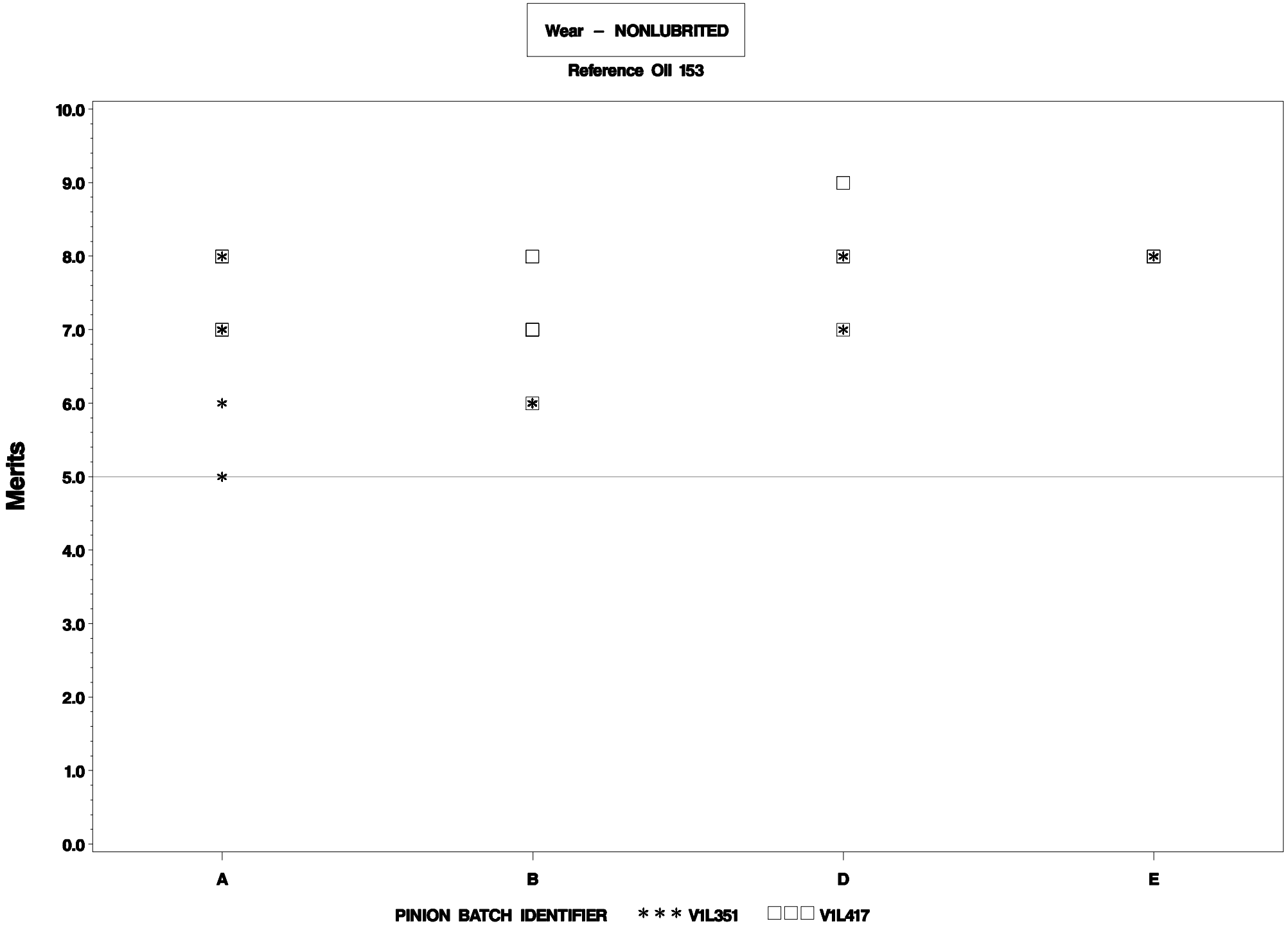
L-37 Reference Oil 153 Performance by LTMSLAB



D02.B0.03

L-37 Surveillance Panel Meeting

11/11/09
2:00 pm – ??
US Army – TACOM
Warren, MI
Galen Greene (The Lubrizol Corporation)

Agenda

I. Call to Order
II. Membership Review
III. Approval of Meeting Minutes
    i. 5/13/09 SP Meeting
IV. Hardware Status
    i. Review Pilot Matrix Results
    ii. Discuss Next Steps
V. Discuss Calibration Frequency
VI. Contact Pattern Study Review
VII. New Business
VIII. Adjournment

2

Membership Review

Galen Greene	The Lubrizol Corporation (Chairman)
Tom Bryson	Volvo Power Train Corporation
Allen Comfort	US Army Tacom-Tardec
John Dharte	American Axle & Manufacturing
Mike Haire	Chevron Global Lubricants
Brian Koehler	Southwest Research Institute
Cory Koglin	Afton Chemical Company
Kenny Miller	Dana Corporation
Don Lind	ASTM Test Monitoring Center
Thelma Marougy	Eaton Corporation
Bruce McGlone	ArvinMeritor Materials Engineering
Dale Smith	Intertek-PARC Technical Services

Total 12 Voting Members

3

D02.B0.03 L-37 Surveillance Panel Meeting

Hardware Status

- Data Review
  - 20 gear sets were built as an initial pilot batch (Pilot 1)
    - Results → Severe pitting/spalling noticed on Lubrited batch, one test with broken teeth
  - 8 remaining axles were re-shimmed to improve performance (Pilot 2)
    - Results → No strong improvement over initial build
  - 20 more gear sets were built to try to improve results (Pilot 3)
    - Group first considered lapping changes but decided that it was not needed as micro pitting was not noticed on Pilot 2
    - Dana made slight geometry modifications
    - Results → No strong improvement, Several non-lubrited tests with broken teeth, several tests had severe pitting/spalling
- Next Steps…

4

Discuss Calibration Frequency

- Current Requirements
  - Section 9.3.3 – “One reference test is required every **two months or after 650 engine hours** on non-reference fluids, whichever comes first.”
  - Section 9.4 – “Calibrate the axle speed measuring system, temperature control system, and torque measuring system to occur at a maximum of **four months or 50 tests** against a known…”
- Discussion…

Pattern Contact Study Review

- Link

Agenda

I. Call to Order
II. Membership Review
III. Approval of Meeting Minutes
    i. 5/13/09 SP Meeting
IV. Hardware Status
    i. Review Pilot Matrix Results
    ii. Discuss Next Steps
V. Discuss Calibration Frequency
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VIII. Adjournment

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